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Drugs and Traffic

A Symposium

June 20–21, 2005
Woods Hole, Massachusetts

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Transportation Research Board
Alcohol, Other Drugs, and Transportation Committee

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Contents

Foreword

The issue of the involvement of drugs other than alcohol has received increasing attention in recent years. In order to synthesize and summarize available information, the Alcohol, Other Drugs, and Transportation Committee of the Transportation Research Board held a symposium to discuss the role of drugs in traffic. The symposium was held at the Jonsson Conference Center in Woods Hole, Massachusetts on June 20–21, 2005. This report provides an overview of the information presented and the discussions among the participants, as well as the background papers prepared for the symposium.

ACKNOWLEDGMENT

This workshop was made possible in part by support and sponsorship of the U.S. National Highway Traffic Safety Administration, the U.S. National Institute on Drug Abuse, and Transport Canada. The workshop was also cosponsored by the International Council on Alcohol, Drugs, and Traffic Safety.

Special thanks to Kathryn Stewart, chair of the Alcohol, Other Drugs, and Transportation Committee, who organized the symposium and prepared this circular.

TABLE 1 Acronyms Used Throughout This Circular

Acronym	Definition
BZD	Benzodiazepines
CNS	Central nervous system
DRE	Drug recognition expert
DUID	Driving under the influence of drugs
DWI	Driving while impaired
GHB	Gamma hydroxybutyrate (steroids)
IACP	International Association of Chiefs of Police
LSD	Lysergic acid diethylamide
MDMA	methylenedioxy-methamphetamine
NSC	National Science Council
PCP	Phencyclidine
SFST	Standardized field sobriety test
THC	Tetrahydrocannabinol
MDMA	3-4 methylenedioxymethamphetamine (Ecstasy)
MDEA	3,4-methylenedioxy-*N*-ethylamphetamine
MDA	3,4-methylenedioxyamphetamine

Overview and Summary

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INTRODUCTION

Impairment by drugs has gained increasing attention in recent years as a possible threat to traffic safety. Research has indicated the presence of psychoactive drugs in killed and injured drivers and experimental studies have demonstrated performance impairment in subjects who have been given certain drugs. Many states and other countries have implemented laws designed to deter drugged driving. Attempts to control drugs in traffic, however, are subject to gaps in knowledge about drugs and an array of practical difficulties. They are also influenced by political concerns.

In response to these issues, the Alcohol, Other Drugs, and Transportation Committee of the Transportation Research Board held a workshop to discuss the current state of knowledge of drugs in traffic. The workshop took place at the Jonsson Conference Center of the National Academy of Sciences in Woods Hole, Massachusetts, on June 20–21, 2005. This report provides an overview of the information presented and the discussions among participants as well as the background papers prepared for the workshop.

BACKGROUND AND STRUCTURE OF THE WORKSHOP

Considerable progress has been made worldwide in the prevention of alcohol-impaired driving. Alcohol-related crashes have been reduced and there is a well-established technology for deterring and detecting alcohol-impaired driving. The laws, policies, and enforcement practices used to address alcohol-impaired driving are based on experimental and epidemiological research clearly indicating the increasing impairment and increasing crash risk related to measured levels of alcohol in the blood and breath. Despite this progress, alcohol continues to cause tens of thousands of crashes, injuries, and fatalities in traffic.

Policy makers and researchers have also become concerned with the effects of psychoactive drugs other than alcohol on traffic safety. A large body of research now exists that provides information about the performance effects of drugs, the risks posed by drugs in traffic, and enforcement strategies for dealing with drugs in traffic. This research paints a complicated picture and many questions remain unanswered.

This workshop provided an opportunity for experts from various areas of traffic safety and drug research to summarize and synthesize the current state of knowledge regarding drugs in traffic.

The workshop was attended by committee members, other researchers, government policy makers, and representatives of advocacy organizations. Attendees came from eight different countries. A list of attendees appears in Appendix B.

Background papers were prepared by researchers on relevant topics. Authors of the papers made brief presentations followed by prepared responses from invited discussants. These invited responses were followed by general discussion.

Topics covered in the workshop were

- The risks posed by drugs in traffic;
- The effects of drugs;
- Medicinal drugs;
- The legal framework for dealing with drugs in traffic; and
- Enforcement issues.

The complete agenda of the workshop is included in Appendix A. The background papers and invited responses by discussants appear in the second section of this circular.

OVERVIEW OF THE DISCUSSIONS

The workshop was designed to review and synthesize the research pertaining to some of the key questions about drugs in traffic.

- What is the actual traffic safety risk posed by various drugs? How does this level of risk compare to that posed by alcohol?
- What are the specific behavioral and performance effects of various drugs? How do these effects impair driving?
- What are the particular issues and challenges posed by the use of impairing medicinal drugs by drivers?
- What laws are currently in place in the United States and in other countries to deal with drugs in traffic? What laws might be considered for implementation? What are the advantages and disadvantages of different legal approaches?
- How can laws against drug impairment best be enforced? What are the major enforcement challenges?
- What are the effects (intended and unintended) of laws against drug impaired driving and the enforcement of these laws? What is the net effect on traffic safety?

The background papers and discussions indicate the complexity of the drugged driving problem. They also highlighted the many questions that research has yet to answer and the practical, technical, and legal difficulties that researchers must deal with.

A summary of the discussion of each the topic areas appear below.

SAFETY RISK OF DRUGS IN TRAFFIC

The traffic safety risks posed by alcohol impairment among drivers were well established decades ago through both experimental research and case controlled studies of traffic crashes. Research on the traffic safety risks of drug use is not nearly so well developed for many reasons, some of which are listed below.

- While alcohol can reliably measured through breath tests, drugs are measured through more intrusive tests of bodily fluids (blood, urine, or oral fluids), preferably blood.
- The correlation between blood levels of drugs and behavioral and performance impairment is very low and unreliable for many drugs.

- The methods of collecting, storing, and analyzing samples can have a major effect on results, making the specific technology used in research very important and sometimes limiting the comparability of different studies.
- Because tests are typically more invasive, refusal rates among survey samples are very high.
- A wide range of drugs are in use and are possibly impairing, requiring more elaborate and expensive analyses.
- The elimination of alcohol from the body occurs slowly and in a predictable pattern; other drugs may be eliminated much more quickly, more slowly or unpredictably, making the timing of testing more critical. Often, practical constraints delay testing after crashes.
- The incidence of drug use among the general driving population as well as among drivers in crashes appears to be lower than that of alcohol; therefore very large samples are required.

These issues, among others, make epidemiological research much more difficult than for alcohol. Some of these difficulties may contribute to variations in the results among studies. Many different drugs, both licit and illicit, are potentially impairing. Much of the research carried out thus far has focused on cannabis, benzodiazepines, and stimulants. Results of studies are complicated, but the following summary provides some of the major findings that can be seen in more detail in the background papers.

Crash Risk

Many studies calculate the odds ratio for crash-involved drivers with measurable amounts of various substances. That means, if a sober driver has a risk of crashing represented by an odds ratio of one, what is the increased risk created by alcohol or drug use? A recent case comparison study in the United States found that at blood alcohol contents (BACs) in the .080 to .099 range, single-vehicle drivers in fatal crashes had a relative risk of about nine and drivers in all (single and multiple vehicle) fatal crashes at that level had a relative risk of about six. The odds ratio for alcohol at .15 or above (a typical BAC at arrest) was over 80 (Zador, Krawchuk, and Voas, 2000). A recent study in the Netherlands measured the odds ratio of alcohol-only cases between .05 and .08 (below the legal limit in the United States) at eight and with BACs of over .13 being 87 times more likely to be involved in a fatal or injury crash than a sober driver. (See background paper by Mathijssen in this circular).

Cannabis

Cannabis (marijuana) is one of the drugs other than alcohol most commonly found among drivers. As summarized in the background paper by Bierness et al., some studies find that the risk of crashing for drivers with cannabis in their systems is actually lower than for drivers with no drugs. Other studies find increases from approximately 1.5 to 2.5 times the risk of crashing as compared to sober drivers. It has been pointed out that some studies of cannabis relied on urine tests, which may have detected cannabis many hours or even days after use, when the driver was no longer impaired. One study that used blood tests, which would detect only more recent use, found the risk of a fatal crash to be 6.4 times that of a non-drugged driver (Swann, 2000). Some studies have used responsibility analysis to classify drivers as either culpable or non-culpable in

crashes. These studies have found an association between cannabis at high levels and culpability for crashes (Drummer et al., 2004).

Cannabis used in combination with alcohol (even at relatively low levels) results in a crash risk greater than for either substance alone.

It was pointed out in the discussion that emergency room studies find a high proportion of trauma patients who are positive for cannabis, indicating a possible link between cannabis use and accidents, including traffic crashes. These studies do not include case controls, however, and do not establish that cannabis plays a causal role in accidents.

Benzodiazepines

The evidence about the crash risks associated with benzodiazepines is also mixed. The level of risk tends to vary with the type of benzodiazepine and how long the driver had been using it, with the greatest risk associated with early use. Crash risk elevation is in the area of 1.6 to 5 times that of a driver with no drugs.

Stimulants

Few studies have examined the crash risk associated with stimulant drugs, including amphetamines and cocaine. Small increases in risk have been found in some studies.

Conclusions

The crash risk associated with typical levels of alcohol is much greater than for other common drugs. Moreover, alcohol is the most common impairing substance found in drivers (either those involved in crashes or selected randomly for testing). Therefore, alcohol is still the drug most likely to have a major effect on traffic safety. The presence of alcohol along with other drugs shows increased risk of crashing. Major informational gaps still exist. For example, at this point, data are not available to establish the prevalence of drug use among fatally injured drivers.

PERFORMANCE AND BEHAVIORAL EFFECTS OF DRUGS

Laboratory, driving simulator, and experimental driving studies have been carried out for many potentially impairing drugs. The results of these tests, as well as observations of patients and arrestees who have used drugs, provide information about the specific effects of these drugs on performance and behavior.

Many illicit, prescription, and over-the-counter drugs may have impairing effects on the skills required for driving. It should be kept in mind, however, that just because a drug affects mental or physical functioning does not mean it will have a net negative effect on driving performance or traffic safety. Some prescription drugs, for example, may enhance performance by decreasing pain, depression, or other conditions that might make drivers less safe.

Understanding the effects of different drugs is important to understanding potential effects on driving performance and traffic safety. Different classes of drugs and different drugs within classes have widely differing effects and widely different potential for traffic safety impact. Some of the issues raised during presentations and discussions included the following:

- There is an enormous number of potentially impairing drugs and the list of drugs in common usage changes constantly. Measuring the performance effects of the whole range of drugs is a huge and costly task.
- The relationship between drug levels in the blood and performance vary widely. For alcohol, there is a clear relationship between blood alcohol levels and performance; that is, higher levels are related to poorer performance. For some drugs, however, concentrations in the blood are *not* clearly related to performance or behavior.
- Some drugs, such as benzodiazepines, taken over time accumulate in the body, increasing concentrations. But these same drugs may result in tolerance and decreased impairment over time. Thus, predicting potential drug effects at a given dose is difficult.
- For ethical and safety reasons, laboratory studies tend to use lower dosages of drugs than might be taken by typical users. This makes the measurement of realistic performance decrements more difficult.
- Laboratory studies can measure performance on specific tasks but cannot measure behavior in actual traffic situations. That is, some drugs may have impairing effects without resulting in effects on traffic safety. Drivers may compensate for drug effects by driving more carefully or avoiding risky situations; drug takers may avoid driving altogether after taking certain very impairing drugs.
- The finding that drivers who use some drugs may be more likely to be involved in crashes does not mean that the drug actually increased the risk. Drivers who take drugs may simply be risk takers or irresponsible drivers regardless of whether they are under the influence of drugs at any given time. For example, illicit drugs are most commonly found among young male drivers, who have the highest crash risk even when not using drugs.
- Individual differences in response to some drugs are very great and may, in fact, be greater in magnitude than the average effects of the drug.

Conclusions

There is considerable evidence that many drugs can impair some measures of performance. Much less is known about the impact of this impairment on driving skills or actual driving. More research is needed, using careful and consistent methodologies, to determine the impairment potential of different drugs. Participants in the workshop suggested that researchers focus first on those drugs most frequently found in drivers and those that are most often used in combination with alcohol. These would include cannabis and benzodiazepines and possibly stimulants.

MEDICINAL DRUGS AND TRAFFIC SAFETY

Potentially impairing medicinal drugs pose different challenges than do illicit drugs and also require different strategies for reducing traffic safety problems. Again, it is important to keep in mind that patients taking medicinal drugs as directed may be improving driving safety by alleviating the underlying condition the drug is treating.

One difficulty in measuring the impact of medicinal drugs on traffic safety is that findings are affected by drivers who are using medicinal drugs illicitly or improperly. Most studies do not have the capacity to eliminate these drivers from the analysis.

The medicinal drug group of greatest concern based on crash studies is benzodiazepines. Other drugs may be present in traffic crashes, but tests are usually not carried out for many potentially impairing drugs. Laboratory studies have also found that some anti-depressants and first generation antihistamines as well as some narcotic analgesics and anti-psychotics can impair performance.

Strategies for preventing impairment by medicinal drugs include:

- Educating physicians and pharmacists to avoid the use of the most impairing drugs. In the case of benzodiazepines and antihistamines, less impairing alternatives are available, though some may cost more or may not be covered by insurance. Physicians might also be encouraged to assess driving ability as part of medical evaluation.
- Educating patients regarding potential impairment, especially through the use of better labeling and package inserts. In particular, for some drugs it is important that patients do not combine the drug with alcohol.
- Developing better systems for risk communications. Various schemes have been developed to provide information for physicians, pharmacists, and patients regarding the potential impairing effects of different drugs, including estimating the BAC equivalent of using a particular drug.

Conclusions

Medicinal drugs may increase crash risk but additional research is needed using standardized methodologies to learn more about the risks posed by medicinal drugs in traffic. Research is also needed to disentangle the traffic safety risks of drugs taken as directed from those used incorrectly or illicitly. At least some portion of the risk posed by medicinal drugs results from the prescribing practices of physicians since less impairing drug alternatives are available in some cases.

LEGAL FRAMEWORK FOR DEALING WITH DRUGS AND DRIVING

Most countries and all states in the United States have some sort of legislation prohibiting or limiting the use of impairing drugs by drivers. There are two main approaches currently used in legislation:

- Impairment-based statutes that specify that the prosecution must prove that the driver was impaired or under the influence. The analysis of drugs in blood or urine only provides corroborating evidence as to the cause of the impairment.
- Per se laws, in which no proof of impairment are required. The presence of an illicit drug in a body fluid is enough to bring a conviction. (It should be noted here that while proof of impairment is not required where per se laws are in use, in the United States, some probable cause, such as erratic driving, is required before a driver may be stopped. In addition, some reasonable suspicion of drug use must be demonstrated before a specimen may be requested.)

Impairment based laws differ in the definition of impairment. One disadvantage of these laws is that impairment is difficult to measure and can easily be missed by a police officer in the field.

Per se laws are often basically zero tolerance laws. That is, any detectable level of specified drugs in body fluids constitutes an offense. This makes prosecution less difficult but does mean, at least in theory, that drivers who are not really impaired can be prosecuted.

A third possibility is under discussion, that is, per se laws based on the establishment of legal limits for drugs similar to those imposed for alcohol, that is, levels that have been demonstrated to be impairing. It has been argued by some that the body of experimental and epidemiological knowledge that has been accumulated allows for the establishment of such limits (Mørland, 2005.) Others disagree that appropriate levels are yet known.

Finland includes some elements of zero tolerance along with impairment measures. That is a driver may be charged with illegal possession of a drug under zero tolerance statutes even if no impairment is present. If there is an indication of impairment, they can be charged with driving under the influence of a drug.

Little is known about the effects of any of these laws on the number of drugged drivers in traffic or on traffic safety. There has been a dramatic increase in prosecutions in countries that have introduced per se laws. A study is currently being funded by the NHTSA in the United States to evaluate the effects of drugged driving laws on enforcement and judicial processes and on traffic safety.

Discussions raised a number of issues regarding the legal framework. One major issue raised was the importance of distinguishing between laws that are intended to improve traffic safety and laws that are intended to punish drug users. To the extent that scarce traffic enforcement resources may be used to identify and prosecute drug-using drivers who pose little safety risk, traffic safety may actually be harmed. This issue is discussed further in the following section.

Conclusions

Different types of drugged driving laws have been implemented around the world. The effects and effectiveness of these laws are not yet known. Most importantly, the extent to which an emphasis on drugged driving may have unintended consequences for traffic safety is not known.

ENFORCEMENT OF DRUGGED DRIVING LAWS

The enforcement of drugged driving laws is subject to many difficulties, including the fact that drugs are not easily detected, either through behavioral observation or through chemical analysis. Typically, drugged driving is suspected when impairment is obvious but BAC is zero or low. The question of drug impairment is often not pursued if the BAC is over the legal limit. The enforcement officer and prosecutors generally charge impaired drivers with driving under the influence of alcohol and whether drugs were also present is not determined. Since in many jurisdictions there is no additional penalty for drug-impaired driving over and above the penalty for alcohol-impaired driving, there is no motivation to do further testing.

Many enforcement agencies in the United States have drug recognition experts (DREs) available to them who have received extensive training in recognizing drug impairment from visible cues and in identifying the type of drug most likely to be causing the impairment. These

officers tend to be called on infrequently and their ability to identify drug impairment through physical signs and behavior only has been questioned. More recent technology for less invasive drug testing using body fluids (especially saliva) makes the identification of drug impairment through behavioral cues less important. Some believe that DRE-trained officers can play a role in establishing probable cause to test for drugs and in raising the profile of drug impaired driving as a traffic safety issue.

The State of Victoria, Australia, has recently implemented random roadside testing for tetrahydrocannabinol (THC), the active substance in cannabis, and for methamphetamines. To date more than 11,000 random roadside tests have been performed. This program complements Victoria's aggressive random breath testing strategy for alcohol. Drivers are first breath tested for alcohol and if illegal alcohol levels are found the driver is prosecuted under existing alcohol legislation. If illegal alcohol levels are not found the drivers are then rapidly drug tested using a very small saliva swab. Drivers with positive drug tests are then given a second test using a different drug screening device which collects approximately 1 ml of saliva. This is done in a roadside drug bus and if a second positive is obtained the saliva is then sent for evidentiary standard laboratory analysis. This enforcement campaign includes mass media television and radio public education and is designed to serve as a deterrent. Data collected thus far finds 1 in 100 drivers have tested positive for illegal alcohol levels, and 1 in 50 drivers test positive in the laboratory for either THC or methamphetamine or a combination of both drugs. The process is as accurate as random breath testing for alcohol with less than 1% false positives being found with the roadside drug screening tests. Enforcement takes place at times most likely to find drivers who have been using alcohol or drugs and also on major freight highways. Evaluation of the campaign is ongoing.

Conclusions

Enforcement of drugged driving laws poses significant logistical and technical challenges. A major point of concern during the discussion of enforcement is the degree to which efforts to enforce laws against drug-impaired driving might lead to a decrease in enforcement of other traffic safety measures, especially alcohol-impaired driving. If the more difficult and time-consuming drug enforcement efforts do detract from other enforcement, a net negative effect on traffic safety might result.

OVERARCHING ISSUES AND FUTURE NEEDS

Considerable public, political, and research attention has been paid to drug-impaired driving and its effects on traffic safety. The nature and level of traffic safety risk posed by drugs is not yet known in any detail. In fact, the research that has been carried out indicates that alcohol still poses the most serious risk and the evidence for risks posed by other drugs is often inconsistent or weak. Nonetheless most jurisdictions around the world have implemented some form of law against drug use by drivers.

The variety of impairing drugs and the difficulty and complexity of measuring their presence and effects makes research and evaluation difficult. Accurate information about optimal strategies for improving traffic safety with respect to drugs will continue to be hard to come by. Suggestions were made by the participants about research priorities and methodologies to help fill knowledge gaps regarding the risks posed by drug use among drivers, the performance and

behavioral effects of specific drugs, the best strategies for minimizing risks posed by medicinal drugs, the effects of laws designed to deter drugged driving, and the enforcement strategies used. These include

- Better case-control studies of the risks of crash for different drugs, especially those using better measures of the presence of drugs;
- More complete data collection on the presence of drugs among fatally injured drivers;
- More thorough studies of the performance effects of the range of commonly used drugs, especially establishing consistent protocols for performance testing most relevant to driving skills;
- Studies of the effectiveness of strategies to improve physician, pharmacist, and patient education regarding prescribing practices and impairing effects of medicinal drugs;
- Crash research to disentangle the effects of medicinal drugs used as prescribed as compared to the same drugs used in overdose or illicitly;
- Evaluation of the effects of various legal approaches to drug-impaired driving; and
- Evaluation of the effects of increased drugged driving enforcement on traffic safety.

The most serious concerns were raised about the potential unintended consequences of implementing and enforcing drugged driving laws. Many jurisdictions move ahead with laws and policies. These actions have been taken in the absence of knowledge about the effects of laws and enforcement policy on traffic safety and the possibility that they may deflect attention away from alcohol impaired driving and other traffic safety strategies that may have a more significant payoff.

Risks Posed by Drugs in Traffic

Role of Cannabis and Benzodiazepines in Motor Vehicle Crashes

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Alcohol is known to increase crash risk, but the evidence for other drugs is much less clear. Studies have been hampered by measurement issues and the small proportions of drivers found with drugs other than alcohol, especially drugs in the absence of alcohol. Cannabis and benzodiazepines (BZDs) are the two drugs other than alcohol most often found among crash-involved drivers. Both have been found to impair driving skills measured in the laboratory, but there are few adequate studies assessing their contribution to crashes, and these studies have mixed results. The weight of the evidence suggests that benzodiazepines increase crash risk, in particular long-acting BZDs prescribed for medical use, at least for the first weeks of use. Further studies of cannabis and benzodiazepines are needed to clarify their contribution to the highway safety problem.

INTRODUCTION

The major role of alcohol as a contributing factor in motor vehicle crashes has long been established (U.S. Department of Transportation, 1968; 1978). The role of drugs other than alcohol is much less clear. There are many drugs that can alter behavior and potentially affect driving, but research to investigate their contribution to crashes has lagged. This is largely because of measurement issues. Blood samples needed to link drug use to driving are not easily obtained, in contrast to breath samples that can be used to measure alcohol use. Alcohol concentrations in the breath can be readily converted to blood alcohol concentrations (BACs), but this cannot be done for other drugs.

Laboratory Studies

There is an extensive body of laboratory research focusing on the effects of both legal and illegal drugs on skills related to driving. Drugs that stimulate the central nervous system, e.g., amphetamines, cocaine, caffeine, have been found to improve performance in the laboratory (Burns, 1993; Higgins et al., 1990; Hurst, 1976). However, many other drugs impair one or more driving skills. Such drugs include cannabis and BZDs as well as barbiturates, antidepressants, and some antihistamines (Linnoila and Seppala, 1985; Sharma, 1976; Starmer, 1985).

Laboratory findings are informative but limited as an indicator of actual on-road driving risks. An impairment or skill enhancement identified in a laboratory test may not show up on the

road because the drugs may lead to other changes in driver behavior. Additionally, laboratory tests can address the effects of drugs only on skills, not judgment, and the latter may be as important when it comes to driving. Thus even if drugs are found to affect driving skills in laboratory tests, actual crash risk may or may not be affected.

Evidence Needed

To establish the contribution of drugs to motor vehicle crashes, it is necessary to demonstrate that the incidence of a particular drug is significantly greater among drivers involved in crashes than it is among drivers not in crashes but whose crash risk is similar.

The second piece of evidence needed to establish the extent of the contribution of drugs to crashes is the frequency with which the drug is used by drivers. It is known that drivers use drugs other than alcohol much less than alcohol. Moreover, drugs often are found in combination with alcohol, which complicates the quest to determine the contribution of drugs by themselves.

Drugs Studied

In studies around the world, the two drugs other than alcohol most frequently found in crash-involved drivers are cannabis and BZDs. Their contribution to crashes is assessed in this report.

Cannabis, an illegal drug in the United States, is sometimes classed as a hallucinogen but has a variety of effects, preventing its classification as a stimulant, sedative, tranquilizer, or hallucinogen. There is considerable evidence from laboratory studies that its principal psychoactive component, delta-9-THC substantially impairs reaction time, attention, tracking, hand–eye coordination, and concentration (Couper and Logan, 2004; Gieringer, 1988; Moskowitz, 1985). Cannabis and alcohol together have additive impairing effects (Chesher, 1986; Henderson, 1994). The presence of cannabis among drivers in injury crashes worldwide has been reported to vary anywhere from 2% to 32% (Kelly et al., 2004), but it typically is reported in around 10% of cases.

BZDs, a group of central nervous system depressants, are used to treat insomnia, relieve anxiety and muscle spasms, and prevent seizures. Hypnotics are generally short- or medium-acting BZDs used primarily to treat insomnia, e.g., prazolam (Xanax), and temazepam (Restoril), while anxiolytics are longer-acting BZDs used to treat various forms of anxiety, e.g., diazepam (Valium) and lorazepam (Ativan).

As central nervous system depressants, BZDs slow reaction time, reduce vigilance, and impair attention tasks and cognition (Drummer, 2002). Laboratory studies generally have found decreased performance on these and other tasks involving visual and speed perception, coordination, and information processing (Couper and Logan, 2004; de Gier et al., 1986; Friedel and Staak, 1993). Studies reporting additive impairing effects of BZDs when combined with alcohol also have been published (Smiley et al., 1985). There is a vast amount of literature on laboratory effects of BZDs, however, and there are some contradictory results, even when assessing the same type and dose of BZD (Albery et al., 1998; Friedel and Staak, 1993). In addition, there is evidence that impairment may be limited to the first few days of BZD use, before tolerance develops (Lucki et al., 1985).

BZDs are among the most commonly prescribed medications and are also a class of drugs abused by some individuals. Thus it is not surprising they are found among drivers on the road and those involved in collisions. Their reported frequency in the crash population around the world has ranged from 2% to 15% (Kelly et al., 2004) and is generally in the range of 5% to 9%.

Note that to the extent BZDs increase crash risk this needs to be balanced against the health benefits for those taking these drugs for medicinal purposes. It may also be the case that those with untreated anxiety or insomnia have heightened crash risk.

Case-Control Studies

The experimental paradigm for investigating the contributory role of drugs in collisions is the case-control study. Cases are defined as drivers involved, injured, or killed in crashes. The frequency and quantity of alcohol or other drugs detected in the cases are compared with the frequency and quantity of the substance detected in a comparable group of drivers who have not been involved in collisions. Typically control drivers are recruited on the roads at the same time of day, day of week, and location as crash-involved drivers. This method has been used extensively in the study of alcohol to generate risk estimates or odds ratios (ORs) that express the increased likelihood of collision at different BACs. Conduct of these studies has been greatly facilitated by the ability to substitute breath samples for blood samples.

However, the application of this method for studying drugs other than alcohol is more complex. Ideally blood should be obtained from both cases and controls because the presence of a drug in blood corresponds best with recent use and the extent of any impairment. Among the cases, obtaining blood samples can be a problem but is minimized if studying fatally injured drivers. In contrast to studies of alcohol in which a breath sample can be used, the need to obtain blood samples from controls in cannabis and BZD studies has been an obstacle. As a consequence, testing rates are often low and estimates unreliable. Indeed, the proportion of non-respondents in the control group can exceed the proportion of those with positive drug results. Assumptions made about the distribution of drugs in the untested sample can have profound effects on the estimates of the magnitude of relative risk.

Because of the difficulties in obtaining blood, many studies have resorted to the use of urine. However, drugs typically can be detected in urine for long periods of time following use, so detection does not necessarily imply an active drug and behavioral effects at the time of the crash. Cooperation of drivers in providing a urine sample also is an issue.

Another methodological problem is the elapsed time between the crash and the drawing of the specimen for analysis. Unlike alcohol, where the rate of elimination from blood is relatively slow and fixed, this is not true of other substances. Of particular interest in this regard is cannabis, most of which is metabolized and removed from the blood within the first hour or two after use. The longer the period of time between the crash and the drawing of the sample, the greater the risk of underestimating the incidence and concentration of the drug. In contrast to blood, urine will continue to test positive for cannabis use long after the psychoactive ingredient (THC) has metabolized.

For prescription drugs, there are ways to get around the problem of getting blood samples from control drivers. In studies of medicinal drugs such as benzodiazepines, a variation of the case-control approach—pharmaco-epidemiological studies—has been used. These studies compare the incidence of crashes among drivers who have or have not been prescribed a specific drug. Information from toxicological tests on drivers is not obtained, so it is not possible to verify that cases actually were taking the prescribed medicine at the time of the crash, or taking it at the prescribed dosage level, or in the absence of other drugs. However, the large sample sizes typically obtained in these studies reduces the possibility of these other factors having a significant influence on the overall results.

Crash Responsibility Studies

Another technique that avoids the control sample problem is responsibility or culpability analysis. The distinguishing features of this approach are the absence of a noncrash-involved group and the inclusion of information concerning the attribution of drivers' responsibility for the collisions. Judgments about responsibility for causing the collision are made by examining the circumstances and events leading up to the crash. A comparison can then be made between the proportion of drivers who tested positive for drugs and judged responsible with the proportion who were responsible but drug-free. The contribution of drugs is inferred from the extent to which a greater proportion of drug-positive cases are deemed responsible for their crashes.

Although this approach alleviates the problems associated with obtaining fluid samples from drivers not in crashes, unlike case-control studies it does not completely control for effects on responsibility of time and location. In addition, the procedure is highly dependent on accurate ratings of crash responsibility. Police reports on the crashes are the usual source of information for these judgments. Police reports and judgments based on the reports involve some subjectivity, and in some multiple-vehicle crashes there is shared responsibility. Despite these issues, responsibility analysis has been used in studies of alcohol and driving, and drinking drivers have been shown consistently to be more likely to be responsible for their crashes (Longo et al., 2000; Williams et al., 1985).

Drug Measurement

Many of the studies of the contribution of cannabis or BZDs to motor vehicle crashes have been based on urine samples, which may reflect only past exposure, or a combination of blood and urine samples, with typically a higher proportion of urine samples among control drivers. In some cases where blood samples have been obtained, drivers positive for cannabis have been based in part not on THC but on the cannabis metabolite, carboxy-THC (Drummer, 1995). This metabolite may persist in blood as well as urine for several weeks following use.

To be meaningful, studies of cannabis have to be based on measurements of THC (the active ingredient of cannabis) in blood. For BZDs, blood concentrations are superior in indicating the drug is active, although without knowledge of drug-taking history this will not always provide a good indicator of behavioral effects, given changing responses with repeated use.

Study Results

Studies since 1985 based on THC and studies of BZDs based on blood samples are described in Table 1. There are five such studies. Three studies included both cannabis and BZDs, one study included only cannabis, and one included only BZDs. Four of the studies were based on responsibility analysis, and the one case-control study was based on crash-involved drivers who were brought to hospital emergency departments, while controls were other emergency department patients. Table 1 also includes information on three pharmaco-epidemiological studies.

TABLE 1 Analytical Epidemiological Studies Assessing the Role of Cannabis and Benzodiazepines in Crashes

Study	Jurisdiction/ Period	Sample (N)	Methodology	Odds Ratios*
Case-Control and Responsibility Studies				
Benzodiazepine/Driving Collaborative Group (1993)	France 1989–1990	Injured drivers (N=2,852)	Responsibility analysis	BZD: 0.96 n.s.
Drummer et al. (2004)	Australia 1990–1999	Fatally injured drivers (N=3,398)	Responsibility analysis	Any THC: 2.7 THC: >5 ng/ml 6.6 BZD: 1.3 n.s.
Longo et al. (2000)	Australia 1995–1996	Injured drivers (N=2,279)	Responsibility analysis	THC: 0.8 n.s. BZD: 2.0
Mura et al. (2003)	France 2000–2001	Injured drivers (N=900), ER patients (N=900)	Case-control	THC: 2.5 BZD: 1.7
Williams et al. (1985)	United States 1982–1983	Fatally injured drivers (N=440)	Responsibility analysis	THC: 0.5 n.s.
Pharmaco–Epidemiological Studies				
Neutel (1995)	Canada 1979–1986	Drivers with prescriptions for BZDs (N=147,726), controls (N=97,862)	Case-control	BZD hypnotics: 1st 4 weeks: 3.9 29–60 days: 1.4 n.s. BZD anxiolytics: 1st 4 weeks: 2.5 29–60 days: 1.2 n.s.
Hemmelgarn et al. (1997)	Canada 1990–1993	Drivers ages 67–84 in injury crashes (N=5,579), controls (N=18,490)	Case-control	Short-acting BZDs: 0.96 n.s. Long-acting BZDs: 1st week: 1.45 61–365 days: 1.26
Barbone et al. (1998)	United Kingdom 1992–1995	Drivers in crashes taking BZDs during the study period (N=1,731)	Case-crossover	BZD hypnotics: 1.19 n.s. BZD anxiolytics: 2.18

*Findings statistically significant at $p < 0.05$ or less unless noted as nonsignificant (n.s.).

Cannabis

The four THC-based studies in Table 1 provide conflicting results. Two of these studies reported a significant increase in risk associated with cannabis use. Using responsibility analysis with samples of fatally injured drivers in Australia, Drummer et al. (2004) reported that drivers with any THC were 2.7 times more likely to be responsible for collisions than nonusers, and those with THC concentrations greater that 5 ng/ml were 6.6 times more likely to be responsible. Mura et al. (2003) found that among hospitalized patients, the crash involved group was 2.5 times more likely to have cannabis concentrations greater than 1 ng/ml. The significant increase in risk in this study was restricted to those younger than 27. However, in contrast to these two studies, Longo et al. (2000) found that injured drivers who tested positive for THC in blood were no

more likely than drug-free drivers to be responsible for crashes they were in (OR = 0.8), and Williams et al. (1985) found the same for fatally injured drivers (OR = 0.5).

Benzodiazepines

Of the four case-control and responsibility studies of benzodiazepines in Table 1, two found statistically significant increases in crash risk (Longo et al. 2000; Mura et al., 2003). One study reported evidence of increased risk (OR = 1.3) that was not statistically significant (Drummer et al., 2004), and one study found no evidence of increased risk, OR = 0.96 (Benzodiazepine/ Driving Collaborative Group, 1993).

All three pharmaco-epidemiological studies in Table 1 reported some overrepresentation of crashes among drivers given prescriptions of benzodiazepines, although with differences by type and duration of use. Neutel (1995) found that both hypnotics (short or medium acting) and anxiolytics (long acting) were associated with markedly elevated crash risk for the first 2 weeks of prescription. Beyond this period crash risk was still elevated for both types of drugs but not at statistically significant levels. Hemmelgarn et al. (1997) found no increased risk among 67- to 84-year-olds for short-acting benzodiazepines, but an increased risk for the longer acting variety that diminished but remained elevated over the first year of prescribed use. Barbone et al. (1998) also found increased crash risk for the long-acting anxiolytics and an elevated risk that was not statistically significant for the short-or medium-acting hypnotics.

DISCUSSION

For benzodiazepines, the weight of the evidence suggests an increased crash risk. On balance, the case-control–responsibility studies and the pharmaco-epidemiological studies in Table 1 found evidence of elevated risk. It does appear from the latter studies that increased risk is greater for long-acting benzodiazepines and in the first days or weeks of use, diminishing after that. Those taking benzodiazepines for medicinal purposes need to be aware of their increased vulnerability to crashes during this period.

Studies of benzodiazepines not shown in Table 1, based on urine, or combinations of blood and urine, have also yielded evidence for increased crash risk. The Quebec study (Brault et al., 2004) found a significant increase in crash risk based on case-control data (OR = 3.9) and an increase, not statistically significant, based on responsibility (OR = 2.5). In an Australian study, Drummer (1995) reported an elevation in risk that was not statistically significant (OR = 2.0) as did Mathijssen et al. 2004 in the Netherlands (OR = 1.2). Statistically significant increases in crash risk for benzodiazepines were found by Movig et al. (2004) (OR =5 .1) and Mathijssen and Houwing (2005) (OR = 3.0).

The studies in Table 1 provide inconclusive evidence for cannabis. This also is the conclusion of other recent reviewers of the literature (Kelly et al., 2004). There are several studies of cannabis that were not included in Table 1 because of drug measurement issues that make interpretation difficult. Generally, these studies have not found consistent evidence of an increase in crash risk. In one such study in Quebec, where both case-control and responsibility analysis were used, the case-control method yielded evidence of a significant increase in crash involvement but the responsibility analysis did not (Brault et al., 2004). All other studies produced nonsignificant findings (Drummer, 1995; Lowenstein and Koziol-McClain, 2001;

Movig et al., 2004; Marquet et al., 1998; Mathijssen et al., 2004; Mathijssen and Houwing, 2005). In several studies odds ratios were less than 1.0, leading one reviewer of the literature to conclude "There is no evidence that consumption of cannabis alone increases the risk of culpability for traffic crash fatalities or injuries, and it may reduce these risks" (Bates and Blakely, 1999).

Exemplary studies of the effects of drugs other than alcohol are very difficult to do, and there are few on which to base conclusions. Alcohol is the drug most firmly established to increase crash risk, and when combined with cannabis or benzodiazepines, the case-control and responsibility studies in Table 1 generally indicate higher risk than when cannabis, benzodiazepines, or alcohol are found alone.

Case-control or responsibility studies of drugs other than alcohol, cannabis, and benzodiazepines are sparse. There are a few such studies of stimulants (amphetamines and cocaine) which can improve performance on laboratory skills, but the results on crashes are mixed, with generally nonsignificant changes being reported (Drummer, 1995; Drummer et al., 2004; Movig et al., 2004).

Drugs other than alcohol are found in smaller proportions among crash-involved drivers, especially in the absence of alcohol. This limits their contribution to the highway safety problem; it also means that very large samples are needed to adequately test for their effects. It may well be that large-scale THC-based studies with adequate statistical power would show further evidence for cannabis as a crash risk factor. Even if so, for cannabis, an illegal drug, it is possible that it is not cannabis but lifestyle factors that produce the elevated crash risk. People who consume illegal drugs have been shown to exhibit a variety of deviant characteristics, including a greater tendency toward risk taking that may predispose them to higher rates of collision (Jessor et al., 1991). This also is the situation for case-control studies concerning the role of alcohol in crashes; however, in the case of alcohol, the repeated demonstration of a dose-dependent increase in crash risk combined with a dose-dependent response relationship in experimental studies provides convincing evidence of the contributory role of alcohol. To date, few analytic studies have quantified the extent of cannabis use and have relied almost exclusively on a simple dichotomy of its presence or absence. Existing evidence is inconsistent. Longo et al. (2000) found no significant increase in risk with higher levels of THC; Drummer et al. (2004) reported higher risk for those with THC levels of 5 ng/ml or greater.

The problem of obtaining blood samples in case-control studies has hampered research progress. For this reason, oral fluid (saliva) is gaining recognition as a readily available and relatively unobtrusive alternative for measuring drugs. The encouraging degree of correspondence between drug levels detected in oral fluid and those in blood, combined with the convenience of collecting a sample of oral fluid, could enhance research efforts. Despite their potential, a recent review concluded that the currently available oral fluid tests are not sufficiently sensitive or specific to give reliable results for all major drugs of interest (Verstraete and Puddu, 2000). However, methods for the detection and quantification for drugs in oral fluid continue to be refined and improved (Teixeira et al., 2004; Toennes et al., 2005).

Drugs other than alcohol are receiving considerable emphasis as a highway safety problem. Definitive studies of their crash risk capabilities are needed to clarify their contribution to the problem.

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European Union Research Project IMMORTAL

The Risk of Drink and Drug Driving— Results of a Case-Control Study Conducted in the Netherlands

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This paper presents the results of a prospective case-control study, conducted in the Netherlands, where the prevalence of psychoactive substances among injured drivers (a hospital sample) was compared with the prevalence in the general driving population (a random roadside sample). The study formed part of the European Union (EU) research project IMMORTAL. The aim of the project was "to provide evidence to propose intervention methods for driver impairment, and support the future development of European policy governing driver impairment legislation."

Eight drug groups were included in the study: alcohol, BZDs, tricyclic antidepressants, methadone, opiates, amphetamines, cannabis, and cocaine.

Among the general driving population, cannabis, BZDs and alcohol were the prevailing substances. Out of the 3,799 stopped and tested drivers:

- 4.5% were positive for cannabis; 3.9% for cannabis alone; and 0.6% for cannabis in combination with other drugs and/or alcohol.
- 2.1% were positive for BZDs; 2.0% for BZDs alone and 0.1% for BZDs in combination with other drugs and/or alcohol.
- 2.1% were positive for alcohol [blood alcohol content (BAC) ≥0.2 g/l]; 1.8% for alcohol alone and 0.3% for alcohol in combination with other drugs.

Drugs of abuse were strongly concentrated in male drivers aged 18 to 24. No less than 17.5% of them were positive for illegal drugs. Psychoactive prescription drugs were strongly concentrated in female drivers aged 50 and older; 11.3% were positive.

Comparison of the road and hospital samples showed that approximately 35% of serious injuries among drivers in the Tilburg police district were associated with self-administered alcohol and/or illegal drugs, and especially with drug-free BAC levels greater than ≥ 1.3 g/l, with drug–alcohol combinations at BAC levels greater than ≥ 0.8 g/l, and with drug–drug combinations. These three categories accounted for 12.7%, 8.3%, and 7.2%, respectively, of the 184 seriously injured drivers included in the hospital sample. The corresponding odds ratios (OR) were 87, 179, and 24, respectively.

BACKGROUND

The present study was conducted in the framework of the EU research project IMMORTAL (Impaired Motorists, Methods of Roadside Testing and Assessment for Licensing). The objective of the study was to examine the relative injury risk of car drivers associated with the use of eight defined groups of psychoactive substances, taken alone or in combination with each other. The eight drug groups included in the study were: alcohol, BZDs, tricyclic antidepressants, methadone, opiates, amphetamines, cannabis, and cocaine. The opiates group was subdivided into morphine, heroin, and codeine. The amphetamines group was subdivided into amphetamine, methamphetamine, and ecstasy (MDMA, MDEA, and MDA). Alcohol use was subdivided into four BAC classes: 0.2–0.5 g/l; 0.5–0.8 g/l; 0.8–1.3 g/l; and ≥ 1.3 g/l.

The European Commission, the Dutch Ministry of Transport, Public Works and Water Management, and the Dutch Ministry of Health and Welfare jointly funded the study.

METHODOLOGY

In order to assess the relative injury risk of driving under the influence of psychoactive substances, SWOV designed an epidemiological case-control study in the Tilburg police district, in the south of the Netherlands. The study was conducted between May 2000 and March 2004. Cases were seriously injured drivers who were admitted to the emergency department of the Tilburg St. Elisabeth Hospital. Blood and/or urine samples were taken on admission. Hospital and ambulance records were examined to control for drugs administered before blood or urine sampling. All patients, or their legal representatives, were asked for informed consent to be included in the study. The hospital's medical ethics committee approved the study protocol. It was expected that it would be possible to include 350 to 400 seriously injured drivers in the case sample.

Controls were taken at random from moving traffic during a total number of 61 roadside survey sessions in the Tilburg police district, which covers the hospital's catchments area. It consists of the city of Tilburg and three smaller municipalities, covering an area of 322 km^2 and a total population of approximately 260,000. It was expected that it would be possible to include approximately 3,500 drivers in the control sample.

The survey sessions were equally divided over the six different police precincts that the Tilburg police district consists of. About 50 different research sites had been selected, most of them along main urban and rural roads. These road types accounted for 88% of serious road injuries in the Netherlands, during the period 2000–2003.

In order to be able to construct a representative control sample, the week was systematically divided into 28 consecutive 6-h periods. For the sake of statistical analysis, these periods were next aggregated into eight day–time categories, which were supposed to be more or less homogeneous with respect to traffic volume and substance use. These eight categories were:

1. The five weekday mornings (Monday to Friday), from 4 to 10 a.m.;
2. The five weekday afternoons (Monday to Friday), from 10 a.m. to 4 p.m.;
3. The four weekday evenings (Monday to Thursday), from 4 to 10 p.m.;
4. The four weekday nights (Monday to Thursday), from 10 p.m. to 4 a.m.;
5. The two weekend mornings (Saturday and Sunday), from 4 to 10 a.m.;
6. The two weekend afternoons (Saturday and Sunday), from 10 a.m. to 4 p.m.;

7. The three weekend evenings (Friday to Sunday), from 4 to 10 p.m.; and
8. The three weekend nights (Friday to Sunday), from 10 p.m. to 4 a.m.

Each of the 61 survey sessions covered one 6-h period. During each session, four different research sites were visited, thus strongly diminishing the predictability of the test sites for (impaired) drivers. In order to make the control sample representative of the whole week, it has been weighted, based on traffic flow distribution over the various day–time categories. The relative injury risk of the psychoactive substances involved in the study was determined by comparing the prevalence of these substances among cases and controls. Odds ratios were computed using the statistical package SAS. Subjects who had used one particular substance or a combination of different substances were related to subjects who had used none of the substances included. 95% confidence intervals were used for significance.

Driver Selection, Data, and Specimen Collection at the Roadside

Drivers were stopped by the police at the request of the acting research coordinator. As soon as one of the two interviewer–nurses was ready for interviewing and urine–blood sampling a driver, the next car approaching the research site was stopped. Stopped drivers were asked to cooperate with the research team on a voluntary basis. Drivers who agreed to cooperate, were interviewed on their drug and medicine use and time of administration. The results for each driver were entered on a uniquely numbered research form. Subsequently, subjects were requested to produce a urine specimen. If they were not able or willing to do so, they were requested to provide a blood specimen. A trained research nurse performed the venipuncture. Subjects who provided a urine or blood specimen, received a €5 reward. All specimens were numbered; the numbers corresponding with those of the subjects' research forms.

Interviewing and sampling of body fluids took place in a specially equipped mobile research unit with private toilet. After the interview and the urine or blood sampling, all subjects were breath-tested for alcohol by a police officer, using a Dräger Alcotest 7410 Plus com screening device. The breath test was compulsory for all stopped drivers. Breath test results were entered on the (anonymous) research form. Apart from self-reported drug use and time of administration, data collection also comprised date and time of selection, gender, age of the subject, and signs of impairment.

Analysis of Blood Specimens

Serum specimens were analysed by the Netherlands Forensic Institute of the Ministry of Justice.

Screening for opiates and cannabis in serum was performed by Cozart® Enzyme ImmunoAssay (EIA), which is based on competition for drug antibody binding sites. After incubating and washing, a substrate was added. The absorbance was measured spectrophotometrically. The cut-offs used were 5 ng/ml for cannabis and 20 ng/ml for opiates. Cannabis- and opiate-positive screening results of injured drivers and opiate-positive screening results of control drivers were confirmed whenever that was possible, allowing for opiates to distinguish between codeine, (nor)morphine, and heroin. For budget reasons, cannabis-positive screening results of control drivers were only confirmed if a driver's self-reported cannabis use was negative.

Confirmation of cannabis was performed by GC/MS (Gas Chromatography/Mass Spectrometry), after solid phase extraction (SPE) and derivatisation with methyl iodide. For

quantification, deuterated analogues from THC, 11-OH-THC, and THC-COOH were used as internal standards. Cannabis confirmation was based on Daldrup et al. (1995). The applied confirmation cut-off level was 2 ng/ml.

Confirmation of opiates was performed by GC/MS after SPE and derivatisation with bis-trimethylsilyl-trifluoroacetamide. For quantification, deuterated analogues from codeine and morphine were used as internal standards. The applied confirmation cut-off level was 20 ng/ml.

For the other drugs included in the study, toxicological serum analysis was performed by HPLC (high-performance liquid chromatography) after SPE. Positive results were not confirmed by GC/MS. HPLC-analysis was based on Gaillard and Pepin (1997). Analytical cut-offs (detection limits) were applied (Table 1).

Urine specimens were analysed by the Dutch Laboratory for Drugs and Doping, Tilburg. Screening of the urine specimens was performed by Enzyme Multiplied Immunoassay Technique (EMIT® II Plus). Like EIA, this technique is based on competition for drug antibody binding sites. For BZDs a special high sensitivity protocol was used with on-line deglucuronidation.

EMIT II Plus ethanol assay was used for injured drivers only (control drivers were breath-tested). This technique is based on oxidation of ethanol in presence of alcoholdehydrogenase with NAD to acetaldehyde.

TABLE 1 Components and Detection Limits of HPLC Serum Analysis

Component	Detection Limit (ng/ml)	Component	Detection Limit (ng/ml)
Amphetamines:		*Benzodiazepines:*	
Amphetamine	50	Alprazolam	30
Methamphetamine	70	Bromazepam	20
MDMA	30	Brotizolam	50
MDEA	30	Chlordiazepoxide	20
MDA	20	Clobazam	20
		Dealkyl flurazepam	30
Cocaine:		Desmethyl diazepam	?
Cocaine	70	Diazepam	50
Benzoylecgonine	50	Flunitrazepam	20
		Loprazolam	10
Tricyclic antidepressants:		Lorazepam	20
Amitriptyline	30	Lormetazepam	50
Clomipramine	100	Midazolam	30
Dosulepine	?	Nitrazepam	30
Doxepine	?	Oxazepam	50
Imipramine	?	Temazepam	20
Trimipramine	?	Zolpidem	10
Desipramine	?	Zoplicon	30
Maprotiline	?		
Nortriptyline	?	*Methadone*	100

In general, urine-screening results were considered to be positive in accordance with the Substance Abuse and Mental Health Services Association (SAMHSA) guidelines for drug abuse testing (www.workplace.samhsa.gov). Only for opiates, a lower cut-off of 1,000 ng/ml was applied instead of the SAMHSA cut-off of 2,000 ng/ml. A SAMHSA guideline for tricyclic antidepressant cut-off levels does not exist. The applied cut-off level of 150 ng/ml was derived from a comparison between screening results and self-reported use of these medicines.

Amphetamine- and opiate-positive screening results of injured drivers were confirmed by GC/MS whenever that was possible. GC/MS-confirmation of opiates allowed distinguishing between codeine, morphine, and heroin. GC/MS confirmation of amphetamines allowed to distinguish between amphetamine, methamphetamine, MDMA, MDEA, and MDA.

Amphetamine- and opiate-positive screening results of control drivers were only GC/MS confirmed if a driver's self-reported amphetamine or opiate use was negative.

Table 2 gives an overview of the cut-off levels for urine screening and confirmation.

Characteristics of the Case Sample

A total of 207 seriously injured drivers were included in the case sample. This number was significantly smaller than expected number of 350 to 400. The main reasons for the relatively small sample size were the lack of a special trial nurse at the emergency department, and the frequent change of the medical teams that manned the department. The surgeons who were in charge of the in-hospital data collection were often not able to immediately instruct new medical teams. The in-hospital data collection was beyond direct control of the SWOV researchers. According to the surgeons in charge, however, the sample of included drivers was not in any way selective.

Out of the 207 included drivers, 23 drivers could not be evaluated. For two drivers, consent was declined; for another two, personal and crash data was missing. And for 19 drivers, specimens of body fluid were missing or containing insufficient material for toxicological analysis. In the remaining 184 valid cases, 121 blood specimens (66%) and 63 urine specimens (34%) were available for toxicological analysis.

TABLE 2 Cut-Off Levels Applied for Urine Screening and Confirmation

Component	Cut-off immunoassay	Cut-off GC/MS
Cannabis (THC-COOH)	50 ng/ml	15 ng/ml
Cocaine (benzoylecgonine)	300 ng/ml	150 ng/ml
Amphetamine	1000 ng/ml	500 ng/ml
Opiates	1000 ng/ml	2000 ng/ml
Heroin (6-MAM)	—	10 ng/ml
BZDs	300 ng/ml	300 ng/ml
Methadone	300 ng/ml	300 ng/ml
Tricyclic Antidepressants	150 ng/ml	Not applicable

In order to test if the case sample was representative of all seriously injured car drivers in the Tilburg police district, its distribution by gender was compared with the distribution according to official Road Accident Statistics. The variable gender was chosen because of its strong correlation with psychoactive substance use.

As shown in Table 3, male drivers were somewhat overrepresented in the case sample. In order to make the case sample more representative with respect to the distribution by gender, it was weighted. Weight factors were computed by dividing Road Accident Statistics fractions by case sample fractions.

Table 4 gives a detailed picture of the prevalence of psychoactive substances among seriously injured drivers, by gender. A further subdivision of the prevalence of psychoactive substances among injured drivers, e.g. by gender and age, was considered as being not very useful because of the small sample size.

The table shows that 54.0% of male drivers and 24.4% of female drivers were positive for one or more of the psychoactive substances included in the study. When considering only illegal drugs and illegal BAC-levels, the difference between male and female drivers was even greater: 49.6% of male drivers and 15.6% of female drivers were positive. Among male injured drivers, no less than 26.6% had a BAC ≥ 1.3 g/l.

Characteristics of the Control Sample

During the roadside survey, a total number of 3,851 drivers from the general driving population were stopped and asked to cooperate. Only 52 (1.4%) of them declined their cooperation with the researchers. All of the 3,799 consenting drivers were interviewed and breath-tested by the police, but 425 (11.2%) were not willing or able to provide a urine or blood specimen. For these drivers, selectivity was examined with regard to gender, age, BAC, and self-reported drug use.

Table 5 shows the missing specimen rates by gender and age. Among male drivers, this rate was slightly lower than among female drivers. Differences by age were much larger: the younger the driver, the higher the missing specimen rate. Among female drivers 18–24, this rate was 2.4 times higher than among male drivers of 50 years and older.

Table 6 shows the differences in psychoactive substance use between drivers who did, or did not, provide urine or blood specimen. For drivers who did provide a specimen, drug and medicine use was based on toxicological analysis. For drivers who did not, it was based on self-reporting. Only drivers who reported drug and medicine use less than 1 week before the interview, were considered to be positive. All drivers were breath-tested for alcohol.

TABLE 3 Comparison of the Tilburg Case Sample and the Road Accident Statistics Sample (2000–2003) of Seriously Injured Drivers by Gender

Sample	Distribution of Seriously Injured Drivers by Gender		
	Male	Female	Total
Tilburg case sample	76%	24%	100%
Road Accident Statistics sample	68%	32%	100%

TABLE 4 Weighted Distribution of Psychoactive Substances Among Cases by Gender

Psychoactive Substance Use	Distribution by Gender		
	Male drivers	Female drivers	All drivers
Negative	46.0%	75.6%	55.4%
Cannabis alone	5.0%	—	3.4%
Amphetamine alone	—	—	—
Ecstasy alone	—	—	—
Cocaine alone	—	—	—
Morphine/heroin alone	0.7%	—	0.5%
Codeine alone	1.4%	—	1.0%
BZDs alone	2.2%	6.7%	3.6%
Tricyclic antidepressants alone	—	—	—
Methadone alone	—	—	—
Combination of drugs	6.5%	8.9%	7.2%
Alcohol* 0.2–0.5 BAC	0.7%	2.2%	1.2%
Alcohol* 0.5–0.8 BAC	2.2%	2.2%	2.2%
Alcohol* 0.8–1.3 BAC	3.6%	—	2.5%
Alcohol* ≥ 1.3 BAC	16.6%	4.4%	12.7%
Alcohol 0.2–0.5 + drug(s)	2.2%	—	1.5%
Alcohol 0.5–0.8 + drug(s)	0.7%	—	0.5%
Alcohol < 0.8 + drug(s)	*2.9%*	—	*2.0%*
Alcohol 0.8–1.3 + drug(s)	2.2%	—	1.5%
Alcohol ≥ 1.3 + drug(s)	10.1%	—	6.9%
Alcohol ≥ 0.8 + drug(s)	*12.2%*	—	*8.3%*
Total (N = 184)	100%	100%	100%

* alcohol alone

TABLE 5 Missing Specimen Rates, by Gender and Age

Gender	Age				
	18–24	25–34	35–49	50+	Total
Male (N=2,682)	15.1%	13.2%	10.1%	6.5%	10.8%
Female (N=1,117)	15.5%	15.4%	10.7%	7.2%	12.1%
Total (N=3,799)	15.2%	13.9%	10.3%	6.7%	11.2%

TABLE 6 Psychoactive Substance Use by Drivers Who Did or Did Not Deliver a Specimen of Body Fluid

Specimen	Psychoactive substance distribution					
	Negative	Illegal drugs	Medical drugs	BAC 0.2–0.5 g/l	BAC ≥ 0.5 g/l	BAC ≥ 0.2 g/l + drug(s)
Urine/blood*	86.2%	6.2%	2.5%	2.4%	2.0%	0.7%
Missing**	85.2%	7.1%	1.2%	1.6%	3.1%	1.9%

*Drug use based on toxicological analysis.

**Drug use based on self-reporting.

The figures in Table 6 indicate that drivers with missing specimens had higher rates of illegal drug use, of illegal BAC-levels, and of combined alcohol and drug use. The actual differences regarding illegal drug use were probably even somewhat larger than the figures in the table indicate. Out of the 3,374 drivers who delivered a specimen, 6.1% reported they had used illegal drugs, but according to the results of toxicological analysis, 6.9% of the specimens were positive.

Based on the above analyses, it was concluded that missing specimens biased the sample of drivers who provided a urine or blood specimen. In order to minimize this bias, it was decided to consider the drivers with missing specimens as valid controls, using their self-reported drug use as an estimate of their actual drug use.

The unweighted control sample could not be considered to be representative of all drivers who participated in road traffic in the Tilburg police district at all days of the week and all times of the day, since the sample distribution over different times and days was not equal to the distribution of traffic flow. The reason for this was the more or less constant sampling capacity of the research team, regardless of traffic flow, which is strongly varying by day of the week (weekdays versus weekend) and by time of the day. Furthermore, the police had a quite understandable preference for enforcement activities during high-risk hours, i.e., the nighttime hours with low traffic volumes. So, in order to make the control sample representative of the whole week, it had to be weighted, based on traffic flow distribution over the various days of the week and times of the day.

The weighting procedure was based on 1999–2000 trip data that was collected by the Dutch Central Bureau of Statistics (CBS).

Table 7 shows a comparison of the control sample and CBS trip distributions. The comparison demonstrates that weekend nights (category 8) and, to a lesser degree, weekday nights (category 4) were strongly overrepresented in the control sample. Drunk driving is strongly concentrated in the nighttime hours. As a consequence, drink driving was overrepresented in the unweighted control sample. Weighting the control sample solved this problem. Weight factors for each of the eight day–time categories were computed by dividing traffic flow (trip) fractions by control sample fractions.

TABLE 7 Comparison Between Day–Time-Distributions of the Control Sample of Drivers and the CBS Sample of Trips

Day–time categories	Distribution of control sample	CBS-distribution of trips
1	4.1%	15.0%
2	12.8%	25.7%
3	15.4%	19.3%
4	8.5%	3.2%
5	6.9%	4.8%
6	9.2%	12.8%
7	17.9%	16.6%
8	25.2%	2.6%

Substance Use by Gender and Age

Table 8 shows the weighted distribution of psychoactive substances among the general driving population of the Tilburg police district by gender.

Among all drivers, 9.9% were positive for one or more of the psychoactive substances included in the study. There was, however, a significant difference between male and female drivers: 11.2% of males were positive versus 6.9% of females. When considering only illegal drugs and illegal BAC levels, the difference between males and females was even larger: 7.7% of males were positive versus 2.9% of females. Furthermore, male drivers had a 70% share in the traffic flow.

Table 9 displays the distribution of psychoactive substances by gender and age, allowing a more detailed insight into the correlation between demographic factors and the use of psychoactive substances.

TABLE 8 Weighted Distribution of Psychoactive Substances Among the General Driving Population by Gender

Psychoactive Substance Use	Distribution by Gender		
	Male drivers	Female drivers	All drivers
Negative	88.8%	93.1%	90.1%
Cannabis alone	4.8%	1.5%	3.9%
Amphetamine alone	<0.01%	--	<0.01%
Ecstasy alone	0.4%	0.2%	0.3%
Cocaine alone	0.4%	0.09%	0.3%
Morphine/heroin alone	0.03%	--	0.02%
Codeine alone	0.5%	0.6%	0.5%
BZDs alone	1.6%	2.8%	2.0%
Tricyclic antidepressants alone	0.2%	0.5%	0.3%
Methadone alone	--	--	--
Combination of drugs	0.6%	0.3%	0.5%
Alcohol* 0.2–0.5 BAC	1.3%	0.1%	0.9%
Alcohol* 0.5–0.8 BAC	0.4%	0.4%	0.4%
Alcohol* 0.8–1.3 BAC	0.2%	0.2%	0.2%
Alcohol* ≥ 1.3 BAC	0.3%	0.1%	0.2%
Alcohol 0.2–0.5 + drug(s)	0.1%	0.01%	0.09%
Alcohol 0.5–0.8 + drug(s)	0.2%	0.01%	0.2%
Alcohol < 0.8 + drug(s)	*0.3%*	*0.02%*	*0.2%*
Alcohol 0.8–1.3 + drug(s)	0.06%	--	0.04%
Alcohol ≥ 1.3 + drug(s)	0.05%	--	0.03%
Alcohol ≥ 0.8 + drug(s)	*0.1%*	--	*0.08%*
Total (N = 3,799)	100%	100%	100%

*Alcohol alone.

TABLE 9 Weighted Distribution of Psychoactive Substances Among the General Driving Population by Gender and Age

Gender and Age	Distribution of Psychoactive Substances							
	Neg-ative	Single Illegal Drug	Single Medical Drug	Drug Combi-nation	BAC 0.2–0.5 g/l	BAC ≥ 0.5 g/l	BAC 0.2-0.8 g/l + drug(s)	BAC ≥ 0.8 g/l + drug(s)
Male drivers								
18–24	79.5%	14.6%	1.2%	1.4%	0.9%	0.9%	1.0%	0.6%
25–34	85.5%	10.9%	0.5%	0.8%	1.0%	0.8%	0.4%	0.1%
35–49	91.6%	3.4%	2.2%	0.5%	1.3%	0.8%	0.2%	—
50+	92.1%	0.6%	4.2%	0.05%	1.6%	1.3%	0.2%	—
Total	88.8%	5.7%	2.3%	0.6%	1.3%	1.0%	0.3%	0.1%
Female drivers								
18–24	95.5%	2.3%	0.3%	—	0.6%	1.3%	—	—
25–34	94.5%	3.4%	1.1%	0.8%	0.04%	0.07%	0.04%	—
35–49	95.7%	1.7%	2.0%	0.03%	0.08%	0.5%	0.03%	—
50+	86.8%	0.04%	11.3%	0.5%	0.04%	1.4%	—	—
Total	93.1%	1.8%	3.9%	0.3%	0.1%	0.7%	0.02%	—

Among male drivers, 6.7% were positive for illegal drugs. By far the highest prevalence of illegal drugs was found among young males aged 18–24. No less than 17.6% of the young male drivers were positive: 14.6% for a single illegal drug, 1.4% for a combination of two or more illegal drugs, and 1.6% for a combination of alcohol and one or more illegal drugs. On top of that, 0.9% had an illegal BAC without having used illegal drugs. Among male drivers above the age of 24, 5.2% were positive for illegal drugs, and 1.0% had an illegal BAC without having used illegal drugs.

The highest prevalence of psychoactive prescription drugs among male drivers was found in the age group of 50 and older: 4.2%. Among all male drivers, 2.3% were positive.

Among female drivers, the rate of illegal drug use was significantly lower than among male drivers: 2.2% of the females were positive. The prevalence among females aged 18–24 was not significantly higher than among older females: 2.2% and 2.1%, respectively. None of females under the age of 25 were positive for a combination of two or more psychoactive substances, while such a combination was found among 0.4% of the older females. On the other hand, 1.3% of the young females had a (drug-free) illegal BAC, versus 0.6% of the age groups above 24.

Psychoactive prescription drug use was significantly higher among females than among males, 3.9% of the females being positive. The use of these medicines was strongly concentrated among females aged 50 and older, 11.3% of them being positive.

Substance Use by Day and Time

Table 10 shows the distribution of psychoactive substances among the general driving population by day of the week and time of the day, allowing a more detailed insight in high-prevalence periods.

TABLE 10 Weighted Distribution of Psychoactive Substances Among the General Driving Population by Day of the Week and Time of the Day

Day and Time	Distribution of Psychoactive Substances							
	Negative	Single Illegal Drug	Single Medical Drug	Drug Combi-nation	BAC 0.2–0.5 g/l	BAC ≥ 0.5 g/l	BAC 0.2–0.8 g/l + Drug(s)	BAC ≥ 0.8 g/l + Drug(s)
Mon–Sun 04–22 h	90.8%	4.4%	2.8%	0.4%	0.7%	0.7%	0.2%	0.06%
Mon–Thu 22–04 h	77.4%	8.4%	3.1%	0.9%	4.6%	4.3%	0.9%	0.3%
Fri–Sun 22–04 h	79.6%	6.1%	1.4%	1.5%	5.0%	4.5%	1.6%	0.4%
Whole week	90.1%	4.5%	2.8%	0.5%	0.9%	0.9%	0.2%	0.08%

The prevalence of illegal drugs and alcohol among drivers was strongly concentrated in the nighttime hours. The combined use of alcohol and illegal drugs was at a higher level during weekend nighttime hours than during weekday nighttime hours. The prevalence of prescription drugs, on the other hand, was lower during weekend nighttime hours than during the rest of the week. Significantly more drivers tested positive for illegal drugs (5.4%) than for alcohol (2.1%).

Concomitant Drug Use

For drug–drug and alcohol–drug combinations, which were detected in 0.8% of the control drivers, the prevalence of the various separate drugs was determined (Table 11).

TABLE 11 Weighted Prevalence of Separate Drugs, Taken Alone and Concomitantly, Among the General Driving Population

Substance	Prevalence		
	Alone	Combined with Other Drug(s)	Total
Cannabis	3.9%	0.6%	4.5%
Amphetamine	0.003%	0.03%	0.03%
Ecstasy	0.3%	0.3%	0.6%
Cocaine	0.3%	0.4%	0.7%
Morphine/heroin	0.02%	0.04%	0.06%
Codeine	0.5%	0.07%	0.6%
BZDs	2.0%	0.1%	2.1%
Tricyclic antidepressants	0.3%	0.04%	0.3%
Methadone	—	0.04%	0.04%
Alcohol (BAC ≥ 0.2 g/l)	1.8%	0.3%	2.1%
Total	9.1%	0.8%	9.9%

Among the drug–drug and alcohol–drug combinations, cannabis prevailed (70%), followed by cocaine (44%), and ecstasy (36%). On the other hand, only 13% of the cannabis-positive drivers had also used one or more other drugs. Among the cocaine and ecstasy-positive drivers, the corresponding shares of concomitant drug use were 52% and 46%, respectively.

Relative Risk Calculations

The relative risk of using one or more of the psychoactive substances involved in the study was determined by comparing the prevalence of these substances among case and control drivers. ORs were computed using the statistical package SAS. Subjects who used one particular substance or a combination of different substances were related to subjects who used none of these substances. An OR of 1.0 was designated to the injury rate of negative drivers (the reference group); 95% confidence intervals were used for statistical significance. The results are shown in Table 12.

A moderately increased risk of serious road injury was associated with a BAC level between 0.5 and 0.8 g/l. At higher BAC levels, the relative injury risk increased more or less exponentially. This result corresponds to the results of various earlier case control studies that demonstrated an exponentially increasing accident risk at BAC levels above 0.8 g/l, e.g., the Grand Rapids study by Borkenstein et al. (1974). Strongly increased injury risks were also associated with the combined use of several drugs, and with the combination of drugs and a BAC

TABLE 12 Relative Injury Risk Associated with the Use of Various Psychoactive Substances by Car Drivers

Psychoactive Substances	Weighted Distribution Among Cases and Controls		Odds Ratio	95% C.I.
	Cases (N=184)	Controls (N=3,799)		
Negative	55.4%	90.1%	1.00	
Cannabis alone	3.4%	3.9%	1.45 (NS)	0.64–3.29
Amphetamine alone	—	<0.01%	Undefined (< 1)	—
Ecstasy alone	—	0.3%	Undefined (< 1)	—
Cocaine alone	—	0.3%	Undefined (< 1)	—
Morphine/heroin alone	0.5%	0.02%	32.4	1.78–592
Codeine alone	1.0%	0.5%	3.04 (NS)	0.65–14.2
BZDs alone	3.6%	2.0%	2.98	1.31–6.75
Tricyclic antidepressants alone	—	0.3%	Undefined (< 1)	—
Methadone alone	—	—	Undefined	—
Combination of drugs	7.2%	0.5%	24.0	11.5–49.7
Alcohol* 0.2–0.5 BAC	1.2%	0.9%	2.12 (NS)	0.54–8.42
Alcohol* 0.5–0.8 BAC	2.2%	0.4%	8.28	2.73–25.2
Alcohol* 0.8–1.3 BAC	2.5%	0.2%	17.6	5.54–56.0
Alcohol*≥ 1.3 BAC	12.7%	0.2%	87.2	39.4–193
Alcohol < 0.8 BAC + drug(s)	2.0%	0.2%	12.9	3.78–44.2
Alcohol ≥ 0.8 BAC+ drug(s)	8.3%	0.08%	179	49.9–638

*Alcohol alone.

between 0.2 and 0.8 g/l. Extremely high relative risks were associated with the use of morphine–heroin only and with the combination of drugs and BAC levels above 0.8 g/l. Morphine–heroin, however, was hardly detected in controls, resulting in a much larger confidence interval than for drugs in combination with a BAC above 0.8 g/l.

Neither a positive BAC level below 0.5 g/l nor the single use of most other drugs or medicines involved in the study were associated with a significantly increased injury risk. An exception was the use of BZDs alone, which was associated with an OR of 2.98 (C.I. 1.31-6.75).

DISCUSSION

In the Tilburg police district, 35% of serious injuries among drivers were associated with self-administered alcohol and/or illegal drugs: 17% were associated with illegal BAC levels without drugs of abuse being involved; 10% with alcohol–drug combinations; and 8% with drugs of abuse without alcohol being involved. Considering the fact that in part of the alcohol and/or drug-related serious injury crashes a sober driver was seriously injured, it can be assumed that alcohol and/or illegal drug use accounted for even more than 35% of serious injuries among drivers in the Tilburg police district. It is not certain that the Tilburg police district is representative of the whole of the Netherlands with regard to psychoactive substance use by drivers, but comparison with the results of earlier national studies (Mathijssen, 1999; AVV, 2002) into drink and drug driving indicates that there are probably no major differences.

In order to be effective, road safety policy in the Netherlands and possibly the whole EU should mainly target high BAC levels (>1.3 g/l), alcohol–drug, and drug–drug combinations. Almost 30% of serious injuries in the Tilburg police district were associated with these three categories of self-administered psychoactive substances. Special attention should be given to young male drivers.

The effects of alcohol–drug and drug–drug combinations on road safety are so detrimental that effective legislation and enforcement are urgently needed. For most alcohol–drug and drug–drug combinations, a legal zero-tolerance limit for each of the substances involved seems to be appropriate. An exception might possibly be made for the combination of alcohol and ecstasy, since in the hospital sample no injured drivers were found who were ecstasy-positive and had a positive BAC below 0.8 g/l. The (unweighted) control sample contained six drivers who had used this alcohol–drug combination. Caution is called for, however, in view of the relatively small size of the sample of injured drivers. On the other hand, the findings from the case control study seem to be supported by the results of an experimental study into the effects of combined alcohol and ecstasy use on driving performance (Ramaekers et al., 2005). The latter study was also conducted in the framework of the IMMORTAL project. Results showed that driving impairment caused by a BAC of 0.5 g/l was slightly diminished by the additional administration of ecstasy. (To avoid any misunderstanding: the alcohol-induced impairment did not disappear by the additional administration of ecstasy!) In addition to legislation, further EU-wide experimental and epidemiological studies into the impairing and risk-increasing effects of poly-drug use are needed.

For illegal drugs, when taken alone, and with the exception of heroin, zero tolerance legislation would seem to produce a massive overkill, however, resulting in very high cost and hardly any road safety benefits. This can be illustrated by taking cannabis use as an example: 87% of all cannabis users among the Tilburg control sample were positive for cannabis alone, which did not result in a significantly increased injury risk. (This does not mean that cannabis

use is harmless to road safety, since the remaining 13% of cannabis-positive control drivers constituted 70% of the high-risk group of poly-drug users).

In order to establish realistic, risk-related legal limits for single-used illegal drugs, multi-center case control studies on an EU-wide scale are recommended, as is the use of a common research protocol.

For most medicinal drugs, like antidepressants, BZDs, and codeine, therapeutical levels may be adequate as legal limits, at least for the time being.

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Commentary on Variability Among Epidemiological Studies of Drugs and Driving

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The paper by Bierness, Simpson, and Williams (2005) reviewed epidemiological studies both on the presence of drugs in the driving population and on the drugs' relative presence in collision drivers versus non-collision control drivers. The authors concluded that there was inconsistent evidence of the risk associated with drug use while driving, with disagreements both among the epidemiological studies and with results obtained from experimental studies.

The paper suggested that the inconsistencies may be due to methodological problems or lapses in the existing studies. Mentioned were several methodological problems, such as (*a*) difficulty in obtaining body fluid samples, primarily blood and especially from control group drivers, (*b*) time between crash and the drawing of body fluids, and (*c*) failure to obtain control samples matched on variables associated with crash probabilities.

The following discussion on methodological problems agrees with Bierness, et al. opinion that methodological problems represent a major barrier to obtaining scientifically consistent results from the different studies.

However some of the problem in obtaining consistent results studies may be due to what I will call intrinsic factors. That is, factors that at this point I see no means of overcoming and thereby reducing the variability of results.

There's agreement among pharmacologists and toxicologists that most urine samples provide little or no information about the likelihood of impairment of a driver. Rather urine typically indicates use within some broad band of time, often days beyond any indication of behavioral influence.

The desired body fluid sample is blood. But even conclusions from blood levels can be misleading. Experience with alcohol studies where samples of blood or from breath and urine have demonstrated they are relatively good indices of the presence of alcohol at receptor sites in the central nervous system that determine behavior. The excellent correlations obtained between blood alcohol concentration levels and behavioral changes, whether in experimental studies or epidemiological studies, support the known physiological evidence that ethanol moves easily throughout the entire body, with small differences in concentration, regardless of region. This is almost universally untrue for any other drug. Most drugs end up in various compartments of the body with little known relationship to what's available at the CNS receptor site.

This may explain why drug blood samples typically show low correlation with behavior. For example with cannabis, delta-9 THC levels rise rapidly within the blood within the first 10 min of smoking and then drops off. Within 2 h after cessation of smoking, THC blood levels typically have dropped below 5 ng/ml, where it remains at low levels. However, it can be found for days at these low levels in the blood as the THC, which has sequestered itself in fatty tissues, is slowly released back into the blood.

Experimental studies have found impairments well beyond this 2- to 3-h window of appreciable THC in the blood and correlations with behavior at any time, with the blood level,

remain very small. As another example, Diazepam remains in the blood for many days, sometimes weeks in chronic users. But evidence of behavioral effects beyond 12 to 24 h is unknown.

These inconsistencies between blood concentration levels, which at the moment are the best samples obtainable, and the effects of the drug on the central nervous system and resulting behavior, places intrinsic limits on obtaining drug level versus collision probability curves such as obtained for alcohol.

This is not to argue that there is no relationship between drug level at the CNS sites and resulting behavior. There are many experimental studies with marijuana which have shown that as you increase the dose you get a perfectly unimodal drug dose curve of increasing impairment. The problem lies with the ability to measure what's going on in the brain. Perhaps some day, with greater knowledge of neuro-imaging, we can obtain knowledge of drug level at the brain, but until then, there are intrinsic limits to what knowledge can be obtained using correlations with blood levels.

As the Beirness et al. paper has indicated, there are other methodological difficulties in the existing studies, which if corrected, could reduce some of the existing inconsistencies.

1. It follows from the discussion on the problem with drug samples, that the use of other body fluid samples, such as urine, attenuates even further any hope for a relationship between drug presence and behavioral impairment and possible resulting collision likelihood. In most situations, urine merely indicates a possible drug user, not that the user is under the influence of a drug when involved in a collision.
2. The Beirness et al. paper has emphasized the unwillingness of subjects, whether those involved in collisions or control subjects, to provide the necessary body fluid samples. I would like to mention another lack of cooperation by subjects that is of even larger magnitude, and that is of subjects who remove themselves from the study. In California, for the last 4 years, 18% of traffic collisions have involved a hit–run driver who absconds from the scene. In our recent Long Beach–Fort Lauderdale alcohol study, Moskowitz et al. (2002), where police managed to apprehend some of these hit–run drivers, it was found that almost 70% of the hit–run drivers had alcohol present. So that if the data had not been adjusted for the absence of hit–run drivers, the study would have lost almost 47% of the alcohol involved collision cases.
3. Based on experiences doing a study on heroin addicts in a methadone clinic some years ago, it is likely that drug users are even more street smart than alcohol abusers, and will exert considerable efforts not to be at the scene when law enforcement arrives. It's interesting that in the 1970s when there were several studies examining accident rates of heroin addicts, comparing their rates the year before entering a methadone treatment program with a year in the methadone treatment program, no evidence was found that heroin users had a higher accident rate. However, in the current Bierness et al. paper, several studies are reviewed involving seriously injured or fatal case drivers, who obviously couldn't drive away, and the studies demonstrate significant opioid effects.
4. Another methodological area raised by Beirness et al., which needs further emphasis, is the importance of the sampling of the control group. Comparing the presence of drugs in a case sample with that of a roadside survey, or even the entire driving population, is inadequate to control for all driver differences, which are determinants of the likelihood of a traffic collision. A study by Blows et al. (2005) on marijuana use and car crash injuries compared 571 crash drivers and 588 control drivers in Aulkland, New Zealand, for the probability of marijuana use within

the 3 h preceding the crash. Information was obtained on possible covariates which might influence crash probability. Acute marijuana use was significantly associated with the probability of crash injury after controlling for several factors such as age, gender, and ethnicity, with an odds ratio (OR) of 3.9. However, after adjusting for all covariates, such as the presence of alcohol, seatbelt use, traveling speed, and sleepiness scores, acute marijuana use was no longer significantly related to crash involvement with an OR of 0.8. What remained was a correlation between habitual use and injury crash probability. Clearly, illicit drug users are unlike the general population in many respects, and it is important to have control members who match as closely as possible these other characteristics that contribute to accident likelihood so that the acute effect of drugs can be examined.

5. The authors discuss the problems associated with studies that rely on relative crash culpability as a dependent measure. Most such studies have relied on the judgment of police officers, or have relied on data collected by police officers, which accident investigators indicate are frequently highly suspect. Even among trained engineers who specialize in accident reconstruction, there are frequently great disagreements about culpability.

The 1968 Alcohol and Highway Safety Report to Congress reported a study by J. Waller that found the probability of crash involvement of people with alcohol present, but who were declared not responsible for the collision by police, were several times greater than for people without alcohol. This suggests the difficulty of relying on the ability of officers to determine crash contributions.

The methodological discussion above reflects only some of the problems facing epidemiological studies. Other problems involve how the drug is sampled, how it is handled and analyzed, if there are fatalities, or whether drug redistribution in the body occurs, etc. These are matters to be discussed by toxicologists.

Table 1 of the Bierness et al. paper summarizes the 19 studies reviewed in the paper. The contribution made by the Bierness et al. paper would be enhanced if the methodological problems identified in the paper were also identified in each of the 19 studies reviewed individually so readers could evaluate the reliability of each study reported.

These comments on the Bierness et al. paper in no way casts doubt on their conclusion that in comparison to alcohol, the drug problem appears of much lower magnitude. Many of the early epidemiological studies on alcohol contribution to driving collision frequency were also characterized by methodological failures. This resulted in varying estimates of the probability of a collision with blood alcohol content (BAC) among the studies. Yet all the epidemiological studies reported increased frequency of accidents with rising BAC, differing only in the rate of rise and the BAC at which increased collision frequency occurred. This was undoubtedly due to the greater magnitude of influence that the presence of alcohol had on crash probability than was found in the drug studies reviewed at this session. In fact, it appears from the studies that the joint presence of drugs with alcohol and drivers has a greater magnitude effect than the drug influence itself, at least as reflected in the reliability of study findings of significantly increased collisions. At this point the magnitude of the drug effects on traffic safety, as reflected by results in the newer and more methodologically reliable studies, appear of less magnitude than the traffic safety effects of sleep problems, distractions such as cell phone use, and fatigue.

Time will only permit short comments on the other two papers presented at this session. The paper by Mathijssen and Houwing reported a case control study in the Netherlands of seriously injured drivers versus control drivers which obviously devoted considerable effort to

rigorous analysis of body fluids obtained. Unfortunately, the analysis was confounded by the fact that in both the injured drivers and control drivers subjects gave either urine or blood making a determination of drug influence difficulty. Moreover, it was questionable whether the control group, a representative sample of the area drivers, were truly representative of the characteristics of the injured drivers. Perhaps, with the collection of additional subjects, the authors can re-analyze the data separately for the urine and blood sampled subjects.

The paper by Zwicker, Preusser, and Compton reviewed a variety of studies which, in addition to control studies, also discussed findings from roadside testing and the drug evaluation and classification program. The reports from these studies were summarized but, unfortunately, no discussion was included as to the methodological problems involved in these studies and their reliability.

In conclusion, assessing the effects of drug use on traffic safety has been limited by procedures that impair the rigor with which scientifically reliable conclusions can be drawn. The majority of studies were clearly marked by methodological limitations of which some are constrained by our technological ability to obtain the desired information, as well as by study design considerations. While experimental studies on the other hand have been more reliable in establishing that many drugs do in fact impair driving-related functions, the resulting effects on traffic safety are obviously a function of the degree to which the drugs are used, the levels at which the drugs are used, the manner in which the drugs are used, and the population in which the drugs are used. At this point in history, the increased probability of driving collisions, as reflected in the control studies epidemiological data, suggests a problem whose magnitude is less than, or certainly no greater, than problems associated with sleep impairment, fatigue, distractions, etc. While many could point to individual cases where drugs have led to accidents, it is an open question as to its relative importance as a major factor in traffic safety.

An analogy might be made to the problem of the elderly driver where one often sees in newspapers stories about an elderly driver losing control of a vehicle. But when one looks at the traffic safety accident and fatality data, the problems engendered by older age are small compared to say, for example, young drivers. Similarly, it appears for drugs at this point in history. Unleashing a war on drug driving would result in the diversion of resources from areas of traffic safety which could be more readily and efficiently result in improved traffic safety. Attempts to divert traffic safety resources into part of the war on drugs will only be counter productive for traffic safety.

Let me conclude by noting that the methodological critique of epidemiological studies of drugs and driving could and should spur efforts to resolve the methodological problems and to perform scientifically rigorous studies that will permit public policy based on science.

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Commentary on the Risks Posed by Drugs in Traffic

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INTRODUCTION

Driving under the influence of drugs other than alcohol has gained considerable attention during the recent years. Increased prevalence of non-alcohol drugs among apprehended and accident drivers have been reported from several countries (Seymore and Oliver, 1999; Christophersen 2000; Logan and Schwilke, 2004; Drummer et al., 2004; Brevik et al., 2004; Mørland, 2004; www.fhi.no). Studies and discussion of accident risks caused by the different illegal and psychoactive medicinal drugs have been in progress for a long time without any conclusion. Several review articles have been published during recent years (Mørland, 2000; Kelly et al., 2004). One problem may be connected to the facts that results from different epidemiological studies (case control, responsibility analyses, and descriptive analytical studies) are inconclusive.

So far, roadside surveys collecting large number of samples to get sufficient positive detections for the individual drug have been difficult to perform. This situation has probably contributed to inconclusive results from risk calculations.

Experimental studies for individual drugs including several performance tests, have contributed to increased knowledge on possible impairment. However, the situation for such studies is different from real traffic.

The following summary includes comments to the presentations and discussion during the Transportation Research Board (TRB) seminar in June 2005 on non-alcohol drugs, what we know about accident risks for the individual drugs, and which type of studies are needed in the futures to change the policy.

COMMENTS TO THE PRESENTATIONS AND DISCUSSION ON THE TRB WORKSHOP

The seminar stated that alcohol is still most common single drug contributing to impaired driving and most frequently detected among accident drivers. The scope of other drugs importance for traffic safety is still debatable. However, some of the referred studies are from the 1980s or early 1990s, while later reports have documented increasing contribution of non-alcohol drugs among both apprehended and accident drivers. Numerous of drivers under the influence of drugs are probably not followed up after apprehension due to lack of evidence based on primary roadside investigation by the police. Therefore, more focus on the problem and special trained police are necessary.

The different factors that may contribute to the variable conclusions with regard to the individual drugs risk factor can be summarized as follows:

1. Most of the epidemiological studies are descriptive. Responsibility and case-control studies have shown variable results compared to other studies. Some studies have even showed risk factors for some individual drugs lower than the control groups (e.g., cannabis)
2. Results from the different epidemiological accident studies are difficult to compare, due to non-standardized protocols with regard to drugs included in the analytical program, their cut-off limits, biological matrix used for analyses (blood or urine), time between accident, and sample collection.
3. Some studies have included inactive metabolites detected in blood or urine for risk calculations.
4. Several studies have used results from urine analyses, or a mixture of blood and urine including inactive metabolites, for risk calculations. It is well known that urine can be positive for a long time (days, weeks) and with no impairment. Such studies may have contributed to the variable risk factors calculated for cannabis (THC in blood or the metabolite THC-acid, or THC-acid detected in urine).
5. Most analytical epidemiological studies include all positive drug findings without differentiating between blood concentration levels. Focus on risk factors related to different blood concentrations levels, would probably contribute to a more conclusive documentation and agreement.
6. For comparison of accident studies and to obtain more data for calculation, it is necessary to use more standardised protocols.
7. More case-control and responsibility studies are necessary. In the lack of such studies, results from single vehicle accidents may be used, where the responsibility for the accident can be linked to the single driver.
8. Only few roadside surveys have been conducted on drugs other than alcohol. Few samples have been collected in most of the studies with only limited number of drug included in the analytical program. To obtain more valuable results, it is necessary to perform more roadside studies including increased number of samples.
9. The increasing use of oral fluid for roadside surveys needs more studies on oral fluid–blood ratios for the individual drugs, including factors that may contribute to the variable ratios. More studies showing which concentrations levels in oral fluid may be important for the evaluation of possible impairment are welcome.
10. Some studies have used immunological methods for screening (oral fluid), which does not include important BZDs, or with poor sensitivity both for BZDs and THC. The saliva–blood ratios for BZDs and THC have been documented to be << 1 and the important concentration levels may not be detected.

The researchers agree that other drugs when used in combination, particularly with alcohol, contribute to increases accident risks (e.g., THC, BZDs). However, several studies have documented increased risk factors from BZDs themselves (Zwinker et al). This information is important information for planning the drug analytical program used to evaluate possible impairment among apprehended drivers. BZDs represent some of the most frequently detected drugs in countries where these compounds are regularly looked for (Christophersen et al, 1999; Mørland, 2004). Companies producing on-site oral fluid tests should also consider the message. Only few tests on the market include BZDs and the available tests have to low sensitivity (Verstraete, 2000). Feedback from the police is that medicinal impairing drugs (e.g., BZDs) are the most difficult to document during the primary on-site control.

ALCOHOL AND DRUGS AMONG ACCIDENT DRIVERS IN NORWAY AND OTHER NORDIC COUNTRIES

As a contribution to the discussion, the situation in Norway concerning drugged driving and some preliminary results from a new study on fatal accident drivers will be described shortly.

The number of apprehended drivers in Norway due to drugs other than alcohol increased by a factor of more than twice during the period from early 1990s and the following 10 years. Cases where the police suspected only alcohol have been approximately stable during the same time period. In 2002, the number of cases with alcohol only or other drugs suspected was at the same level, e.g., approximately 5,000 for each group (4.5 million inhabitants). One or more drugs have been detected in approximately 80% of the drugs suspected cases, compared to 85% to 90% of the cases with alcohol only suspected (legal limit 0.05% until 2002, then changed to 0.02%). THC, amphetamines, and BZDs (most frequently diazepam and flunitrazepam) have been the most frequently detected compounds after alcohol (Mørland, 2004; www.fhi.no). The main reasons for apprehensions have been accidents and reckless or dangerous driving.

In order to investigate if the occurrence of alcohol and other drugs among apprehended drivers are reflected among fatal accident drivers, a study comparing alcohol and other drugs among fatal accident drivers has been performed in the Nordic countries. To obtain comparable results; a protocol that had to be followed by all five countries (Finland, Sweden, Denmark, Iceland, and Norway) was prepared.

The protocol included the following items for comparison.

- All fatal accident drivers died within 24 h after the accident during 2001 and 2002.
- Results from analyses of bloods samples only have been used, except for the confirmation of 6-monoacetylmorphine (6-MAM) in urine. Positive results form urine analyses should not be used, e.g., where no blood or insufficient sample volume was available for analyses, or the quality of blood samples were not suitable for confirmation analyses after positive screening (mainly THC).
- The same compounds have been included in the analytical program and used for comparison:
  - Alcohol,
  - Amphetamines and Ecstasy,
  - Cannabis (THC in blood),
  - Opioides,
  - Cocaine,
  - Gamma hydroxybutyrate,
  - Hypnotica/sedativa (e.g., BZDs, zopiclone, zolpideme),
  - Muscle relaxants,
  - Antiepileptics,
  - Antihistamines (first generation),
  - Antipsychotics, and
  - Antidepressants.
- All countries have used the same cut-off levels for all compounds. All laboratories have for many years participated in the same quality control program.

The results have been divided in groups with regard to total number of accidents, single accidents, and accidents with several cars involved, cars and motorbikes, sex, and age groups.

RESULTS

The study is in the final stage and the results are therefore preliminary:

The total number of drivers who died during the period from 2001–2002 in the Nordic countries was approximately 1,900. The number of fatal accident drivers during these 2 years varied from 64 to more than 90 million inhabitants in each country. The most striking difference between the different countries was the frequency of investigated cases where autopsy and full toxicological programs had been performed, variable from more than 95% to approximately 16%. For half of the cases representing the country with the lowest frequency of autopsy, full toxicological program could not be performed, meaning that less than 10% of the cases had followed the analytical program for comparison with the other countries.

The frequencies of alcohol and drugs, alone or combined, among from single vehicle drivers (n = 94) in Norway are summarized in Table 1, while results from all fatal accidents are summarized in Table 2.

The most frequently detected drugs among all Norwegian accident drivers were BZDs (24%) (diazepam and flunitrazepam most often detected), alcohol (23%), THC (12%) and amphetamines (11%). Female drivers represented 13% of the cases and drivers between 20 to 35 years old. In many cases, more than one drug was detected, alcohol combined with other drugs or non-alcohol drugs in combination.

When comparing single-vehicle accident in Norway and Sweden, minor differences with regard to the frequency of total positive samples (66% to 64%) were found. Alcohol only was more often found among the Swedish drivers (32% versus 23%), while drugs (totally) were higher in Norway compared to Sweden (43% versus 34%).

Similar drug pattern was detected in both countries. No differences were recorded for age and sex. In all countries, antipsychotics, antidepressants, and antihistamines were detected in very few cases, mainly in combination with alcohol or other drugs.

TABLE 1 Alcohol and Other Drugs among Fatal Accident Drivers in Norway During 2001–2002: Single Vehicle Accidents (n = 94)

Total Positive	Drugs Other Than Alcohol	Alcohol + Other Drugs	Alcohol Only	Negative
66%	25%	18%	23%	34%

TABLE 2 Alcohol and Other Drugs Among Fatal Accident Drivers in Norway During 2001–2002: Total Number of Accidents Investigated (n = 247)

Total Positive	Drugs Other Than Alcohol	Alcohol + Other Drugs	Alcohol Only	Negative
48%	26%	10%	12%	52%

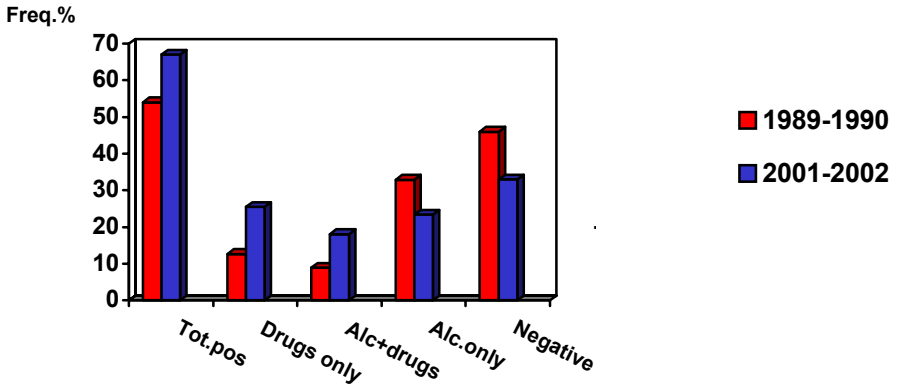

FIGURE 1 Alcohol and other drugs among single-vehicle accident drivers in Norway: comparison between accidents in 1989–1990 and 2001–2002.

The results from Norway have also been compared to a similar study performed in 1989–1990 (Gjerde et al., 1993). Comparison of single-vehicle accidents shows increased frequency of positive samples from 1989–1990 to 2001–2002 (54% versus 66%; Figure 1). Drugs other than alcohol alone or combined with alcohol were responsible for the increase (22% versus 43%). The frequency cases with alcohol only decreased, while no changes for the total frequency of alcohol was observed (due to increased frequency of alcohol combined with other drugs; Figure 1). There are only minor changes in the analytical program between the first and second study. The results from the accident study seem to be comparable to findings among apprehended drivers. A follow-up study for 2001–2001 is planned, including responsibility analyses.

CONCLUSION

Based on the results from some Nordic countries, the occurrence of non-alcohol drugs are at the same level or close to alcohol (alone or alcohol–drug combinations). Further, it is an indication that accident-related non-alcohol drugs have increased, parallel to what have been recorded for drivers apprehended due to the suspicion of impairment. It will be of great importance to investigate all or the majority of all fatal accidents, including toxicological analyses. National database including results from drug analyses in samples from accident drivers should be established, including information to perform responsibility analyses. Such data would be of great importance for the calculation of risk factors, to follow the development on alcohol and other drug-related accidents, to establish preventive actions, and to evaluate these actions.

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Commentary on the Risks Posed by Drugs in Traffic

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The large numbers of persons who report driving after drinking and driving after drug use indicate it is important to study whether driving after drug use in the absence of alcohol increases traffic crash risk and whether driving after drug use further increases the already clearly established risks of driving after drinking alcohol. Evidence will need to be triangulated from a variety of different types of studies: experimental laboratory studies, road course and driver simulation studies, self report surveys and observational roadside surveys that use breath and blood tests and/or saliva tests as well as case/control studies that compare drivers in crashes with drivers stopped in roadside surveys not in crashes. In addition to those studies, driver crash culpability studies and longitudinal driver record studies of patients prescribed specific medications will need to be examined.

According to data from the National Household Survey on Drug Use and Health (*1*), a national representative sample of 67,784 persons 12 and older in the United States conducted in 2003 in the previous year 50% of respondents (representing 119 million persons nationwide) drank alcohol and 8.2% used illicit drugs (19.5 million people). Just under one third of drinkers 13.6% (32.3 million people) drove under the influence of alcohol. Over half of illicit drug users drove after drug use—4.6% of respondents (10.9 million people). One percent (2.4 million people) drove after using drugs but not alcohol while 3.6% (8.6 million people) drove after both drug use and consumption of alcohol.

According to the National Longitudinal Epidemiology Study of 42,862 persons 18 and older conducted for the National Institute on Alcohol Abuse and Alcoholism in 1992 (*2*) many people believe they have been in motor vehicle crashes specifically because of their drinking and drug use. In face to face interviews 66% of respondents indicated they ever drank alcohol (12+ drinks in at least 1 year of their life) and 22% (35% of ever drinkers) reported ever driving after drinking too much. Of all respondents 3.5%, 16% of those who drove after drinking too much reported they were in crashes because of their drinking, or the equivalent of 8.5 million people.

According to the same survey a smaller percentage of respondents ever used drugs: 16%. However, among drug users a greater percentage ever drove under the influence of drugs (45% of ever drug users or 7% of the sample). A smaller percentage of those who drove after drug use, 6% said they were ever in a crash because of their drug use: 0.4% of the total sample, the equivalent about 1 million people nationwide.

During the year of the survey 44% of the sample drank alcohol; 5% drove after drinking too much (11% of past year drinkers); and 0.2% (5% of those who ever drove after drinking too much) were reported to be in crashes because they had too much to drink representing about one half million people. In the year of the survey 5% of the sample used drugs and 1% drove under the influence of drugs (24% of past year drug users). In the past year, <0.1% of the sample or about 1% of those who drove after drug use were in a crash because of their drug use, at least 200,000 people nationwide.

More contemporary information on the proportions of the U.S. adult population 18 and older who drive after alcohol or drug use can be found in the National Epidemiologic Study of Alcohol Related Conditions (NESARC) (*3*), a face-to-face survey completed in 2002 (N = 43,093 response rate 80% of a representative sample of U.S. adults). Sixty-six percent of respondents ever drank and 22% (35% of ever drinkers) said they more than once drove after drinking too much. Twenty-three percent ever used drugs and 7% (33% of ever drug users) more than once ever drove under the influence of drugs.

During the year of the survey 44% of respondents drank alcohol and 5% more than once drove after drinking too much (11% of past year drinkers or about 12 million people). During the year of the survey 6% used drugs and 1% (21% of past year drug users) more than once drove under the influence of drugs. Roughly 2.4 million people drove in the United States under the influence of drugs in the past year. Among persons who ever drove after drinking 25% reported that they had also driven after drug use. In contrast only 2% who never drove after drinking reported driving after drug use. During the year of the survey 13% who drove after too much to drink also drove under the influence of drugs. However, less than 1% who did not drive after drinking drove after drug use in the past year.

POTENTIAL INTERVENTIONS TO REDUCE DRUG IMPAIRED DRIVING

Studies of screening and brief interventions in trauma center settings and emergency departments have been shown to reduce driving after drinking. Gentilello (*4*) reported that 46% of patients treated at the Harborview Trauma Center in Seattle, Washington, had been injured under the influence of alcohol. In a randomized trial half of those injured patients received a 30-min counseling session where they were told how their drinking patterns compared to people of the same age and gender nationwide, what their risks of illness injury were if they continued their current drinking practices, and where they could receive counseling. One year later those in the intervention group averaged 21 fewer drinks per week, and over a 3-year post intervention period experienced a 23% reduction in drinking driving arrests, a 47% reduction in emergency department injury visits, and a 48% reduction in hospitalization for injury. Similar reductions in drinking or drinking and driving have been reported in emergency department settings by Monti et al. (*5*), Longabough (*6*), and Mello et al. (*7*). These findings suggest that when injured people are treated in trauma centers and emergency departments, that may offer a teachable moment to effectively address risky drinking practices. This is important because there are an estimated 8,000,000 alcohol-related emergency department visits annually in the United States (*8*) but only 2.2 million actually have alcohol mentioned in their medical records (*9*). One reason for the under recording may be laws on the books in 28 states plus the District of Columbia that allow insurance companies to withhold medical reimbursement for treatment of people injured under the influence of alcohol or drugs (*10*). Despite the reported efficacy of mandated treatment of convicted drunk drivers in reducing recidivism (*11*), efforts to use treatment to prevent drinking driving fatal crashes should expand beyond the criminal justice system. That is because most drinking drivers in fatal crashes have never been arrested previously for driving under the influence of alcohol.

Recently Bernstein and colleagues (*12*) published the first screening and brief intervention study in an emergency department setting that showed these techniques can also reduce use of psychoactive drugs such as heroin, cocaine, and opiates. Whether these types of interventions can reduce driving after drug use and traffic crashes resulting from drug-impaired

driving has not been tested. Further work should examine whether combining screening and counseling for both alcohol and other drugs simultaneously could produce greater reductions in drinking and drug use and associated traffic crashes than screening and counseling for each alone.

Research has also shown that treatment of alcohol problems can not only reduce drinking but also driving after drinking (*13*, *14*). Whether combining alcohol treatment with drug use treatment will also produce greater declines in both drinking and drug use and related crashes warrants study.

The Immortal Project presented by Matthesson (*15*) provides a useful model for future studies in the United States and other countries. Roadside surveys where drivers are tested for alcohol as well as other drugs should be conducted in states or countries where testing of fatally injured drivers for both alcohol and other drugs is comprehensive. This will allow for the development of case control studies comparing fatally injured drivers (case) to persons randomly stopped and tested at roadsides but not involved in crashes (controls). If sufficient numbers of drivers test positive for drugs alone, alcohol alone, and drugs and alcohol in combination, analyses can assess whether each substance independently increases fatal crash risk and whether if used in combination fatal crash risks increase additively or synergistically.

If case control studies show elevated fatal crash risk for persons who drive after using drugs, and drugs and alcohol in combination, that will provide a rationale for comprehensive testing all fatally injured drivers for these substances. Part of the reason for the strong progress during the past two decades in reducing alcohol-related fatal crashes in the United States was the comprehensive testing the blood alcohol content of fatally injured drivers in traffic crashes. This permitted researchers to conduct studies comparing pre and post law trends in alcohol- and non-alcohol-related fatal crashes in states that passed laws to reduce alcohol-related fatal crashes such as raising the minimum legal drinking age, per se laws, administrative license revocation, and lower legal blood alcohol limits. Trends in those states could be compared to trends in states that did not enact such legislation.

Similarly if states start to enact new drug driving laws, comprehensive testing will be needed to assess whether the laws produce reductions in drug driving fatal crashes as well as alcohol-related fatal crashes. Studies of new legislation to reduce alcohol-related fatal crashes will not only have to consider potential confounding effects of other pre existing drinking and driving laws and alcohol policies but also drug driving laws particularly those enacted is close temporal proximity to the drinking and driving laws.

Laws that mandate screening and counseling for both alcohol and drug use among persons convicted of either driving after drinking or after drug use or both also need to be evaluated. Screening, brief intervention, and treatment studies both within the context of legal actions against impaired drivers and in trauma centers and emergency departments should follow over time the driver records of persons offered and not offered alcohol and drug counseling to test whether these screening and treatment programs produce greater declines in alcohol and other drug use and in turn greater declines in motor vehicle crashes involving driver use of alcohol and other drugs.

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Effects of Drugs

Drug Effects and Their Significance for Traffic Safety

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This paper is limited to the discussion of illicit as well as legal, but not-used-as-prescribed psychoactive drugs. The two topics, drug effects and the impact of drugs on traffic safety, have been researched extensively and a detailed review of the literature in both areas is well beyond the scope of this paper. Instead this paper will present information related to both areas mostly in terms of what we know or need to know about the seven National Institute on Drug Abuse (NIDA) drug categories and in terms of the shortcomings of the data that is useful for law enforcement in the context of highway safety and the directions that research should proceed to be more useful for highway safety programs in general, and traffic law enforcement in particular.

ASSUMPTIONS ABOUT DRUGS AND DRIVING

When addressing the "drug problem" we often make several implicit assumptions:

1. Psychoactive drugs should have an effect not only on mood but also on cognitive and psychomotor functioning. Furthermore, these effects should be reflected in performance on measures related to these functions (such as stability, reaction time, speech) should reflect some significant deviation from the norm.
2. These cognitive changes are expected to be of such magnitude that they are both observable to a trained person, and quantifiable with some standardized tests.
3. Since driving is a fairly complex psychomotor and cognitive task, drug impairments should affect driving performance, and usually in a negative manner.
4. Unfortunately, people who take drugs often drive while under their influence, either because they do not appreciate their impairments or because their judgment is impaired.
5. The resulting driving under the influence of drugs (DUID) problem can be dealt with in much the same way as driving while intoxicated (DWI).

Unfortunately most of these assumptions are incorrect, at least some of the time.

1. Measuring impairment using objective tools is not an easy task. It is complicated by the fact that different drugs have different effects; the threshold at which these effects are first manifest varies as a function of the measure used (e.g., alcohol-based horizontal nystagmus is evident much earlier than slurred speech). The most sensitive measures are typically ones that can only be made under strictly controlled laboratory conditions, and these are impossible to create in the field or in a police station. In addition, what constitutes a "norm" must be specified as a range of values, since there are large individual differences in the norm, even in the absence of any drugs. For example, systolic blood pressure is within the norm anywhere from a low of 100 to a high of 140. Thus a person with relatively low blood pressure can show an increase in

blood pressure that would still be within the norm, while another person's "normal" systolic blood pressure may exceed the norm even without ingesting any drug. Since law enforcement officers typically arrest drivers who have already exhibited impairment, assessing impairment on the basis of measured signs and symptoms without any knowledge of these people's baseline is very difficult.

2. Driving is not only a complex task, but it is a planned behavior. Different people may drive from the same starting point to the same end point while deploying different strategies: from the level of trip planning (choosing the route), to navigation (deciding on the lane and when to change lanes given different traffic situations), to reacting to specific situations (in adopting different strategies of braking, accelerating, scanning the scene, and responding to hazards). This also means that measuring driving is not simple. For example, people under the effects of alcohol often feel overconfidence in their driving and they speed. In contrast, people under the effects of marijuana often feel impaired and tend to drive slower. However, both drugs impair judgment and the ability to respond correctly to emergency situations.

3. The approach to DUID enforcement is much more complicated than that of DWI enforcement. The per se laws are based on solid evidence that show a myriad of driving-related impairments that increase in number and magnitude as a function of blood alcohol content (BAC), and several studies—in the United States and in Europe—that showed over-involvement in crashes when alcohol levels were beyond .04% BAC. In parallel, the development of the SFST was a rigorous process based on controlled studies that assessed the relationship between BAC and various measures (primarily nystagmus). Conducting and interpreting these studies was much easier than with drugs other than alcohol, because alcohol has the unique property of being equally absorbed by all tissues, whereas other drugs are differentially absorbed in different tissues and therefore it is hard to correlate impairment when the drug concentration is conveniently sampled from the blood or urine, rather than from the brain where it has its effects.

THE STATE OF RESEARCH ON DRUGS AND DRIVING

Despite these problems, the scientific interest in drugs and driving has been increasing over the past decade, and there are now at least several hundreds of studies that have focused attention on that issue. A conservative estimate of the number of such studies can be obtained from the numbers in Table 1. That table presents the number of entries in various data basis for published studies where the words "drugs and driving" were included in the study title, abstract, body of the paper, or key words.

Four search engines with partially overlapping coverage are listed in the table:

1. NIDA has produced 428 such research reports.
2. The Web of Science, Science Citation Index (www.isinet.com) provides access to current and retrospective bibliographic information, author abstracts, and cited references found in "3,700 of the world's leading scholarly science and technical journals covering more than 100 disciplines. The Science Citation Index Expanded format, available through the Web of Science and the online version, *SciSearch*, cover more than 5,800 journals." "Today the ISI database covers over 16,000 international journals, books and proceedings in the sciences, social sciences and arts and humanities including 8,700 international journals that ISI covers on an annual

TABLE 1 Number of Times "Drugs And Driving" Are Cited in Scientific Publications in Different DataBases

Source	Number of Listings	In Title
NIDA	428 entries	2
–Since 2000:	—	1
ISI Citation Index	659	70
–Since 2000:	326	20
Pubmed/Medline	1,383	121
–Since 2000:	452	21
Scholar.Google	49,100	237
–Since 2000:	23,100	45

basis." (ISI, 2005). The ISI Citation Index is also the academic gold standard for peer-reviewed publications. This index lists over 650 "drugs and driving papers."

3. Pubmed is the U.S. National Library of Medicine database of biomedical citations and abstracts that is searchable on the web (http://pubmed.gov) at no cost. MEDLINE, the largest component in PubMed, covers more than 4,800 journals published in the United States and more than 70 other countries primarily from 1966 to the present. In addition to MEDLINE citations, PubMed also contains pre-1966 citations from the old medline, citations of articles considered out of scope of medicine, but contained in Medline-covered journals, and citations for "in-proces citations."

4. Google Scholar (www.scholar.google.com) lists nearly 50,000 publications with "drugs and driving" somewhere in the text. In Google's own words "Google Scholar enables you to search specifically for scholarly literature, including peer-reviewed papers, theses, books, preprints, abstracts and technical reports from all broad areas of research. Use Google Scholar to find articles from a wide variety of academic publishers, professional societies, preprint repositories and universities, as well as scholarly articles available across the web". While this definition is somewhat vague the number of citations is huge! Even more important than the total number of publications, is the number that has been published in this century alone: roughly one-third to half of all studies.

Such an enormous body of scientific research is most likely to yield some significant and robust findings that can be useful in the process of the identification of drug impairment for the purpose of traffic law enforcement. Unfortunately the three most recent comprehensive reviews of the scientific literature, published in this century, examined research that was published—at the latest—in 2001. The Drug Fact Sheets by Couper and Logan (2004) are based on deliberations of an "International Consultative Panel on Drugs and Driving Impairment" held in Seattle, Washington, in August 2000; Jones, Shinar, and Walsh's (2003) "State of Knowledge on Drug Impaired Driving" is based on research published between 1981 and 2001; and Shinar's (2000) report on "The Feasibility of Developing an On-Site Detection and Evaluation of Drug Impairment Based on Observable Signs and Symptoms" is based on research from the previous century. Thus, the most recent, and possibly the best research still have to be integrated into a coherent critical review.

Seven NIDA Drug Categories

One difficulty in a general discussion on drug effects is that different drugs have different pharmacological properties, result in different physiological and physical signs and symptoms, and consequently have different effects on attitudes and behavior in general and driving-related attitudes and behaviors in particular. NIDA classifies the illicit drugs into seven major drug classes on the basis of their effects on the central nervous system (CNS). These classes and sample drugs within each class are listed in Table 2, and the following sections of this review will deal with each in turn.

The review of each drug is based primarily on the NIDA Listing of Commonly Abused Drugs (2005) and the Couper and Logan's Drugs and Human Performance Fact Sheets (2004). Both summaries constitute laudable attempts to synthesize the results of very many and methodologically different studies into a few paragraphs that are simple to understand. Unfortunately, this necessitates some generalizations that are often not very accurate, and often describe the effects of different drug categories in the same or similar terms, making them indistinguishable from each other. This is not a critique of the two summaries, but a cautionary note in their interpretation. In that respect, what follows for each category suffers from the same limitations.

The review of each category contains the

1. Drugs in that class (on the basis of the NIDA 2005 listing);
2. Blood–urine dose response relationship (on the basis of Couper and Logan's 2004 Fact Sheets);
3. Duration of the drug effect (on the basis of Couper and Logan's Fact Sheets);
4. Psychoactive effects (on the basis of the NIDA listing and Couper and Logan's Fact Sheets);
5. Observable physical–physiological signs (on the basis of the NIDA listing and Couper and Logan's Fact Sheets);
6. Drug Evaluation and Classification Program (DECP) signs and symptoms (also summarized by Couper and Logan); and
7. Involvement in driving and crashes (on the basis of Couper and Logan's Fact Sheets and Jones, Shinar, and Walsh's 2003 literature review).

TABLE 2 NIDA Drug Categories and Selected Drugs in Each Category

Drug Category	Drugs in Category
1. Cannabinoids	Marijuana, hashish
2. CNS depressants	Barbiturates, benzodiazepines, GHB, methaqualone
3. Dissociative anesthetics	PCP, ketamine
4. Hallucinogens	Mescaline, psilocybin, LSD
5. Opioids and morphine derivatives	Fentanyl, codeine, heroin, morphine, opium, oxycodone, HCL
6. CNS stimulants	Amphetamines, methamphetamines, cocaine, MDMA, methylphenidate, nicotine
7. Other compounds	Inhalants, anabolic steroids

In connection with the DECP signs and symptoms, this review also includes the results of an evaluation of the ability of experienced drug recognition experts (DREs) to identify specific drug categories based on these signs and symptoms (Shinar and Schechtman, 2005; Schechtman and Shinar, 2005). This evaluation is stated in terms of the DRE's sensitivity and specificity. Sensitivity is the probability of correctly identifying a drug category, given that the drug was ingested. Specificity is the probability of correctly rejecting drug impairment given that the drug was not ingested. The complement of sensitivity is the percent of time that a drug is missed and the complement of specificity is the percent of false alarms or "cry wolf."

For the sake of expediency, in the following sections the NIDA drug listings will be simply noted as NIDA, the Couper and Logan Fact Sheets will be simply noted as FS, the Jones Shinar and Walsh conclusions will be noted as JSW, and the results of the analyses by Shinar and Schechtman will be noted as SS.

Cannabinoids

- Drugs in class (NIDA): Hashish, marijuana (NIDA)
- Dose response relationship (FS): It is difficult to establish a relationship between a person's THC blood or plasma concentration and performance impairing effects, though some relationship between performance on eye–hand coordination and THC has been noted.
- Duration of effect (FS): Effects from smoking are felt within minutes and reach their peak in 10 to 30 min. Significant performance impairments are usually observed for at least 1 to 2 h following marijuana use.
- Psychoactive effects: According to NIDA the effects include euphoria, slowed thinking and reaction time, confusion, impaired balance and coordination, cough, frequent respiratory infections, impaired memory and learning, increased heart rate, and anxiety. Similar but with noticeable differences effects are noted in the FS, and they include problems with memory and learning, sensory functions are not highly impaired, but perceptual functions are significantly affected including distorted time and distance perception, sleepiness, difficultly in thinking and problem solving, loss of coordination, and the ability to concentrate and maintain attention are decreased. Heavy users have difficulty sustaining and shifting attention.
- Measurable signs and symptoms (FS): Impairment of hand–eye coordination is dose-related over a wide range of dosages. Impairment in retention time and tracking, subjective sleepiness, distortion of time and distance, vigilance, and loss of coordination in divided attention tasks. However, subjects can often "pull themselves together" to concentrate on simple tasks for brief periods of time.
- DECP signs and symptoms: Gaze nystagmus not present; there is a lack of convergence; pupil size is normal to dilated; reaction to light is normal to slow; pulse rate is elevated; blood pressure is elevated; body temperature is normal to elevated. Additional signs include bloodshot eyes, body and eyelid tremors, relaxed inhibitions, incomplete thought process, and poor performance on field sobriety tests. However, the analysis of performance based on these signs and symptoms alone yielded sensitivity = 49%, specificity = 69%, and a phi correlation of 0.14 between marijuana ingestion and marijuana detection.
- Involvement in driving–crashes (FS): Marijuana has been found to impair performance on driving simulator tasks and on open and closed driving courses for up to approximately 3 h. However, some drivers may actually be able to improve performance for brief periods by overcompensating for self-perceived impairment. According to JSW the results

are mixed. In a recent evaluation in a simulator Shinar et al. (2005) found that driving speed is reduced but vehicle control is still compromised, and heart rate variability increases (indicating reduced attention).

CNS Depressants

- Drugs in class (NIDA): Barbiturates, BZDs, methaqualone, GHB.
- Dose response relationship (FS): For diazepam blood concentrations will not provide a good indication of likely behavioral effects. The long half-life of diazepam may cause accumulation to occur with repeated use, and blood concentrations may be several-fold higher after chronic use compared to single use
- Duration of effect (FS): For diazepam (for single doses 5 to 20 mg) maximal effect occurs at approximately 2 h post dose, and lasts up to at least 3 to 4 h.
- Psychoactive effects (NIDA): Include reduced anxiety; feeling of well being, lowered inhibitions, slowed pulse and breathing, lowered blood pressure, and poor concentration–fatigue. In the case of barbiturates they include sedation, drowsiness–depression, unusual excitement, and irritability. BZDs produce sedation, and drowsiness or dizziness. GHB produces drowsiness, nausea or vomiting, and headache. Methaqualone produces euphoria or depression, poor reflexes, and slurred speech. Diazepam (according to FS) in low doses produces sleepiness, drowsiness, confusion, and some loss of anterograde memory, and in high doses it causes excitement, disinhibition, and severe sedation.
- Measurable signs and symptoms: According to NIDA the typical signs include confusion and impaired coordination, memory, and judgment. Barbiturates cause fever, poor judgment, slurred speech, and dizziness. Flunitrazepam causes visual and gastrointestinal disturbances, urinary retention, and memory loss while the person is under the drug's effects. According to FS diazepam impairs divided attention, eye–hand coordination, tracking performance, vigilance, information retrieval, psychomotor and cognitive skills, and lengthens reaction time (up to 9.5 h post dosing).
- DECP signs and symptoms: include horizontal gaze nystagmus, vertical gaze nystagmus in high doses, lack of convergence, normal pupil size, slowed reaction to light, lowered pulse rate, lowered blood pressure, and normal body temperature. Other characteristic indicators may include behavior similar to alcohol intoxication without the odor of alcohol, staggering and stumbling, lack of balance and coordination, slurred speech, disorientation, and poor performance on field sobriety tests. However, the analysis of performance based on these signs and symptoms alone (SS) yielded sensitivity = 47%, specificity = 80%, and a phi correlation of 0.23 between alprazolam ingestion and alprazolam detection.
- Involvement in driving–crashes (FS): Diazepam produces significant driving impairment over multiple doses. Single doses of diazepam can increase lateral deviation of lane control. According to JSW the effects vary for different drugs. Diazepam, flurazepam, and lorazepam increase accidents in simulator and degrade vehicle control but buspirone does not. Also effects on the same subjects were observed in simulator but not in real driving.

Dissociative Anethetics

- Drugs in class (NIDA): Include ketamine, PCP, and analogs.

- Dose response relationship (FS): There are some contradictions in the summary since it notes that "Effects are usually dose dependent"… (but later notes that) … "there is no direct correlation between PCP concentration and behavioral or physical findings."
- Duration of effect (FS): PCP onset of effects is very rapid when smoked or injected (1 to 5 min) and are delayed when snorted or orally ingested (30 min), with a gradual decline of major effects over 4 to 6 h. A return to "normal" may take up to 24 h.
- Psychoactive effects: According to NIDA the effects include numbness and nausea or vomiting. Ketamine at high doses causes delirium and depression. PCP and analogs cause panic, aggression, violence, loss of appetite, and depression. According to the FS, PCP causes euphoria, calmness, feelings of strength and invulnerability, lethargy, disorientation, loss of coordination, distinct changes in body awareness, distorted sensory perceptions, impaired concentration, disordered thinking, illusions and hallucinations, agitation, combativeness or violence, memory loss, bizarre behavior, sedation, and stupor.
- Measurable signs and symptoms: According to NIDA the signs are increased heart rate and blood pressure, and impaired motor function or memory loss. According to FS the effects include disorientation, drowsiness, dizziness, ataxia, double or blurred vision, body image changes, disorganization of thoughts, combativeness, impairment of eye–hand coordination, memory impairment, paresthesia, slowed reaction time, and distorted perceptions of space. Most common physical findings in one study were combativeness–agitation (64%), depressed level of consciousness (50%), hypertension (43%), miosis (43%), and tachycardia (43%).
- DECP signs and symptoms: PCP impairment is manifest in horizontal gaze nystagmus, vertical gaze nystagmus, lack of convergence, normal pupil size, normal reaction to light, and elevated pulse rate, blood pressure, and body temperature. Other characteristic indicators may include rigid muscles, cyclic behavior, sudden turn to violence, lack of response to painful stimuli, trance-like state or blank stare, sweating, and incomplete or delayed verbal responses.

Hallucinogens

- Drugs in class (NIDA): LSD, psilocybin, mescaline.
- Dose response relationship (FS): Threshold toxic dose in humans has been reported with 100 to 200 mg with associated blood concentrations of 2 to 30 ng/mL. Intravenous doses of 1 to 2 mg /kg have been associated with blood concentrations of 1 to 5 ng/mL LSD.
- Duration of effect (FS): The onset of LSD effects is rapid following intravenous administration (10 min). Following oral ingestion, onset of the first effects are experienced in 20 to 30 min, peaking at 2 to 4 h, and gradually diminishing over 6 to 8 h. Flashbacks may occur suddenly.
- Psychoactive effects (NIDA): Include altered states of perception and feeling, nausea, and persisting perception disorder (flashbacks). For LSD specifically there are persistent mental disorders, and for psilocybin there is nervousness and paranoia. According to the FS, LSD's effects are unpredictable and will depend on the dose ingested, the user's personality, mood, and expectations, and the surroundings. In general the effects include hallucinations, increase in color perception, altered mental state, thought disorders, temporary psychosis, delusions, body image changes, and impaired depth, time, and space perceptions. Users may feel several emotions at once or swing rapidly from one emotion to another. "Bad trips" may consist of severe, terrifying thoughts and feelings, fear of losing control, and despair.

- Measurable signs and symptoms (NIDA): For LSD and mescaline they include increased body temperature, heart rate, and blood pressure, loss of appetite, sleeplessness, numbness, weakness, and tremors. According to FS, LSD causes tachycardia, hypertension, dilated pupils, sweating, dry mouth, tremors, speech difficulties, and piloerection. They also cause longer simple and choice reaction time (auditory and visual), and reduced visual acuity for up to 4 h. Impaired divided attention, ataxia, and grossly distorted perception have also been reported.
- DECP signs and symptoms: For LSD the signs are dilated pupil size, normal reaction to light, elevated pulse rate, elevated blood pressure, elevated body temperature, hallucinations, paranoia, and changes in sensitivity to light, hearing, touch, and smell.
- Involvement in driving–crashes (FS): Epidemiological studies suggest the incidence of LSD in driving under the influence is extremely rare.

Opioids and Morphine Derivatives

- Drugs in class (NIDA): Codeine, fentanyl, morphine, heroin, opium.
- Dose response relationship (FS): Depends heavily on the dose of morphine or heroin, the route of administration, and previous exposure. Tolerance makes interpretation of blood or plasma morphine concentrations extremely difficult.
- Duration of effect (FS): Peak plasma morphine concentrations occur within an hour of oral administration, and within 5 min following intravenous injection. Onset of effects is within 15 to 60 min and effects may last 4 to 6 h. The duration of analgesia increases progressively with age although the degree of analgesia remains unchanged. Following heroin use, the intense euphoria lasts from 45 s to several minutes, peak effects last 1 to 2 h, and the overall effects wear off in 3 to 5 h, depending on dose.
- Psychoactive effects (NIDA): Include euphoria, drowsiness, nausea, and confusion. According to FS, following an intravenous dose of heroin, the user generally feels an intense surge of euphoria (“rush”) accompanied by a warm flushing of the skin, dry mouth, and heavy extremities. The user then alternates between a wakeful and drowsy state (“on the nod”). Other effects include feeling of well being, relaxation, drowsiness, sedation, lethargy, disconnectedness, self-absorption, mental clouding, and delirium.
- Measurable signs and symptoms (NIDA): For heroin the signs include staggering gait and, according to FS, nausea and vomiting, flushing of face and neck due to dilatation of subcutaneous blood vessels, cramping, sweating, fixed and constricted pupils, diminished reflexes, and depressed consciousness.
- DECP signs and symptoms: Constricted pupil size, little or no reaction to light, reduced pulse rate, lowered blood pressure, and lowered body temperature. Other characteristic indicators may include presence of fresh injection marks, track marks, flaccid muscle tone, droopy eyelids, drowsiness or “on-the-nod,” and low raspy slow speech. However, the analysis of performance based on these signs and symptoms alone (SS) yielded sensitivity = 45%, specificity = 72%, and a phi correlation of 0.14 between codeine ingestion and codeine detection.
- Involvement in driving–crashes (FS): Driving ability in cancer patients receiving long-term morphine analgesia (mean 209 mg daily) was considered not to be impaired by the sedative effects of morphine to an extent that accidents might occur. There were no significant differences between the morphine-treated cancer patients and a control group in vigilance, concentration, motor reactions, or divided attention. A small but significant slowing of reaction

time was observed at 3 h. In several driving under the influence case reports, where the subjects tested positive for morphine and/or 6-acetylmorphine, the observers noted slow driving, weaving, poor vehicle control, poor coordination, slow response to stimuli, delayed reactions, difficultly in following instructions, and falling asleep at the wheel. In addition JSW also report one study of codeine-impaired driving in closed course.

CNS Stimulants

- Drugs in class (NIDA): Amphetamine, methamphetamine, cocaine, MDMA, nicotine.
- Dose response relationship (FS): In the case of cocaine impairment a given blood concentration cannot usually be associated with a degree of impairment or a specific effect for a given individual without additional information including individual levels of tolerance to the drug.
- Duration of effect (FS): A hit of smoked crack (cocaine) produces an almost immediate intense experience and will typically produce effects lasting 5 to 15 min. Similarly, snorting cocaine produces effects almost immediately and the resulting high may last 15 to 30 min.
- Psychoactive effects (NIDA): Include feelings of exhilaration, energy, increased mental alertness, nervousness, and insomnia. Amphetamine causes delirium, panic, paranoia, impulsive behavior, and aggression. Cocaine causes headaches, panic attacks, and nausea. MDMA causes mild hallucinogenic effects, increased tactile sensitivity, and empathic feelings. Methamphetamine elicits aggression, violence, and psychotic behavior. According to the FS, the early phase of cocaine impairment causes euphoria, excitation, feelings of well being, general arousal, increased sexual excitement, dizziness, self-absorbed, increased focus and alertness, mental clarity, increased talkativeness, motor restlessness, offsets fatigue, and loss of appetite. Higher doses may exhibit a pattern of psychosis with confused and disoriented behavior, delusions, hallucinations, irritability, fear, paranoia, antisocial behavior, and aggression. The late phase is characterized by dysphoria, depression, agitation, nervousness, drug craving, fatigue, and insomnia. Physiological indicators include itching or picking or scratching, normal heart rate, and normal pupils.
- Measurable signs and symptoms (NIDA): Include increased heart rate, blood pressure, and irregular heart beat. Amphetamines symptoms include rapid breathing or tremors, and loss of coordination. Cocaine symptoms include increased temperature or chest pain. MDMA results in impaired memory and learning, and hyperthermia. Methamphetamine causes impaired memory and learning. According to the FS, cocaine in the early phase actually improves performance in some simple tasks, but does not enhance learning, memory, and other cognitive processes. It increases heart rate, blood pressure, light sensitivity and body temperature. It causes dilated pupils, constriction of peripheral blood vessels, rapid speech, dyskinesia, nausea, and vomiting.
- DECP signs and symptoms: Dilated pupil size, slowed reaction to light, elevated pulse rate, elevated blood pressure, and elevated body temperature. Other characteristic indicators may include excessive activity, increased alertness, talkativeness, irritability, argumentativeness, nervousness, body tremors, anxiety, redness to nasal area, and runny nose. However, the analysis of performance based on these signs and symptoms alone (SS) yielded sensitivity = 10%, specificity = 91%, and a phi correlation of 0.01 between amphetamine ingestion and amphetamine detection.

- Involvement in driving–crashes (FS): Cocaine is associated with speeding, losing vehicle control, causing collisions, turning in front of other vehicles, high-risk behaviors, aggressive driving, and inattentive driving.

Inhalants

- Drugs in class (NIDA): Solvents (toluene) and gasses.
- Dose response relationship (FS): In non-exposed individuals, average toluene concentrations have been measured at 0.47 m g/L (non-smokers) and 1.14 m g/L (smokers). Blood concentrations of less than 1.0 mg/L corresponded to an odor of "chemical" on the subject's breath; some signs of impairment were observed at concentrations of 1.0 to 2.5 mg/L; 50% of subjects with concentrations of 2.5 to 10 mg/L were hospitalized with marked intoxication including hallucinations. A Norwegian study with 29 impaired drivers found no simple dose-response relationship, but almost all people with more than 9.2 mg/L were judged impaired.
- Duration of effect (FS): Toluene is detectable in arterial blood within 10 s of inhalation exposure; the onset of effects is almost immediate and the effects generally last several hours.
- Psychoactive effects (NIDA): Include stimulation, loss of inhibition, headache, nausea or vomiting, slurred speech, and depression. According to the FS, toluene causes dizziness, euphoria, grandiosity, floating sensation, drowsiness, reduced ability to concentrate, slowed reaction time, distorted perception of time and distance, confusion, weakness, fatigue, delusions, and hallucinations.
- Measurable signs and symptoms (NIDA): Include loss of motor coordination, muscle weakness, and memory impairment. According FS toluene symptoms include nystagmus, slurred speech, ataxia, staggering, impaired color vision, memory loss, vigilance, nausea, vomiting, respiratory depression, and convulsions.
- DECP signs and symptoms: Include horizontal gaze nystagmus (in high doses), vertical gaze nystagmus (in high doses), lack of convergence, normal pupil size, slow reaction to light, elevated pulse rate and blood pressure, and normal body temperature. Other characteristic indicators may include strong odor of solvent or chemical on breath or clothes, residue of substance around nose, mouth or hands, slurred speech, and general intoxication.
- Involvement in driving–crashes (FS): No observations, driving, or simulator studies exist for toluene. Blood toluene concentrations above ~1.0 mg/L were detected in 114 drivers arrested on suspicion of driving while intoxicated in Norway 1983–1987. In 29 of these cases toluene was the only detected drug, with mean blood concentrations of 10 mg/L (range 1 to 29.3 mg/L). Almost all drivers with blood toluene concentrations greater than 9.2 mg/L were considered impaired or highly probably impaired.

DRUGS AND CRASH INVOLVEMENT

Jones, Shinar, and Walsh (2003) attempted to summarize the literature on drug involvement in crashes. The results displayed in Figure 1 show the average percent of fatally injured drivers that were tested positive for various drugs. These averages are based on data obtained from different studies, conducted in different parts of the world, using different drug identification methods.

Therefore these averages should be viewed with extreme caution. However, even with this caveat in mind, it is obvious that in North America marijuana, at 15%, is by far the most common drug found in fatally injured drivers. Next are cocaine and BZDs, which were found in 5% to 6% of the fatally injured drivers. The picture is not as clear in Europe, where no particular drug appears to be dominant. Of course these results do not indicate whether or not the drug impairment was a causal factor in these crashes. To attempt to answer that question, Jones et al. also evaluated the risk of fatal injuries. This was obtained either directly from studies that included a causal analysis, that directly evaluated the cause of the crash, and indirectly by attempting to relate crash involvement of drugs to their prevalence in the driving population. Both methods are extremely error prone: the first because of its clinical speculative process and the second because the exposure data is not taken from the same populations of drivers driving the same roads at the same time. Nonetheless, for as good as they are, the data are presented in Figure 2.

In Figure 2, bars labeled "single studies" are for studies using responsibility analysis and information about drug use to calculate relative risk. Bars labeled "separate studies" are for risk estimates based on data from separate studies for crash data and for non-crash data. The conclusions that emerge from this figure are somewhat different from those that might be derived from Figure 1. They show that cannabis is over-involved in fatal crashes; narcotics, BZDs, and cocaine (depressants) are probably not; and stimulants other than cocaine may actually be under-involved. The most obvious conclusion that from these data is that a much more rigorous and coordinated efforts involving multiple studies are needed before any conclusions can be drawn.

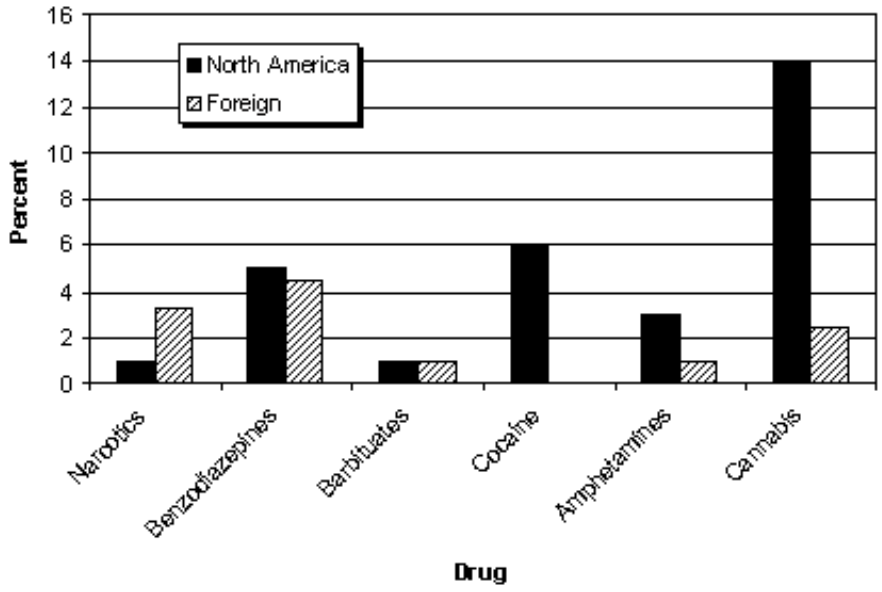

FIGURE 1 The average percent of fatally injured drivers with various drugs in their blood, based on data from North American and foreign countries.

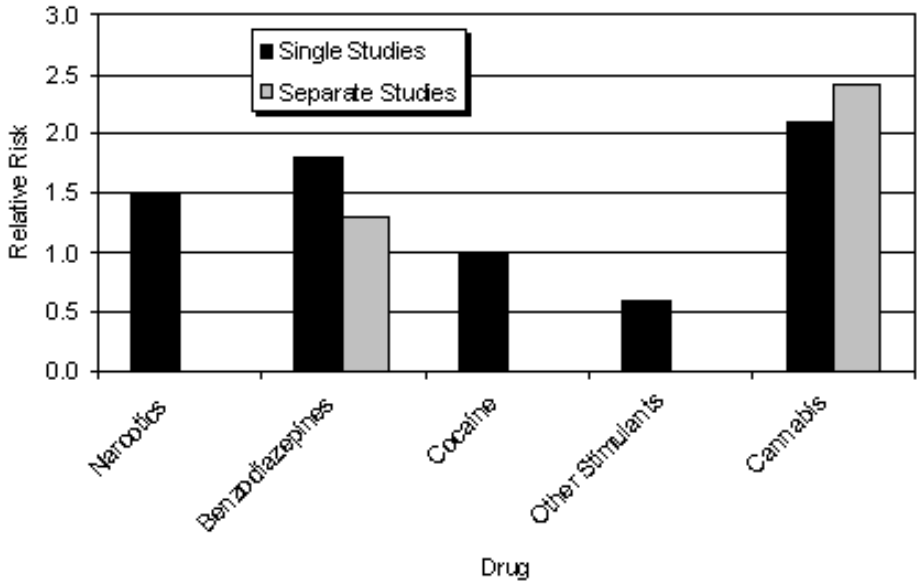

FIGURE 2 The relative crash risk posed by various drugs averaged across all studies reviewed by Jones et al. (2003).

CONCLUSIONS

This review indicates that

1. Some detrimental drug effects on driving performance and driving safety are fairly well established. However, most of the support for over-involvement in crashes comes from epidemiological field studies that examine the probability of drug presence *given* a crash or impaired driving.
2. Much less is known on the impairing effects of drugs that are actually manifest in driving; i.e., the probability of impaired driving or a crash *given* the ingestion of a drug. This is the real question of interest and it is much more difficult to study.
3. The relationship between physical and psychological impairment and the blood–plasma levels is elusive and difficult to establish. This is especially true for marijuana, cocaine, diazepam, and PCP.
4. Often variations in effects among drugs within a class or a NIDA category are too large to be lumped together. An extreme example is the difference between two depressants: diazepam that has many driving-related negative side effects and flurazepam that has very few, if any.
5. Physical signs and symptoms in reaction to drugs vary widely, and individual differences are often greater than mean drug effects, making signs-based diagnosis very difficult.
6. We do not know the inter-observer reliability in recording signs and symptoms. Past research on experienced neurologists (Shinar et al.) casts doubt on some measures used to assess drug impairments.

RECOMMENDATIONS

1. There is an immediate need for a thorough and updated literature review on the relationship between drug ingestion and performance on driving-related tasks. This is needed In light of the plethora of recent scientific research that has been published after the most recent reviews in this area have been published.
2. A systematic approach that will include a research plan to validate drug effects on physical signs and symptoms—relative to known individual differences (e.g., past exposure)—should be developed. This was the approach taken with alcohol impairment but it has never been done for drug impairment. The formulation of the DECP guidelines was an early attempt based on very little scientific data, and recent analyses suggest that it is not very valid.
3. A progressive approach to the problem should focus first on the drugs (*1*) that are most commonly abused, and (*2*) for which there is greatest amount of scientific data. These drugs are marijuana and BZDs. The initial focus should be on marijuana since it is a single drug, and then probably on one of the more commonly abused BZDs.

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Commentary on Cannabis and Crash Risk
Concentration Effect Relation

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DOES THC IMPAIR DRIVING PERFORMANCE?

The role of THC in driver impairment and motor vehicle crashes has traditionally been established in experimental and epidemiological studies. Experimental studies have repeatedly shown that THC impairs cognition, psychomotor function, and actual driving performance in a dose-related manner. The degree of performance impairment observed in experimental studies after doses of up to 300 µg/kg THC was equivalent to the impairing effect of an alcohol dose producing a blood alcohol concentration (BAC) ≥0.05 g/dl, the legal limit for driving under the influence in most European countries. Higher doses of THC, i.e., > 300 µg/kg THC, have not been systematically studied but can be predicted to produce even greater impairment. The detrimental effects of THC were more prominent in certain driving tasks than others. Highly automated behaviours, such as road tracking control, were more significantly affected by THC than more complex driving tasks requiring conscious control.

CONTRASTS BETWEEN THE RESULTS OF EPIDEMIOLOGICAL AND EXPERIMENTAL STUDIES

Epidemiological findings on the role of THC in vehicle crashes have sharply contrasted with findings from experimental research. Most epidemiological surveys show little evidence that crashed drivers who only used cannabis are more likely to cause accidents than drug-free drivers. This apparent discrepancy between experimental and epidemiological results may be related to the use of unreliable indictors of recent cannabis use among crashed drivers in epidemiological surveys.

ROLE OF HIGHER DOSES AND RECENT OR PAST USE OF THC

Most surveys have established cannabis use among crashed drivers by determining the presence of an inactive metabolite of THC in blood or urine. Unfortunately, this metabolite can be detected in body fluids for days after smoking and can only be taken as evidence of past use of cannabis. Recent use of cannabis can only be established by directly measuring THC in the blood. The latter procedure was followed in only a few epidemiological surveys. These surveys showed that THC positives, particularly at higher doses, are two to six times more likely to be responsible for their crash than subjects who had not used drugs or alcohol. Together, this epidemiological data suggests that recent use of cannabis may increase the crash risk, whereas past use of cannabis does not.

THRESHOLD LEVELS FOR THC

Experimental and epidemiological study indicate that a legal limit for THC in the 7 to 10 ng/mL range (measured in blood serum or plasma, equivalent to 4 to 6 ng/mL measured in whole blood) offers a reasonable separation of unimpaired from impaired drivers who may pose a higher risk of causing accidents.

COMBINED USE OF ALCOHOL AND THC: INCREASED RISKS EVEN AT LOW DOSES

Experimental and epidemiological research yields similar findings for the combined use of THC and alcohol in traffic. Combined use of THC and alcohol produced severe impairment of cognitive, psychomotor, and actual driving performance in experimental studies and sharply increased the risk of the driver's culpability for the accident in epidemiological analyses. The effects of alcohol and THC on experimental and epidemiological outcome measures appeared to be additive, but their sum was large and potentially dangerous, even at low doses.

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Medicinal Drugs

Medicinal Drugs

Critical Review of Present Knowledge and Statements for Discussion

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INTRODUCTION

The overall assessment of the effects of medicinal drug use on driving performance results from the literature on epidemiology, impairment, risk assessment and risk factors, risk perception, risk communication, and assessment of fitness to drive (Walsh et al., 2004; Kelly et al., 2004). In reviewing the literature some common findings are presented allowing us to make up our minds and to conclude how our present knowledge will guide us to actions in order to prevent the use of medicinal drugs to be of concern to traffic safety.

PREVALENCE AND EPIDEMIOLOGY

In general we have limited knowledge on the prevalence of drugs other than alcohol in road traffic due to methodological problems encountered with epidemiological studies of drugs and driving. These problems can be categorized as problems with sample collection and data collection (Simpson and Vingilis, 1992). Epidemiological studies, however, can provide strong evidence for drug-related crash-risk estimates where an increased frequency of drug use among drivers who sustained injuries compared with that by drivers who were not involved in accidents, indicates a positive association and a higher odds ratio (OR).

PREVALENCE OF DRUG DRIVING AMONG THE GENERAL POPULATION

In surveys of drug use in the general population data gathering is generally through the use of questionnaires or interviews. Two of the most common observed problems relate to representativeness and refusals. General population surveys include both drivers and non-drivers and do not allow extrapolation to the driver population.

According to the National Household Surveys in the United States and Australia in 2001, 4% of American and Australian residents reported drug driving in the preceding 12 months, where 10% of American and 13% of Australian residents reported drunk driving during this period (Kelly et al., 2004). In these reports no distinction has been made to indicate the proportion of medicinal drug driving, compared to illicit drug driving.

In most European countries, however, the regular use of psychotropic medication in the general adult population has been estimated to be from 5% to 10%. Since most of the users of psychotropic medication have driving licenses, these users are at risk of being involved in drug-impaired driving.

PREVALENCE OF MEDICINAL DRUG DRIVING AMONG THE GENERAL DRIVER POPULATION

In a survey conducted for the Pompidou Group of the Council of Europe focus has been given to the prevalence of illicit drug use in road traffic in thirteen European countries (de Gier, 1999). Although the use of illicit drugs has been frequently reported in most studies, the prevalence of medicinal drugs has been reported as well. Most study outcomes do not allow comparisons across different European countries due to the different methodological problems. However, one can estimate that the prevalence of illicit drug use in the general driver population will fall (at least in Europe) in the range of 1% to 5%, whereas the prevalence of medicinal drugs affecting driving performance will be higher (5% to 10%). In an overview of studies on drug impaired driving in the United States, it was reported that BZDs were found to be present in 4% of the non-crash-involved drivers (Jones et al., 2003).

PREVALENCE OF MEDICINAL DRUG DRIVING AMONG DUID SUSPECTED DRIVERS

High prevalences of medicinal drug use (primarily benzodiazepines) are reported in the European survey for the Pompidou Group ranging from 14% to 74%. It is unclear what proportion of those drivers did use the BZD illicitly. For other medicinal drugs, prevalence is unknown or very low, primarily because only a limited number of medicinal drugs are included in the screening procedures. Sometimes drug screening procedures include medicinal drugs that are no longer of practical relevance (e.g., the barbiturates).

The high prevalence for BZDs depends in most cases on the perception and awareness of police officers in the different countries who decide on the inclusion of a driver in the sample. For example in Norway the police force seems to be focused very much on drugs other than alcohol, which causes large differences in prevalence of drug use among drivers in comparing the results from various Nordic countries. BZDs appeared in an average of 30% of suspected drivers tested in European studies versus 14% in studies conducted in the United States (Jones et al., 2003).

The combination of drugs and alcohol is expected in samples selected for suspicion of driving under the influence of alcohol–drugs. In most studies the data for separating prevalence of combinations of alcohol with illicit and medicinal drugs are lacking. The prevalence in drug positive cases is 25% in Norway, whereas the prevalence in all drivers in two Swiss studies ranged from 18% to 28%.

The prevalence of multiple drug use is reported in a few studies for the total of medicinal and illicit drugs, with a high prevalence (62%) observed by Swiss researchers.

PREVALENCE OF MEDICINAL DRUG USE IN ACCIDENT-INVOLVED DRIVERS

The prevalence of medicinal drug use in accident-involved drivers presented in the different studies reviewed in the Pompidou Group survey ranged from 6% to 21%. Two large-scale studies from Belgium and Italy both show prevalence of BZD use of 8.5%, whereas in some scale studies prevalence ranged from 2% to 14%.

The prevalence of the combination of drugs and alcohol use has been reported for medicinal and illicit drugs together in most studies. In the Belgian study the prevalence in drug positive drivers was 27%; in a Norwegian study and a Spanish study the prevalence was 46% and 65%, respectively. In some other studies the prevalence is reported including the whole sample of drivers. The figures presented are lower ranging from 3% to 20%.

The prevalence of multiple drug use is mostly reported for all drugs other than alcohol together and ranged from 20% in the Belgian study to 36% in a Norwegian study. When considering the complete driver samples in some other studies, the prevalence is lower, from 5% to 17.5%.

IMPAIRMENT OF DRIVING PERFORMANCE

In the literature many examples are presented to clarify the relationship between medicinal drug use and driving impairment, including laboratory, simulator, closed-circuit, on-the-road, and field studies. Laboratory studies have generally found decreased performance due to BZDs, BZD-like drugs, first generation antihistamines, tricyclic antidepressants, narcotic analgesics, and antipsychotics (O'Hanlon and de Gier, 1986; Ramaekers, 2003; Vermeeren, 2004). Several laboratory tests related to driving have been developed that are sensitive to sedation. However, their predictive validity is sometimes questionable. Therefore measuring a safety-related performance parameter in an actual driving test conducted in normal traffic would the ultimate approach in addition to conventional laboratory testing. In an over-the-road driving test (developed by O'Hanlon at Groningen and Maastricht Universities in the Netherlands) subjects operate (supervised by an instructor with access to redundant controls) an instrumented vehicle over a 100-km primary highway circuit in normal traffic. Speed and lateral position are recorded and standard deviation of the lateral position (SDLP) is the primary outcome variable (the "weaving index"). Since then it has been applied in more than 75 major published studies with psychiatric and neurological patients and impaired elderly and healthy volunteers. In a double-blind, placebo and active controlled, cross-over design this test proved to be sensitive in detecting (power >90%, $p \leq .01$) impairment caused by BAC .05%.

A series of driving studies with hypnotics is presented (Figure 1) to evaluate the residual sedation after sleep at times 5 to 17 h post-dosing. The difference in SDLP relative to placebo is presented with indication for the calibrated BAC levels that were measured in a separate driving study with increasing BAC concentrations. By using these as comparison with the impairment caused by medicinal drugs, it is possible to show that many prescribed hypnotics have a detrimental effect on driving even in the afternoon of the day following the dosing in the night before. This example shows that prescribing doctors and dispensing pharmacists can offer a relatively safer alternative to patients who drive and need hypnotic medication.

Similar patterns of variation in impairment can also be shown for anxiolytics, antidepressants, and antihistamines. Again it is possible to indicate safer alternatives in these drug classes.

Laboratory studies have generally shown evidence of greater impairment in psychomotor performance when alcohol is combined with other psychotropic drugs. Impairment in driving performance has been shown to increase when alcohol is combined with psychotropic medication, with generally an additive effect on performance.

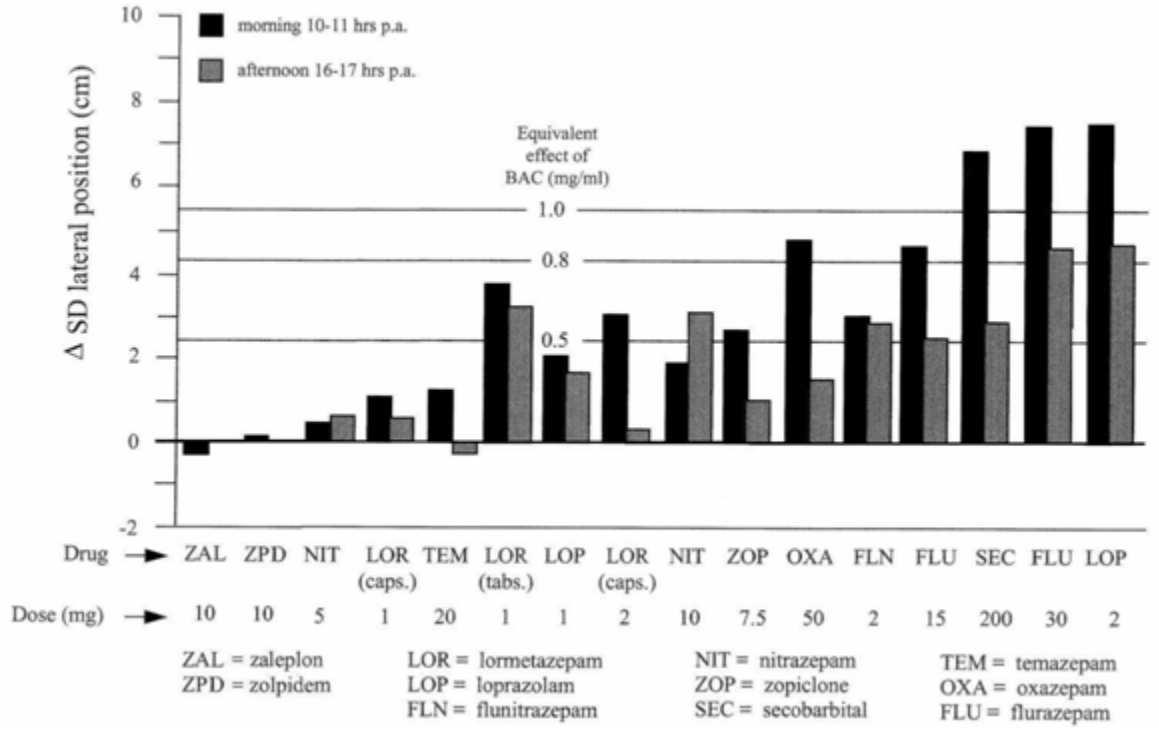

FIGURE 1 Residual effects of hypnotics (courtesy of Dr. E. R. Volkerts).

RISK ASSESSMENT

In pharmacoepidemiological studies for risk assessment the use of drugs among injured drivers is generally ascertained from prescription records (Ray et al., 1992; Leveille et al., 1994; Neutel, 1995, 1998; Hemmelgarn et al., 1997; Barbone et al., 1998). Many of these studies successfully established elevated ORs for BZD users, where risk estimates equal or exceed the risk of accidents associated with a BAC of 0.05%. Misclassification of drug exposure might easily occur due to the absence of non-prescription drugs, such as sedating antihistamines that are sold over the counter, leading to an underestimation of crash risk. Confounding by drug treatment duration and concentration in epidemiological studies can be expected if certain drug groups are considered, e.g., tricyclic antidepressants, where complete tolerance to the initial impairing effects after 1 or 2 weeks of repeated dosing can occur (Ramaekers, 2003). A failure to find a positive association between tricyclic antidepressants and traffic accidents merely reflects the occurrence of tolerance in drivers after prolonged treatment. A positive association might have been found in drivers during the first weeks of treatment with these drugs.

Comparing the data from experimental research with some data obtained in pharmaco-epidemiological studies, where data bases on dispensed medication are linked to data bases on accident involvement, it becomes clear that different relative risks pattern are present for some BZDs and related compounds (Table 1). This confirms some of the results obtained in experimental research allowing us to conclude that these differences in risk can guide prescribing doctors to use the least impairing medication for their patients (ICADTS, 2001).

TABLE 1 Relative Risks of Injurious Road Accidents Associated with the Use of Hypnotics and Anxiolytic Drugs

Drug	Relative Risk	Comparable to BAC (%)	Reference
Diazepam	3.1	.08	Neutel, 1998
Flurazepam	5.1	.10	Neutel, 1998
Lorazepam	2.4	.07	Neutel, 1998
Oxazepam	1.0	< .05	Neutel, 1998
Triazolam	3.2	.08	Neutel, 1998
Zopiclone	4.0	.09	Barbone et al., 1998

In a more recent publication the incidence of drugs in 3,398 fatally injured drivers was determined in three Australian states—Victoria, New South Wales, and Western Australia—for the period of 1990–1999 (Drummer et al., 2003). Responsibility studies were carried out to determine the effect of drug use on the proportion culpability among drivers. Drugs other than alcohol were present in 26.7% of the cases and comprised cannabis (13.5%), opioid (4.9%), stimulants (4.1%), BZDs (4.1%), and other psychotropic drugs (2.7%). Almost 10% of the cases involved both alcohol and drugs. There was no significant increase in culpability when BZDs were the only drugs taken by the drivers.

The prevalence of alcohol, cannabinoids, BZDs, and stimulants among 2,500 injured drivers and their role in driver culpability was studied by Longo et al. (2000) in Adelaide, Australia. For those drivers with BZDs at therapeutic concentrations and above, there was a significant increase in culpability. Barbone et al. (1998), in his pharmacoepidemiological study linking accident data to pharmacy medication records of injured drivers, also reported a dose–response relationship for BZDs. ORs for traffic accidents increased by dose from 1.27 to 1.68 for the low and intermediate dose classes, respectively, to 2.67 for high doses.

A recent Dutch case control study to assess the risk for personal injury in road accidents associated with the use of psychoactive substances revealed an elevated risk (OR = 5.05) for the use of BZD (Movig et al., 2004).

Risk Factors and Risk Perception

There is a well-established association between younger drivers and increased drug driving risk, due to factors such as limited driving experience and more profound risk-taking behavior. However, this is not the case for BZDs, as driving under the influence of drugs (DUID) of these drugs has been found to be more common in middle-aged to older drivers, presumably due to the high rates of BZD prescriptions among these age groups (Christophersen et al., 1990; Longo et al., 2000). A study on the effect of age on risk of accidents after BZD use showed both a lower rate for injurious traffic accidents for older persons (OR = 2.8) than younger persons (OR = 3.2), and a smaller increase in risk after benzodiazepine use (Neutel, 1998).

Females are more likely to test positive for BZDs (Skurtveit et al., 1995). However, females show a lower accident risk than men (OR = 1.42 versus OR = 2.78) while taking psychotropic medication (Herings, 1994).

Although there is an association between alcohol use problems and drunk driving, there is a lack of research to show whether such an association exists between medicinal drug use problems and drug driving.

The majority of studies on risk perception related to impaired driving have been conducted on drunk driving. However, there has been no research on the association between medicinal drug driving and risk perception.

Risk Communication

Information concerning the increased potential for crash risk as a consequence of using hazardous therapeutic drugs must be meaningfully communicated to patients. The simplest way to achieve this would be by means of clear warning labels on the package (de Gier, 2003). Most European Union (EU) member states, however, do not require exterior warnings on packaging, and patients are informed about impairing effects only by the package insert. Since 1992, European legislation has required warnings regarding the ability to drive or use machines, written in lay language, to be part of the content of the patient drug information leaflet (Council Directive 92/27/EEC).

A new warning system based on consensus among scientists and introduced in 1991 (Wolschrijn et al., 1991) was meant to replace the dichotomous systems of therapeutic class warnings. The major improvement of the system was its scheme for categorizing drugs according to their potential for impairing driving skills (Table 2). Recently France was the third country in Europe officially introducing a categorization system for drugs having a potentially dangerous effect on driving. Belgium was the first country that officially introduced the categorization system in April 1999, at the time that the traffic law was changed into a zero tolerance law for illicit drugs (Charlier et al., 1999). Medicinal drugs were not included in this, but the Belgian Minister of Transport considered these to be dealt with by preventive measures, such as prescribing and dispensing guidelines and a clear patient information leaflet. In 2001, Spain became the second country in Europe to officially introduce a categorization system for drugs having a potentially dangerous effect on driving (Del Rio Garcia, 2001).

In order to make the users of the categorization system aware of the meaning of each category a comparison to the impairing effects of alcohol, which are well known, is suggested. Data collected in experimental research, in which over-the-road driving tests have been applied with most frequently used medicinal drugs and alcohol (as “calibration”), have allowed

TABLE 2 Categorization System with Reference to Impairment Caused by Alcohol in Different BACs

Category	Impairment Description for Medicinal Drugs	Comparison with BAC
I	Presumed to be safe or unlikely to produce an effect	Equivalent to BAC <0.5 g/l (<0.05%)
II	Likely to produce minor or moderate adverse effects	Equivalent to BAC 0.5–0.8 g/l (0.05–0.08%)
III	Likely to produce severe or presumed to be potentially dangerous	Equivalent to BAC >0.8 g/l (>0.08%)

researchers to interpret weaving effects by any drug as equivalent to that produced by a particular blood alcohol concentration (see Table 2).

The most important advantage of the three-tier system over older dichotomous (drug class-based) systems or systems based on quotations of long lists of side effects is the focus on the least impairing medications in each therapeutic class.

Professional organizations such as the International Council on Alcohol, Drug and Traffic Safety and the World Pharmacy Organization have applied the same system in their efforts to support physicians and pharmacists in selecting the relatively safer drugs for patients who drive. Although pharmacists can contribute to the use of safer drugs by monitoring patient outcomes with respect to behavioural impairment, no research has been carried out to evaluate the improvements of warnings and information leaflets in countries where the drug categorization has been introduced.

Assessment of Fitness to Drive

A Norwegian study reported a drug concentration-related effect of BZDs on performance-based examinations of DUID suspected drivers by forensic physicians (Bramness et al., 2002). Based on the same data set the researchers provided evidence that many tests in the standardized field sobriety test significantly related to blood BZD concentrations (Bramness et al., 2003). So far this type of research has only been conducted for drivers apprehended for DUID in revealing BZD impairment, not for any other class of psychotropic medication.

CONCLUSIONS

In conclusion, the current knowledge on the impact of medicinal drugs on traffic safety is best documented for the BZDs. A few studies show a concentration–impairment relationship for drivers who are stopped for DUID, and a dose–response relationship for an increased risk of involvement in traffic accidents. Many studies successfully established elevated ORs for BZD users, where risk estimates equal or exceed the risk of accidents associated with a BAC of 0.05%.

Prevalence of BZD use in various populations are estimated to be 5% for the general driver population, between 15% to 30% among DUID suspected drivers (very much dependent upon focus by police forces), whereas in accident involved drivers prevalence were shown to be between 8% to 15%. Since comparisons across countries are not possible due to methodological problems categorized as problems with sample collection and data collection, caution should be given to extrapolations and presentations of the kind as given above.

In general the multiple drug use among the various populations has been reported for all drugs other than alcohol together between 20% to 35%, with some exceptional high prevalence in a very few studies. A lack of information on the nature of BZD intake (on prescription or illicit drug use) in studies on prevalence in driver populations does not allow us to conclude on the impact of BZDs taken as prescribed medication. However, the pharmacoepidemiological surveys are specifically based on dispensing data of prescription drugs and show that exposure to these medications increase the risk of being involved in a traffic accident by at least a factor of 2.

A few studies show that there is a tendency to lower rates for injurious accidents for the older age groups (where about 70% of BZD users are to be expected) compared to younger age groups and a smaller increase in risk after BZD use.

Prevalence of the combination of medicinal drugs and alcohol is hard to predict since most surveys do not show separate figures for illicit and medicinal drugs.

Impairment of driving performance has been extensively documented in a large series of studies using the same standardized driving test in actual traffic conditions for the most frequently used psychotropic medicinal drug groups, such as hypnotics, anxiolytics, antidepressants, and antihistamines. For these drug classes safer alternatives within each class have been identified, based on the application of the same standardized methodology. In addition to the conventional laboratory tests this body of information should have an important impact on decisions of physicians and pharmacists while selecting the least impairing medication for their patients.

In risk communication there is some progress by introducing categorization systems for medicinal drugs having a potentially dangerous effect on driving. However, there are no evaluations on the effects of improved warning systems public information campaigns related to the categorization system. Some encouraging initiatives have been described where international organizations of health providers refer to the categorization systems in motivating their members to use the new knowledge in their medical and pharmaceutical practices.

In assessing fitness to drive some important research findings have been published by Norwegian scientists, although these findings only relate to the impairment caused by BZDs. Based on a extensive data set the researchers provided evidence that many tests in the standardized field sobriety test significantly relate to blood BZD concentrations in DUID suspected drivers where a BZD was the only drug present in the driver's blood sample. This indicates the need for more discussion on legal limits for BZDs in relation to driving.

Gaps in our knowledge primary exist based on the limited information we can derive from studies in which only a limited set of drugs are included for screening of DUID and (fatally) injured drivers. Standardized methodologies are needed and sample selection should be based on clear inclusion criteria, where preferably all fatally injured drivers should be tested for a larger variety of psychotropic medication than BZDs and some illicit drugs. Only pharmacoepidemiological studies based on large data sets of some millions of patients allow us to consider individual substances within various classes of medicinal drugs and provide opportunities to specifically determine risk at the initial phase of drug treatment and after some time of medication, as well as risk after using combinations of psychoactive medicinal drugs. Studies of that kind have not yet been conducted, except a smaller scale study on a few BZDs, but are badly needed.

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Commentary on Medicinal Drugs and Driving

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Han de Gier gave an excellent overview of the role of medicinal drugs in driving safety. It seems difficult to base regulations for medicinal drugs on epidemiological data due to the important number of substances involved. Only BZDs have shown a sufficient effect on driving ability to induce statistical evidences.

The role of BZDs in general and of anxiolytics in particular remains highly controversial. Undeniable over consumption and abuse as well as non-negligible risk have resulted in recommendations concerning good practice in the use of BZDs at both the national and European level. These recommendations advise such approaches as restricting prescription of BZDs to short-term regimens and proposing first-line treatment for active patients comprising therapeutic alternatives devoid of sedative or disinhibitory effects. Thus prolonged prescription of BZD anxiolytics in clinical practice should be accompanied by more careful assessment and these drugs should be substituted wherever possible with anxiolytics that have less marked effects on cognitive function.

The recommendations concerning all the medicinal drugs should be based on a categorization of medicines regarding to their effects on driving ability and behavior.

Such categorization might be combining a pharmacological classification, like the one introduced by Wolschrijn and Col, but also a clear information for health professionals and patients, like the three-level warning system introduced in France by the Road Safety Association, and then by the French medical agency.

The pharmacological classification can be based only on the effects of substances, but regulations also must be based on doses, way of use, and therapeutical indications. For example, some anti epileptic drugs are not sedative by themselves, but their use concerning patients whose ability to drive under treatment must be evaluated, and patients treated with those medicine should be clearly informed about association with alcohol or other drugs.

The classification introduced in France is based on a three-level warning, with a triangle including a car, printed on the box.

- The yellow level, for minor drugs, means "read carefully the package insert before driving."
- The orange level means "don't drive without the advice of a health professional" (pharmacist or medical doctor).
- The red level means "don't drive without the authorization of you doctor" or during a certain duration (hypnotics).

Such a system allows to take into account not only the simple pharmacological effect of the substance, but also all other facts concerning the medicinal drug, like what is it used for, for which pathology etc.

In the future, such categorisations will be the base of prevention campaigns, of training programs for health professionals, and of regulations for driving licences.

Commentary on Medicinal Drugs

Critical Review of Present Knowledge and Statements for Discussion

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Almost 40 years ago in a discussion concerning the problems of drinking and driving in this country it was noted that "The extent to which the public is unaware of this problem is truly startling and the same can be said of many legislatures and professionals in fields of research closely related to traffic safety" (*1*). Since that time, one can safely say that throughout the motoring mechanized world the lay public, regulatory bodies, and injury prevention professionals fully recognize the association of alcohol misuse with crash causation.

While de Gier's review indicates that a considerable body of literature has been published addressing drugs and driving, a similar compelling body of evidence is not currently available that allows for an "awareness" of a "truly startling" problem relative to medicinal drugs and driving. De Gier correctly notes that while "there is an association between alcohol use problems and drink driving, there is a lack of research to show whether such an association exists between medicinal drug use problems and drug driving." Further, he notes the majority of risk perception and impaired driving have focused on alcohol. I think he is correct in stating "there has been no research on the association between medicinal drug driving and risk perception." Finally, in the case of drivers who are impaired by a medicinal (licit) drug, it is usually not known whether the dose taken is affecting safe driving, whether the drug is being abused, i.e., the driver knowingly is taking too much of the drug for effect, or the drug has been obtained illegally.

A number of comments about this paper are the result of being former full-time faculty (and now adjunct faculty) at the R. Adams Cowley Shock Trauma Center at the School of Medicine of the University of Maryland in Baltimore. The vast majority of individuals injured in vehicular crashes are treated and—in most cases—released from emergency departments (ED). Indeed, it is estimated for each of the over 40,000 individuals annually killed in crashes, 53 require ED care and another nine require hospitalization (*2*). In the United States, the most severely injured crash victims requiring hospitalization are frequently triaged to trauma centers. The American College of Surgeons National Trauma Data Bank (*3*) indicates that 48.5% of the 633,435 adult patients admitted to over 400 trauma centers were the victims of vehicular trauma. Crashes victims utilize the most hospital and intensive care unit days.

In a report of alcohol and other drug testing practices in U.S. trauma centers in 1989 (*4*), it was noted that routine alcohol testing was conducted at 64% and other drug testing at only 40%. A recently completed study (*5*) of over 5,500 injured drivers (cars, light trucks) treated at the Shock Trauma Center indicates that BAC determinations were available for 96% of injured drivers, while only 46% of those patients were tested for other drugs. Not only are a much smaller percentage of injured drivers treated in trauma centers tested for drugs other than alcohol, inconsistent methods of reporting data do not allow for comparison of results in reports (*6,7*). Commenting on a number of such reports, Blondell et al. (*7*) highlights a problem in trauma centers studies noted by de Gier in general about drugs and driving studies. They note

that analyses are often "based on a general category of 'drug abuse' rather than specific drug used," and it is not possible to determine licit from illicit drug use.

In addition to the problems cited above, others need to be addressed in studying medicinal drug use in injured drivers treated in the acute care settings. While this reviewer is not aware of any survey of drug screens used in acute care settings, de Gier's observation that the use of "drug screening procedures include medicinal drugs that are no longer of practical relevance (e.g., the barbiturates)," is probably true in many EDs and trauma centers. One can only speculate as to whether screening practices in acute care settings have been updated to include currently prescribed drugs (e.g., newer anti-seizure drugs). Finally, while there are no survey data about ED alcohol and other drug testing practices, based on clinical practice in that setting, testing is probably done much less frequently than in trauma centers.

In his discussion of the high prevalence of BZDs documented in a European survey de Gier notes that "The high prevalence for BZDs depend in most cases on the perception and awareness of police officers in the different countries who decide on the inclusion of a driver in the sample." He notes that "For example, in Norway the police force seems to be focused very much on drugs other than alcohol, which causes large differences in prevalence of drug use among drivers in comparing the results from various Nordic countries." This observation makes much sense. In general, one is more likely to find what one is looking for. However, one may not find what one is looking for. A number of reports indicate that not only are police assessments of impaired driving often unreliable in acutely injured patients, such assessments even by clinicians in in-patient settings are not reliable. This is well illustrated in a report by Gentilello and et al. (*8*) in which they found almost 25% of acutely intoxicated injured patients were not identified by physicians.

Relative to benzodiazepines, de Gier notes that "the pharmacoepidemiological surveys are specifically based on dispensing data of prescription drugs and show that exposure to these medications increase the risk of being involved in a traffic accident by at least a factor 2." A closer examination at one of the studies cited reveals a number of pitfalls in attributing crash risk using that methodology, i.e., a pharmacoepidemiologic survey. Hemmelgarn et al.'s (*9*) Canadian study documented an increased risk of crash involvement among elderly (67 to 84 years of age) drivers using long-half-life BZDs within the first week of use and up to 1 year. Based on prescribing information, that study indicated that 6.9% of the population had used long-half life BZDs and 14.4% had used short-half-life BZDs. These data prompted an analysis of available toxicology test results for injured patients admitted to the Shock Trauma Center encompassing a period of 6 years before and after the index year in the Canadian study. Of the 28,133 patients in the cohort, 63% were crash victims. Overall, 1.1% tested positive for BZDs. Positive test results relative to age were as follows: 14 to 29 years, 0.68%; 30 to 50 years, 1.7%; 51 to 69 years, 1.0%; and 70 years of age or greater, 1.2% (*10*)

Possible reasons for the disparate proportions of BZD using elderly patients in the general population Canadian study and the trauma center population are provided Green and Wintfeld (*11*). Commenting on Hemmelgarn et al.'s study they note that "Determining if a driver took a benzodiazepine on the crash date by examining his or her pharmacy's records requires an assumption that the patient complied with his or her prescription; yet surveys indicate that patients skip doses, borrow and lend medication, and keep drugs at home for use as needed." Another observation raises another important consideration in considering the use of medicinal drugs and driving. They note that in such studies it is necessary to control for the confounding

factor of "health status" relative to the presence of such conditions as depression, cardiovascular disorders, and diabetes.

While the emphasis of de Gier's paper and most reports on medicinal drugs and driving focus on the psychoactive effects of drugs, one must consider underlying diseases and the drugs used to treat those conditions as important factors in crash risk. Medications prescribed may be a clue to increased crash risk. For example, an older driver taking a medication for memory problems may be suffering from early dementia which places that person at higher risk of being involved in a crash.

Diabetes and insulin presents an interesting risk–benefit dilemma for drivers. The randomized Diabetes Control and Complications Trial (DCCT) (*12*) found that insulin-dependent diabetics who maintain their blood glucoses at lower levels by intensive monitoring compared with others insulin-dependent diabetics benefit by having less end organ morbidity. A consequence of "tight" glucose control is the development of hypoglycemic unawareness. This phenomenon can result in either loss of consciousness or an altered sensorium that requires the assistance of another person. Epilepsy and anti-epileptic drugs present a similar dilemma. Obviously, any type of seizure that causes loss of consciousness or altered sensorium or motor problems poses a high risk of crashing. On the other hand, side effects from medications used to prevent seizures can cause alterations in sensorium that raise crash risks.

Sheth et al. (*13*) compared disease-specific risk of fatal crashes associated with seizures and other medical conditions. The incidence rate of fatal crashes for persons with epilepsy was 2.3 times that of individuals with cardiovascular and hypertensive disease and 4.6 times that of individuals with diabetes. The study did not provide data as to the role of medications in crash causation. (This reviewer is not aware that such data are available.) Sheth et al. also documented that the rates of fatal crashes among individuals with diagnosed alcohol abuse and alcoholism are 39 times, 19 times, and 8 times higher for diabetes, seizures, and cardiovascular/hypertensive conditions, respectively. Again, in the case of alcohol use problems it is not know what percentage of the crashes are the direct result of acute impairment due to driving or mental and physical impairments associated with chronic alcohol abuse.

The reader is referred to the *Physician's Guide to Assessing and Counseling Older Drivers* (*14*) This American Medical Association publication produced in cooperation with the NHTSA provides an excellent overview of assessing crash risk relative to medical conditions and medications that is pertinent to drivers of all ages. Along with the innovative categorization system for medication impairment discussed by de Gier, the guide is another useful resource to assist clinicians in selecting medications that make driving safer.

This reviewer is in full agreement with de Gier relative to the gaps in our present knowledge about medicinal drug impairment and driving. More information is needed to define the problems to promote public awareness and to guide policy decisions aimed at promoting safe driving conditions for users of medications and others who use roadways.

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Legal Framework for Dealing with Drugs in Traffic

Legal Framework for Dealing with Drugs in Traffic

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CURRENT STATE OF OUR KNOWLEDGE

Globally, drugged driver legislation is very complex. Judge Roderick Kennedy (State of New Mexico, Court of Appeals) has written about the complexities of interpreting U.S. driving under the influence of drugs (DUID) law from a legal perspective:

> Alcohol is a substance which affects the brain in a broad, non-specific fashion. That is, alcohol acts on the entire brain when it is present, in a pretty much uniform, predictable fashion. Drugs often (if not usually) don't act as broadly. Drugs act on specific areas, functions or receptors in the brain, and often with different results in different persons. Poly-drug abuse only increases the possibilities. In a "normal" drug case like possession or sale the problem pertaining to a drug is what it is. In DUI/DRUG cases, the issue is what the drug does. Both cases can deal with amount of a drug, but in the first instance, the problem is purely quantitative (how many units?), where the latter blends quantitative considerations with qualitative—is the amount of drug enough to impair this person at the time the person is driving? Lawyers familiar with the vagaries of alcohol effects can expect the effects and symptomatology of alcohol to look very stable compared to what happens when drugs, humans and vehicles hit the road. Quantifying driving behavior, quantifying drug doses which are sufficient to cause a decreased ability to drive a car, and then relating them all is challenging, to say the least. Add to this the differing statutory schemes nationwide (worldwide) concerning driving while under the influence of drugs, and the universal facts become merely that drivers ingest drugs that impair driving abilities, and drug-impaired drivers cause accidents. How these things are handled is not universal.

PER SE AND IMPAIRMENT LAWS AND THE PROS AND CONS OF DIFFERENT LEGAL APPROACHES

Each developed country has its specific legislation on DUID. This text will give a broad overview of the different types of legislation that exist, and illustrate them with examples. Generally, one can distinguish two types of legislation on DUID: impairment and per se or analytical (sometimes also called zero-tolerance laws).

Most countries [e.g., all the countries of the European Union (EU)] have a legislation based on the demonstration of impairment—in short, impairment laws. Impaired driving must be

demonstrated by the prosecution, and the analysis of drugs in body fluids (blood or urine) only provides corroborating evidence as to the cause of the impairment.

Analytical or per se-laws forbid driving if a drug is present in the body of a driver. No proof of impairment is required anymore. The demonstration of a drug in a body fluid (mostly blood, but sometimes also urine) is sufficient to bring a conviction.

Australia

The Parliament of Victoria, Australia, has recently amended the Road Safety Act of 1986 to focus enforcement efforts on drugged driving. The Road Safety (Drug Driving) Act 2003 allows police and other authorized officers to demand oral fluid samples from drivers at the roadside for the purpose of drug testing. The act specifically authorizes testing for cannabis and methamphetamine and prohibits a driver from testing positive within 3 h of driving. This legislation extends the existing enforcement system relating to drunk driving to the new drug driving offenses, such as requirements to cooperate in tests, power for police to prevent drivers who test positive for the target drugs from continuing their journey, and proof of offenses through use of certificate evidence. This law has taken effect in December 2004. This law is a "Sunset Law" which only authorized a 12-month trial period. In order to be made permanent it must be demonstrated as effective during the trial.

Europe

An overview of the DUID legislation in Europe is presented in Table 1, based on an overview of the legislation on drugs and driving in the 15 EU countries and Norway written by the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA) in 2003.

To illustrate the different types of legislation, several examples are given:

- Norway: No one must drive or attempt to drive a motor vehicle when he is under the influence of alcohol or of other intoxicating or narcotic agent. If the breathalyzer test is negative, the police may take him to be examined by a medical practitioner who can take blood (and urine) tests or otherwise seek to ascertain the degree of influence.
- In Denmark, a power-driven vehicle is not allowed to be driven or attempted to be driven by any person who is, because of illness, debility, strain, too little sleep, influence of drugs, or for similar reasons, in such a condition that such person is incapable of driving such vehicle properly. In this case, the police may hold a person in order to have laboratory specimens of such person's blood and urine taken.
- United Kingdom: Section 3A/4 Road Traffic Act 1988 states that "a person who, when driving, attempting to drive, or in charge of, a mechanically propelled vehicle on a road or other public place is unfit to drive through drink or drugs is guilty of an offence".

TABLE 1 Overview of the DUID Legislation in Europe

Country	Type	Administrative /Criminal	Fine (€)	Prison (days)	License Withdrawal (months)
Austria	Impairment	Administrative	581–3633		1
Belgium	Per se Impairment	Criminal Criminal	1,100–1,1000		Possible
Denmark	Impairment	Criminal	Fine	365	
Finland	Per se Impairment	Criminal Criminal	Fine 60 day fines	182 700	 Max 60
France	Per se	Criminal	4,500	730	36
Germany	Per se Impairment	Administrative Criminal	250 ~1 month of salary	 365–1,825	1 ~10
Greece	?	Criminal	147	60	3–6
Ireland	Impairment	Criminal	1,270	180	24
Italy	Impairment	Criminal	260–1,030	30	0.5–3
Luxembourg	Impairment	Criminal	250–5,000	8–1,095	possible
Netherlands	Impairment	Criminal	Acc: 11,250 Fatal: 45,000	1,095 3,285	60
Norway	Impairment	Criminal		365	12
Portugal	Impairment	Criminal	360–1800	365	2–24
Spain	Per se Impairment	Administrative Criminal	302–602	 8–12 WE arrests	3 12–48
Sweden	Per se	Criminal	Day–fines	730	1–36
Switzerland	Per se	Criminal	26,000	3–1,095	3
UK	Impairment	Criminal	7,000	180	12–

Proving impairment requires the assessment of a medical doctor or a specially trained police officer (drug recognition expert or DRE). Despite standardization efforts, this remains somewhat subjective, and many countries experience difficulty in obtaining convictions.

ANALYTICAL OR PER SE LEGISLATION

For this reason, and in analogy to alcohol, some countries have added new per se legislation.

In Europe, Germany was the first country to introduce such a law—the §24a of the Road Traffic Act was amended in March 1998. Under this amendment, any person driving a vehicle in road traffic under the influence of cannabis, heroin, morphine, cocaine, amphetamine, or designer amphetamines commits an offense. A person is deemed to be under the influence of a drug if the drug is detected in his blood. This does not apply if the substance originates from having taken prescribed medication as intended for a specific illness. In Germany these analytical cut-off limits have not been included as such in the law, but they are used by the forensic laboratories for implementation. In addition, Germany still has its impairment law

(§316): if impairment is proven, it is a criminal offense. This law covers all psychoactive drugs. The sanctions can go to 1 year in prison, a fine of up to 360 daily rates, and a license revocation from 6 months to 2 years.

In Belgium a similar law was voted in March 1999. A driver can be stopped by the police and asked to perform a standardized test battery to establish the presence of external signs of influence by drugs. If this is positive, a urine sample is taken and an on-site immunoassay is performed. If this is positive, a medical doctor is called to examine the subject and take blood. The blood is than sent to a laboratory for GC/MS analysis with deuterated internal standards. If drugs are present in the blood (the analytical cut-offs are mentioned in Table 2), the driver can be condemned to fines similar to those for driving with a blood alcohol greater than 0.8 g/L. In case of a positive analysis, the driver must also pay for the costs of the analysis.

Sweden also introduced a per se law in 1999. It introduced zero tolerance for narcotics (including BZDs), except if the drugs are taken according to a medical prescription, the dose is not too high, and no impairment is present. Practically the detection of DUID is performed by an eye examination. If there is reasonable suspicion a further examination is carried out. If drugs are found in the blood, the driver is also sanctioned for drug use. After the introduction of this law in 1999, the number of prosecutions was multiplied by five (see Figure 1, page 92).

France introduced per se legislation in February and June 2003. A driver is sanctioned if blood analysis shows prior exposure to illicit drugs. The law covers all illicit substances; there are no cut-offs. The penalties are severe:

Fatal accident:	€100,000 fine and 7 years in prison
Severe injury:	€75,000 fine and 5 years in prison
Light injury:	€45,000 fine and 3 years in prison
No accident:	€4,500 fine and 2 years in prison

Finland also introduced per se or zero tolerance legislation in 2003. The drugs covered are those listed in the United Nations conventions on narcotics. The law is not applicable if the drugs are used according to a physician's prescription. Finland also still has the impairment law. In this case impairment most be proven based on the documentation of police officer, a clinical sobriety test by a physician and the lab report with the drug findings and a pharmacological evaluation. A few examples illustrate how the different pieces of legislation are used:

- If BZDs are positive in blood, with a medical prescription, but the driver is impaired, he will be sanctioned according to the impairment law
- If BZDs are positive in blood, without a medical prescription, the driver will be sanctioned according to zero tolerance law
- If THC is present in blood, the zero tolerance law will apply
- If no THC is found in blood, but THCCOOH is present in the urine, there will be no sanction for DUID, but a sanction for drug consumption.

In Switzerland, since September 2004 a driver is considered unfit to drive each time it is proven that his blood contains THC, free morphine, cocaine, amphetamine, methamphetamine, MDEA, or MDMA. If one of these drugs is used on medical prescription, expert advice is sought. The cut-offs agreed upon by the toxicology group of the Swiss Society of Legal Medicine are mentioned in Table 2. They are based on the results of proficiency testing, taking

TABLE 2 Analytical Cut-Off Limits in Blood, Serum, or Plasma for Some Drugs as Agreed Upon or Proposed in Different Countries (All Concentrations in ng/mL, except Sweden: ng/g)*

	Germany		Belgium	France	Sweden	Switzerland
	1998	**2002(3)**				
Amphetamine	50	25	50	LOQ	30	15*
MDMA	50	25	50	LOQ	20	15
MDEA	50	25	50	LOQ	20	15
MDA				LOQ	20	
MBDB			50	LOQ	20	
Cocaine			50	LOQ	20	15
Benzoylecgonine	150	75	50	LOQ	20	—
Morphine (free)	20	10	20	LOQ	5	15
THC	2[a]	1[a]	2	LOQ	0.3	1.5

LOQ: limit of quantitation. The new cut-offs have not yet been approved by the states in Germany.
* For Switzerland: also 15 ng/mL for methamphetamine. A measurement error of 30% is added to these cut-offs, so they are 22 and 2.2 ng/mL respectively.
[a] In Germany, by decision of the Bundesverfassungsgericht of December 21, 2004, the cut-off for cannabis has been set at 1 ng/mL.

into account a measurement uncertainty of 30%. In special cases, (e.g., consumption of several drugs, or of other drugs than those mentioned in the law, or long time interval between the fact and blood sampling, or if there are symptoms of withdrawal) an expert advice based on the "three pillars" (police observations, medical examination, and toxicology results) will be sought. The legislation also foresees the possibility of using on-site tests for urine, saliva, or sweat.

With per se laws**,** the question arises whether, similarly to alcohol, legal limits can be determined. In 1985, a consensus panel concluded that per se levels could not be determined, because the blood concentration–impairment relation is more complex with illicit drugs than it is with ethanol. 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. For this reason, the cut-offs used are analytical cut-offs, i.e., any detectable concentration of a drug is enough, and these laws are also called zero-tolerance laws.

Based on the six examples of analytical legislation, one can see that there are differences between the per se laws.

- The sample can be blood, serum, or plasma.
- The scope can be a limited list of illicit drugs or all narcotics.
- In some countries, some medicinal drugs are included under certain conditions, while in others they are not included.
- The cut-offs can either be included in the law, determined by a consensus of experts, or be based on the analytical capabilities of the laboratories (see Table 2).
- The consequences can be administrative or penal.

LEGISLATION ON OBTAINING SAMPLES AND TESTING

In the last years, several countries have introduced legislation that allows roadside sampling and testing:

- Spain: the category of the infraction of DUID was changed, so that a blood sample can be taken.
- Austria: since Jan 2003 a blood sample can be taken if there is suspicion of DUID.
- Italy: Highway code June 2003.
- UK: July 10, 2003: Railways and Transport Safety Act.

In the United Kingdom, the UK Railways and Transport Safety Act of 2003 gives a constable the power to administer preliminary tests if the constable reasonably suspects:

- That a person is driving, is attempting to drive, or is in charge of a motor vehicle on a road or other public place, and has alcohol or a drug in his body or is under the influence of a drug;
- That a person has been driving, attempting to drive, or in charge of a motor vehicle on a road or other public place while having alcohol or a drug in his body or while unfit to drive because of a drug, and still has alcohol or a drug in his body or is still under the influence of a drug;
- That the person has committed a traffic offense while the vehicle was in motion;
- That the person was driving, attempting to drive, or in charge of the vehicle at the time of the accident.

Three types of preliminary tests are mentioned: a preliminary breath test, a preliminary impairment test (observation of performance of tasks and other observations of physical state to indicate whether person is unfit to drive) and a preliminary drug test (this involves obtaining a specimen of sweat or saliva and the use of the specimen for the purpose of obtaining an indication whether a person has a drug in his body).

In Europe, random testing is allowed in nine countries—Belgium, Denmark, Germany, Spain, Italy, Luxembourg, Portugal, Finland, and Norway (only for alcohol)—while some suspicion is needed in six countries—France, Ireland, Netherlands, Austria, Sweden, and the UK.

REGULATIONS ON DRIVER'S LICENSE

Annex III of Council Directive 91/439/EEC of 29 July 1991 on driving licenses states that "driving licenses shall not be issued to or renewed for applicants or drivers who are dependent on psychotropic substances or who are not dependent on such substances but regularly abuse them". Recognizing that such substances may be medicines issued on a valid prescription, it also laid down that "driving licenses shall not be issued to, or renewed for, applicants or drivers who regularly use psychotropic substances, in whatever form, which can hamper the ability to drive safely where the quantities absorbed are such as to have an adverse effect on driving. This shall apply to all other medicinal products or combinations of medicinal products which affect the ability to drive."

In some countries like Germany, Italy, France, and Spain, hair analysis for drugs of abuse has become a routine test to demonstrate that a driver who had his driving license suspended is no more dependent.

In the United States, all of the states, except Texas and New York, use the phrase "under the influence" in their DUID statutes. A total of 14 states (Alabama, Arkansas, Illinois, Kansas, Nevada, Maryland, New Mexico, North Dakota, Oklahoma, Pennsylvania, South Dakota, Vermont, Wisconsin, and Wyoming) define the standard that constitutes "under the influence" within the body of the statute as "incapacity" (i.e., the influence of the drug "renders the driver incapable of safely driving"). Incapacity to drive safely is thus linked to the drug ingested and the prosecutor must show a connection between drug ingestion and the incapacity of the driver.

For a variety of reasons, existing laws often hinder the prosecution of drugged drivers. Notwithstanding sufficient evidence, it is often very difficult to prove a nexus between the observed impairment and a drug as required by most statutes. In addition, in most U.S. states, there is no incentive for police to look for drugs if alcohol is present above the legal limit because the law doesn't provide for additional penalties.

Eight states (Arizona, Florida, Hawaii, Indiana, Kentucky, Montana, South Carolina, and Virginia) use an impairment standard to define "under the influence." This impairment definition suggests a requirement of proof that is less stringent than one that renders the driver incapable of safely driving; nevertheless, the prosecutor must still prove that the impairment is directly related to the drug ingested.

In contrast to alcohol, the interpretation of drug concentrations in biological fluids, especially with regard to behavioral effect, requires some knowledge about the dose, the route of administration, the pattern or frequency of drug use, and the dispositional kinetics (distribution, metabolism, and excretion) of the drug. Interpreting the meaning of either drug–metabolite concentration in a single biological specimen with reference to impaired driver performance is therefore an extremely difficult task for a scientist and even more difficult for a prosecutor. The variables involved create a sufficiently great range of possible interpretations to render any specific interpretation questionable, other than to conclude the individual has used a specific drug in the immediate past (days) (Hawks and Chang, 1987). These complicated pharmacokinetic relationships have prevented the establishment of specific levels of drug concentrations, which could be interpreted as evidence of impairment either in blood, urine, or other bodily substance (Consensus Development, 1985). As a result, these factors make it very difficult for prosecutors to prove that a specific drug "caused" the driving impairment which is required under most state laws. Consequently, there is limited enforcement of DUID laws in those states that require prosecutors to prove that drug consumption caused the driving impairment.

Currently, there are 19 states that have variations of per se legislation. Five states (California, Colorado, Idaho, Kansas, and West Virginia) make it illegal for any drug addict or habitual user of drugs to drive a vehicle in their states. Two states (North Carolina and South Dakota) make it illegal for any person under the age of 21 to drive with any amount of a prohibited drug or substance in their bodies. One state (Nevada) has determined that driving with specific cut-off levels of certain prohibited drugs or substances other than alcohol is a per se violation of its DUI statute. Eleven states (Arizona, Georgia, Indiana, Illinois, Iowa, Michigan, Minnesota, Pennsylvania, Rhode Island, Utah, and Wisconsin) have so-called "zero tolerance" per se laws that prohibit operating a motor vehicle with any amount of prohibited drug in the body.

The compelling argument for adoption of the per se statute in most of these states, was that a driver was far less likely to be prosecuted for impaired driving if the driver were under the influence of an illegal substance than if the driver were under the influence of a legal substance (alcohol). The per se strategy creates an important legal distinction between having to prove a nexus between the observed driver impairment and drug use (causal relationship) and simply demonstrating that observed impaired driving behavior was associated with specified concentrations of drug–metabolite in the individuals body while operating the motor vehicle. In essence, the per se drug statute attempts to remedy the inequality of dealing with alcohol and other drugs by making the per se drug limit "any amount" of a controlled substance, and by making this offense equivalent to the per se alcohol offense. NHTSA currently has a project underway to evaluate the effectiveness of the per se strategy.

In a recent consensus development process (Walsh et al., 2002) experts agreed that per se DUID laws are an acceptable extension of DUI laws and represent a reasonable strategy to deal with the increasing problem of drugged driving. However, a critical point made repeatedly by police, prosecutors, and judges was that from a practical point, a per se DUID law is a good concept but not a panacea. Legal requirements and practicality tell us that reasonable suspicion, and ultimately, probable cause is required to obtain toxicological evidence of drugs in the person's body. Generally, judges will require that the state present some evidence of impairment, and have some reasonable suspicion that drugs have been used. If the state cannot meet these prerequisites, the analytical data may not be admissible in court. The consensus was that a per se DUID law could arguably facilitate or at least assist in the prosecution of drugged drivers and could produce real improvements in traffic safety.

WHAT WE KNOW ABOUT THE EFFECTS OF THESE LAWS

Few evaluations of the per se legislations have been carried out, although studies are in progress in Germany and Belgium. Presently, no data are available on the influence of the newer DUID legislations and their enforcement on drugged driving.

However, new data are developing that show that the number of prosecutions has dramatically increased since the introduction of per se laws. In Sweden, in the first 6-month period that the per se law was applicable (the second half of 1999), the number of prosecuted cases increased five-fold. In 1999, 1,700 drivers were arrested, while in 2000, there were 3,800 cases, and by the end of 2003 over 5,000 cases (see Figure 1). In Belgium, there were nearly no cases that were prosecuted before the per se law. In 2000–2001, 896 samples were analyzed by the National Institute for Criminalistics and Criminology in Brussels (Maes, 2003) and in 2003, there were 790 cases. In Germany, the number of cases has tripled since the introduction of the new legislation. In Switzerland, a tripling of the cases was also observed (Peter Iten, personal communication, July 2005).

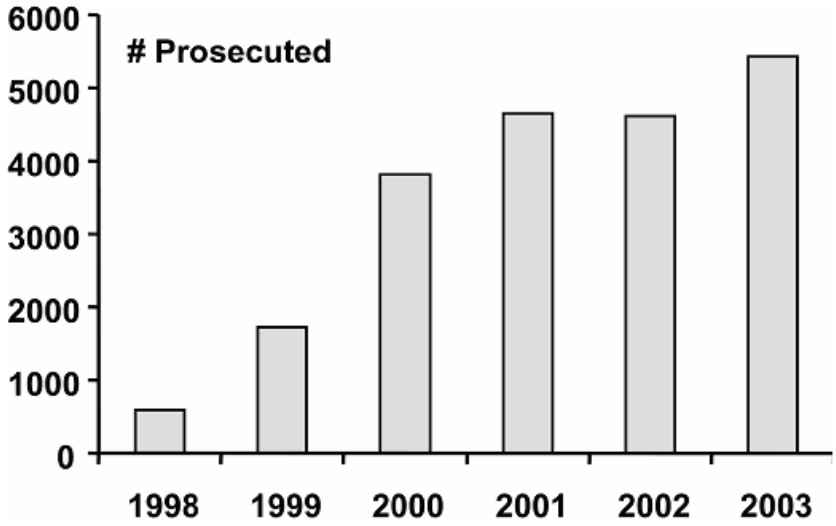

FIGURE 1 Number of suspects prosecuted for drugged driving in Sweden, 1998–2003. (Source: Swedish Police Board)

RECOMMENDATIONS FOR FURTHER RESEARCH

1. Evaluation of per se laws: This is a critical area for international collaboration where standardized protocols with core variables being collected by research teams in different nations could provide global data as to the effectiveness of the per se law strategy.
2. International guidelines: The United States with the European Commission and the Council of Europe should foster scientific meetings bringing together researchers and policy makers to develop a set of international guidelines for dealing with the public health problem of drugged driving.
3. Best practices: The increased identification, conviction, and referral for treatment of drugged drivers presents a series of research opportunities to develop "best practices." Studies to examine the effectiveness of fines, license suspensions, and jail time should be supported. Economic impact studies to determine the most cost-effective strategies should also be supported.
4. Development of a practical screening test for drugs of abuse: A simple, reliable, rapid, inexpensive screening test for drugs is sorely needed to enforce drugged driving laws and to conduct more accurate epidemiological studies.
5. Develop drug tests using alternative matrices (e.g., breath, sweat, or saliva): Most state laws currently require that police test blood or urine to determine drug use. These invasive tests often discourage police from enforcing the law. Less invasive testing is needed to make routine drug testing possible.
6. Support independent evaluations of test devices being marketed for drugs of abuse: Many manufacturers have entered the drug testing market and in most countries manufacturers' claims are not regulated. Research to independently evaluate drug testing devices should be supported to provide police forces with accurate information.
7. Develop more efficient behavioral tests to rapidly identify impairment due to drug use: The British Home Office is evaluating various psychomotor tests to develop a behavioral

test battery to identify drug use. Considering the availability of handheld computer devices we believe that additional research into the development of behavioral assessment batteries could be an important strategy.

POLICY IMPLICATIONS OF CURRENT KNOWLEDGE

Lack of a rapid assessment device to accurately and reliably test for drugs clearly is a limiting factor in the implementation and enforcement of DUID laws.

CONCLUSIONS

From a global perspective there is increasing knowledge regarding the prevalence of drugs other than alcohol in road traffic, and it appears that drugged driving is a significant problem worldwide. "Drugs and Driving" is a hot topic in different parts of the world and in the last five years there have been many new laws and changes in legislation. There is clearly a move towards per se legislation, although some countries at this time have decided to stay with impairment legislation. In addition, several countries have introduced legislative changes to allow testing. Globally, there is a lack of uniformity in the way in which nations approach the drugged driver problem. Efforts to support standardization or harmonization of laws through the development of "model" legislation should be encouraged. Furthermore, there is a clear need for better data, more harmonization of data collection techniques, and a standardization of core data variables to establish a better epidemiological database. Training for police and prosecutors should be made a high priority. The recent trend to adopt per se type statutes which make it illegal to operate a motor vehicle with illicit drugs within the body seems to be a reasonable strategy but data to demonstrate the effectiveness of this approach must continue to be developed. Last, but not least, international collaboration between different countries would be most welcome and is highly recommended.

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Commentary on Legal Framework for Dealing with Drugs in Traffic

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We are just starting the development of a legal framework for dealing with drugged driving. While we know that drugs can impair driving and that people are driving impaired by drugs, we do not know the size of the problem. We do not know if drugged drivers are repeat offenders or if there is only one arrest per 1,000 drugged driving trips. We do not understand what sanctions will deter drugged drivers or prevent recidivism. Yet, there is a push to do something about the problem, and we have our experiences from developing the legal framework for alcohol-impaired driving that we can use as a guide. As one legislator put it, however, "you can convict someone of murder with one sentence in the State Code, but it takes 46 pages to convict someone of DWI." The sooner we can answer the questions, the better chance we have to develop a less convoluted and more effective legal framework.

Personally, I feel that it is important that any legal framework for drugged driving have "anti-crash" as the ultimate goal. That is, the goal for punishment, sanctions, and countermeasures is designed to prevent future drugged driving incidents, crashes, injuries, and fatalities. If drugged driving laws are put in place simply to deter drug use, it adds an entirely new dynamic to highway safety. The politics and pitfalls of the "war on drugs" would distract highway safety advocates. And such a position could be perverted into making opponents to alcohol-impaired driving appear to be simply anti-alcohol, a position that brings back all the controversy of Prohibition.

One of the first issues to be addressed is whether drugged driving laws will establish unacceptable driving levels for each drug (just like 0.08% BAC is the per se illegal level for alcohol), whether drugged driving laws should require a showing of impairment, or whether drugged driving laws will be zero tolerance laws. Unacceptable driving drug use levels could prove problematic given the many different types of drugs and the varied way in which drugs affect each individual. According to the paper, an impairment standard has also proved problematic.

Zero tolerance laws initially could create concern that the drugged driving law is really an anti-drug, not anti-crash, law. Laws already exist that prohibit drug use; making it illegal to operate a motor vehicle simply with drugs in the system and without some evidence of impairment could appear to be a gimmick for penalizing drug use. The evidentiary test (of blood or urine), however, is conducted post-arrest. And before the police officer arrests the driver, the police officer must have probable cause that the driver is operating the vehicle while impaired. Such probable cause is established by observing the driver's behavior and physical condition. Once the police officer arrests the driver, the drug test will simply confirm what the likely source of impairment is. The evidence of impairment required prior to the arrest and subsequent evidentiary test, in my opinion, makes zero tolerance more palatable. As advocates promote new or upgraded drugged driving laws across the states, this point should be made to assuage any concerns on the part of legislators that the law is anti-drug.

To determine if a driver is currently under the influence of drugs, police officers must test or request a test of bodily fluids. With the extensive framework for alcohol-impaired driving already in place, a police officer will likely pursue a breath test for alcohol (at least in states where an evidentiary breath test is permitted) first. Should the test reveal a positive BAC, because there are no additional penalties if the driver was also under the influence of drugs, the police officer may not pursue a second test for drug content. A second problem emerges in some states that allow only one evidentiary test. If the BAC is negative, but the police officer has evidence to support the conclusion that the driver is impaired, he may not be able to seek a second test for drug content, and the driver ultimately goes free. As a result of these two issues, we are not getting vital data on the substances drivers are using; the drugged driving problem (or polysubstance abuse problem) could be greater than we think. Both problems should be addressed while developing the legal framework.

Mandatory assessment and, when appropriate, mandatory treatment, in my opinion, deemed is another necessary element of any drugged driving legal framework. When the United States first responded to the alcohol-impaired driving epidemic, it seems as if the initial reaction was to treat the problem as a crime, with appropriate fines, jail sentences, and license suspensions. Only in the last 5 to 10 years, as the nation has focused more on the hardcore drinking driver, has the real push for mandatory assessment and treatment emerged. While alcohol-impaired driving is a crime that puts many people at risk every day, many offenders suffer from underlying alcohol-use problems. Sanctioning the crime without addressing the underlying problem simply ensures repeat business for law enforcement and prosecutors.

Drivers under the influence of drugs are taking those drugs in one of three circumstances. Either, the driver is taking a legal (prescription or over-the-counter) drug that happens to cause impairment. Alternatively, the driver is illegally taking a legal drug (taking more than prescribed or recommended or procuring a prescription drug without a prescription). Finally, the driver may be taking an illegal drug. Given that two of three cases involve illegally using a substance, I think it is likely that addiction plays a role in the decision to take the drug and then operate a vehicle under the influence of that drug. It is paramount that any legal framework include from the beginning provisions for mandatory assessment and, when necessary, mandatory treatment.

The legal framework for alcohol-impaired driving includes a variety of sanctions and rehabilitative countermeasures, none of which do we know will work for drugged driving. For example, ignition interlocks, an effective tool when on the vehicle, rely on rolling breath tests. Breath tests for drug use, however, are not viable at this point. We also do not know the characteristics of a drugged driver like we know the characteristics of an alcohol-impaired driver, especially hardcore drinking drivers. We know that countermeasures for hard core drinking drivers will deter social drinking drivers. Diversion and community service are not viable countermeasures for alcohol-impaired drivers. License suspensions are effective, but hard core drinking drivers are likely to drive on suspended licenses. As a result, we have continuously revised the legal framework to address these issues. Whether vehicle sanctions, plea bargaining limits, and eliminating diversion are appropriate for drugged drivers remains to be seen; we must be careful not to establish sanctions and countermeasures for drugged driving before we have some basis for concluding that such countermeasures will deter drugged driving.

Commentary on the Legal Framework for Dealing with Drugs in Traffic

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The development of legal, policy, and public awareness and recognition of alcohol as a significant road safety challenge has evolved over a period of time and has lead to significant improvements in road safety. One challenge facing policy makers and legislators will be to manage the expectations that drug impaired driving can be dealt with in a similar fashion. This includes issues related to roadside testing, the relationship between drug use and actual behavioural impairment and available sanctions. It is also important to note that drug impaired driving legislation and policies will happen within the context of the years of impaired driving policy, legal opinion, and public acceptance of the issue and the challenges. How existing laws regarding impaired driving may impact new legislation is one issue, but an equally important issue is how proposed legislation may impact current legislation and programs related to alcohol impaired driving.

Canada is currently considering legislation that will detail the investigative steps necessary to pursue a drug-impaired prosecution. The hearings into the proposed changes to the Criminal Code of Canada highlights some of the legislative and policy challenges faced when attempting to address this issue specifically in law.

A significant challenge identified has been to better document that a significant problem exists in addition to that which is already addressed by alcohol or impaired driving legislation. This is compounded by an interpretation, at least by some people, that the term drugs conjures up the image of illicit drug users, who, may already be targeted by other programs and laws. In addition, those drivers who use both alcohol and drugs may well already be covered under existing impaired driving legislation. When other types of drugs, prescription and over the counter, are included in the equation, the concerns become more complicated for legislators and policy makers. This is further compounded by the issue of multiple drug use on assessing levels of drugs in the system and the subsequent impact on driving behaviour.

The evidence with respect to alcohol and driving is relatively clear. Based on on-road and laboratory research, which has taken place over a significant number of years in many jurisdictions, the link is well established. Based on this evidence and acceptance of this by the public, as well as the demonstrated costs to society, legislators have taken increasingly stringent positions regarding alcohol impairment, both with respect to thresholds and investigative techniques as well as sentencing and related outcomes. One significant concern expressed by many has been that such a link has not been made with respect to many drugs, especially those prescribed by a physician. Without direct evidence showing that a significant problem exists and an ability to define with some precision, the levels at which the problem becomes aggravated, it will be very difficult to sway public acceptance of the issue as serious enough to move forward with specific legislation to combat the situation. It has been observed that legislators are more receptive when presented with solutions rather than complex challenges. In the case of drug-

impaired driving legislation, we are still examining the challenges and the solutions may not yet be apparent enough to prompt direct legislative action.

In Canada, the level of alcohol impairment while driving has been monitored by examining police collision records, roadside surveys to assess general prevalence and a fatality database which contains alcohol use information on fatally injured drivers and pedestrians. The latter data are collected each year from coroner and medical examiner databases across Canada. This information has been very useful in demonstrating the size of the problem and the direction of change over time. Such data systems are not yet fully in place to address the issue of drug impaired driving. While the database has been expanded to included tests for substances other than alcohol since 2000, a number of challenges have been identified. While the testing rate for the presence of alcohol in a fatally injured driver or pedestrian is very high, testing for the presence of drugs is not as high in all jurisdictions. A number of jurisdictions routinely test for some substances, but these tend to be smaller jurisdictions with a small pool of fatalities requiring testing. Larger jurisdictions often only test when drugs are previously identified as a possible contributing factor to the collision. Frequently this decision is a resource or fiscal issue; however, it significantly impacts the ability to track drug-impaired driving in the same fashion as alcohol-impaired driving. Until resources are in place to track both types of impaired driving at a similar precision level for those substances most likely found in the driving population, it will be very difficult to make the same link with driving for drugs as made for alcohol and subsequently more difficult to get the necessary support from the public or legislative bodies to undertake substantive policy initiatives to address the problem.

The definition of the term drug has also been an issue before the committee. On issue is how evidence of the use of illicit drugs might be used beyond prosecution for impaired driving. It is not the intention of the legislation; however, it has been identified as a concern. Another challenge has to do with prescription medications being used as an illicit drug by a person who was not prescribed the drug. In short, the challenge is about how to protect the information collected for the purpose of an impaired driving prosecution from being used for non-intended purposes. It is important that this be done is such a way as to not limit the data from being used for other road safety appropriate uses. For example, in Canada the sanctions related to impaired driving and license suspension are administered by the provinces and territories, which also have additional requirements related to licence reinstatement. The limits placed on the data usage should not hamper these administrative sanctions and requirements for reinstatement from being applied, both in the case of alcohol and drug use.

Concern has been expressed with respect to linking the presence of a drug in a driver's system to possible impacts on their ability to drive. In many ways this represents a crucial piece of the puzzle and is a significant difference between alcohol- and drug-impaired driving prosecutions. In the case of controlled substances, it is possible to take a zero tolerance approach to the drug. Any presence in the system can be taken as an indication of a problem. While this policy may make prosecutions more straightforward, significant concern was expressed that drivers should not be held criminally accountable if their driving ability was not impaired while they were driving. A further challenge concerns a different set of rules related to illicit drugs vs. prescription or over the counter drugs and driving.

It is important that any new legislation not be seen to be targeted at a specific sub-group. Young drivers were identified as a possible target if the focus of the legislation or enforcement is on illicit drug use. If the legislation or policy makes pursuing a prosecution for illicit drugs more straightforward, then more emphasis may be put towards this type of enforcement, which may

differentially affect young drivers. Alternatively, if the focus of the law includes behavioral indices of impairment to be a necessary component of the evidence collection, this bias may be reduced.

In the case of medicinal drugs, legislation concerning drug impaired driving may impact the responsibility of drug makers and those that prescribe them to be aware of, and inform users, of the possible impacts on driving. It is not clear how well prepared these groups are to address this issue, especially in the case of drug interactions. This is a significant concern that should be a focal point for future research in terms of the legal liability as well as the current state of knowledge regarding medications as they impact driving.

Another concern expressed was the impact on an increasing number of drug tests on the police and forensic laboratory resources. The procedure as currently proposed allows for a bodily fluid sample to be demanded by a drug recognition expert (DRE) if they believe a specific substance is present in the driver's system. What bodily fluid is used, how the police officer collects and maintains the chain of evidence and the subsequent impact on the forensic lab resources is significant. A strong case was made that any legislative changes must address these additional resource pressures on the enforcement and analysis components of the system. Failure to do so may result in resources being reallocated from existing tasks, potentially reducing the level of support available for those tasks.

The reliance of roadside testing equipment to generate reasonable and probable grounds to pursue an investigation for alcohol-impaired driving has reduced the number of officers on patrol who are trained and certified in the use of the standardized field sobriety test (SFST). The new procedures call for the SFST to form the basis for a DRE officer to become involved in the case. Concern was expressed that the use of a roadside device for alcohol but a behavioral test for the impacts of drugs on the ability to drive may cause some confusion. In order to support the new legislation, a higher percentage of patrol officers will have to be trained and certified to use the SFST and there will have to be an acceptance in the courts that roadside testing for alcohol is acceptable without the corresponding SFST evidence.

As mentioned above, the administration of vehicle and driver sanctions related to a conviction for impaired driving are administered by provincial and territorial jurisdictions in Canada. These sanctions include vehicle impoundment, administrative driver licence suspensions, medical assessment and treatment before reinstatement and the use of ignition interlocks to shorten or extend a suspension. How all of these programs will be impacted by drug impaired driving legislation is a significant issue. Some jurisdictions can use short-term suspension for drug impaired driving, but how administrative suspensions will be impacted is an open question. Where treatment, assessment and ignition interlock provisions are currently designed to address alcohol use, drivers convicted of impaired driving by drugs will have to follow the same rules, but it is not clear if it will have the desired impact on these drivers. Changes to the federal criminal legislation regarding drug impaired driving must be done in coordination with provincial/territorial legislation as to maximize the benefits of the legislation on drug-impaired drivers. If gaps and inequities are allowed to exist between the levels of jurisdiction or between alcohol impairment and drug impairment, there is a risk of increasing court challenges and utilizing more resources but not achieving the maximum benefits.

There is some survey evidence that drivers are already aware of differences in the way drug impaired driving and alcohol impaired driving are treated by police at the roadside and by provincial–territorial sanction. Preliminary evidence suggests that young drivers, who face a zero blood alcohol content limit in many Canadian jurisdictions, believe that they are less likely to

encounter problems if they use recreational drugs such as marijuana prior to driving rather than using alcohol. The current discrepancy in the manner and likelihood of a conviction and possible differences in sanctions may be sending an unintended message to these young drivers. It is imperative that the message be that impaired driving is not tolerated and there is no advantage choosing one substance over another. Other groups may also come to similar conclusions should this inequity remain entrenched in legislation and policy for an extended period of time.

In summary, any new legislation concerning drug impaired driving will happen within the context of the current environment of alcohol impaired driving enforcement. In many respects the situation is similar, but in others it is not. Legislators, the judicial system and the public are aware of the situation with alcohol impaired driving which may help or hinder new policies and programs related to drug impaired driving. It will be important to exploit the similarities but identify and manage the differences in order to bring in legislation which is both effective and accepted by the police, courts and drivers. This includes making the requisite resources available to support any legislative or policy changes implemented. It will be very important to ensure that new legislation does not complicate prosecutions or existing sanctions for alcohol impaired driving.

Enforcement Issues

Drug-Impaired Driving
Improving Integration of Toxicology, Technology, and Enforcement

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In May 2004, a group representing toxicologists, DREs, and prosecutors active in the area of DUID cases, was convened under the auspices of the National Safety Council's Committee on Alcohol and Other Drugs (COAD), and its subcommittee on Drugs: Pharmacology and Toxicology. The panel was charged with identifying problems with the current system of prosecuting drug impaired driving cases, from the point of detection through adjudication.

The group conducted a front to back analysis of the DUID arrest process from the initial contact with police to the prosecution or disposition of the case, and an examination of the shortcomings at each step, involving issues such as prioritization of DUID among other delegated responsibilities, effective use of current resources and tools, and preparedness of police, toxicologists, and prosecutors to handle their area of responsibility.

This manuscript is adapted from these wide-ranging discussions, and focuses on opportunities for enhancing law enforcement's contribution to this process, and identified areas for improvement as discussed below. The role of prosecutors, the courts and toxicology laboratories supporting these programs will be the subject of future reports.

ISSUE 1
Greater efforts in overall traffic enforcement will detect drug and alcohol impaired driver.

A traffic stop for impaired driving, whether caused by alcohol or other drugs, removes that driver from the road, and prevents the risk of injury or death to that driver, and other road users. Additionally, it initiates a process which, when it works, can change the behavior of that individual and reduce the risk for future re-offense. There is no magic bullet for detecting drug impaired driving. The same cues identified for alcohol impaired driving will likely net individuals whose impairment is caused by other drugs. Specially trained DRE officers can be used effectively as part of emphasis patrols in high drug-use areas identified through technologies like computer-aided dispatch systems, many of which now map locations of contacts. Music concerts and other festivals associated with drug culture have also been identified as good opportunities for highly visible DUID enforcement, sending a strong message about how seriously this issue is taken.

In practice, traffic law enforcement has not been a priority for many law enforcement agencies, operating under onerous fiscal restraints, and with thinly stretched resources. In many agencies, particularly urban police agencies, traffic enforcement is perceived as expensive due to court overtime costs, and the corresponding loss of manpower for what is considered a "minor crime." However, it can be argued that traffic law enforcement initiates a contact which will lead to detection of other major crimes. Offenders who disregard felony laws often have very little regard for traffic laws.

Law enforcement agencies should be encouraged to see traffic law enforcement as an integral part of community policing, and their public safety charge and to invest additional resources in impaired driving enforcement, and officer training. Federal incentives and support of the DRE program such as paying for training, initiating, and sustaining DRE programs, and financing impaired driving emphasis patrols all help in this process.

Innovative strategies to offset the costs of DUI enforcement include use of fines which can fund targeted traffic enforcement efforts. One example is assessment by the courts of "cost recovery" fees which have demonstrably improved resources for DUI enforcement. Imposition of these fees is within the discretion of the courts in many jurisdictions, but is not being taken advantage of. In other jurisdictions legislative action may be required.

Public pressure and citizen activism groups can help guide policy by raising the profile of impaired driving enforcement within communities, using media and networking resources. This pressure will help shape law enforcement priorities. Agency management must buy in to the importance of this issue for their agency, but once they do so the results can be dramatic.

In summary, placing the issue of drug and alcohol impaired driving in the public eye, will result in more general traffic law enforcement activity, which is the first critical step in creating the first contact between the offender and the criminal justice system.

ISSUE 2

Law enforcement officers often do not have sufficient training to assist them in recognizing symptoms of drug impairment in drivers.

Once these contacts are made, law enforcement officers need to be trained so that they are receptive to the clues displayed by the drug impaired driver. Historically, officers have been trained to look for common symptoms of "drunk driving" such as bloodshot, watery eyes, slurred speech and an odor of alcohol on the breath. In the detection of drug impaired drivers, caution needs to be taken to avoid decision making based solely on portable breath test devices, which may indicate the absence or low amounts of alcohol, and may result in impaired drivers being released. Evidence of cognitive or psychomotor impairment during the contact (confusion, slow responses, sleepiness, inappropriate responses, motor difficulties, etc) together with signs of drug effects such as fast or confused speech, excessive sweating, abnormal pupil size, muscle tics or tremors, or drug odors, are all important clues to drug impairment, but may be overlooked by officers without appropriate training.

Curricula do exist for training every law enforcement officer in recognizing symptoms of drug use, through the IACP. These classes, typically lasting 8 to 16 h provide law enforcement officers with the necessary articulable suspicion to initiate an investigation for drug use by the driver and to develop the case to collect other evidence be it behavioral, physiological, or toxicological. Without this level of awareness, more sophisticated resources such as the option of calling in DRE officers, and use of complex toxicology testing will be underutilized.

The DRE program, established by NHTSA in 1988, and managed by the IACP is a structured program of assessment of suspected impaired individuals which systematically collects and documents these and other symptoms of drug use and impairment, and provides a framework for the interpretation of this evidence, indicating the class or classes of drugs most likely to be responsible. In doing so it establishes the necessary probable cause for collection of a

biological sample for toxicological testing, completing the major elements needed for a robust DUID prosecution.

In Washington State, the introduction of the DRE program in 1995 was accompanied by extensive training for all law enforcement officers in recognizing drug effects. All patrol officers were trained in an 8-h class on recognizing symptoms of drug impairment. Figure 1 shows the rapid increase in DRE evaluations conducted once the program started, but more importantly shows the overall increase in DUI drug arrests by all officers who had received basic training in recognizing drug impairment.

This is attributed to their increased awareness of the issue.

Additionally, Figure 1 shows that while over time growth in the total number of DUI drug arrests has slowed, an increasing proportion now involve a DRE officer. In 2005, it is projected that 55% of all suspected DUI drug arrests will involve a DRE officer, resulting in better quality investigations.

Our observation is that existing tools if better utilized, can improve both the quantity and quality of DUI drug arrests, and it is recommended that law enforcement agency management should ensure that all officers receive a minimal level of "Drugs that Impair" training, such as the IACP 8-h curriculum.. This can be better achieved and promoted if agencies also adopt or participate in the DRE program. This program established in 38 states, provides a framework to make this general drugged driver training available to all law enforcement officers. Without the tools to establish a reasonable suspicion of drug impairment at the roadside through behavioral signs and symptoms, subsequent elements in successful prosecution of these cases become moot.

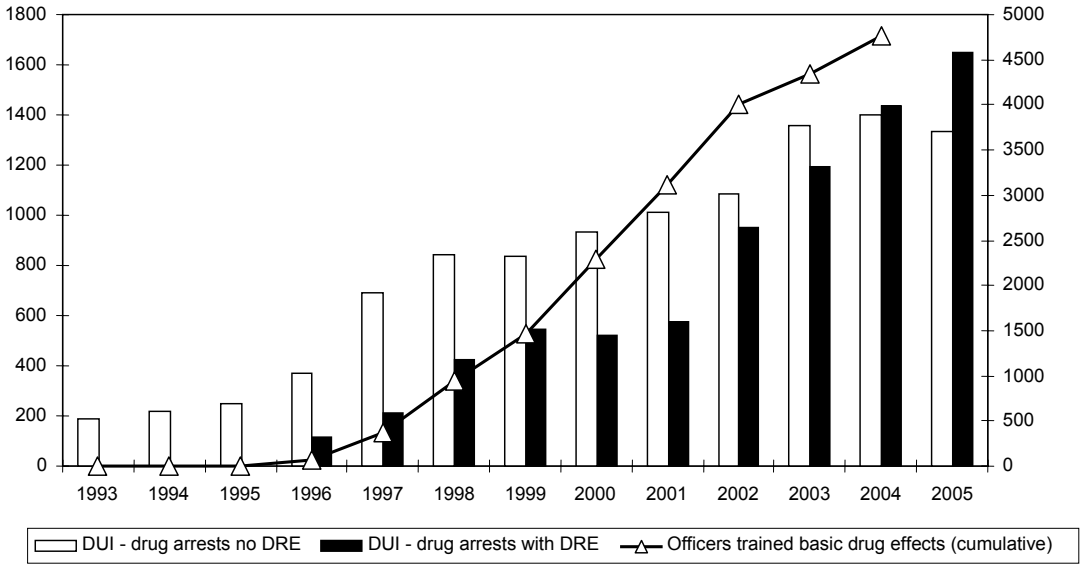

FIGURE 1 Relationship between 8-h training provided to officers in drug symptoms and effects [right axis—number of officers trained (cumulative)], and the number of DUI drug arrests both with and without a DRE evaluation (left axis). In 2004 the number of cases with a DRE surpassed 50%.

ISSUE 3

There is often poor documentation of the signs and symptoms of drug intoxication which are needed to make a convincing case in court.

Generating a suspicion of drug impairment is only the first step in developing a DUID case which will withstand legal challenges. Ideally, drivers suspected of driving under the influence are subjected to tests which document the effects of the intoxicants. In the case of alcohol, this is well understood, and subjects are generally given rudimentary psychomotor tests such as the NHTSA recommended SFST panel, which document impairment in the divided attention skills necessary for safe driving, as well as evidence of CNS depression. Officers are also well versed in documenting other evidence of alcohol use such as bloodshot eyes, odor of an alcoholic beverage on the breath, slurred speech, difficulty in extracting their license, problems with balance, and so on. Additionally, effects of alcohol are generally well understood by both judges and juries.

Since collecting evidence of impairment is the first step in the adjudication process irrespective of whether alcohol or drugs are involved, officers need to be thoroughly trained in the use of the validated field sobriety test battery. Many officers do not follow the validated SFST approach, which weakens the quality of the whole case. Agencies need to be encouraged to train and certify law enforcement officers in SFST methodologies and to periodically refresh and update that training.

In the case of drug-impaired driving, officers may not recognize the significance of many signs associated with drug use, and most are not trained to collect other evidence, such as pulse and blood pressure, muscle tone, sensitivity of the eyes to changes in light, indications of drug use, etc, which go beyond casual observation.

Recent data from Washington State suggests that as many as 40% of alcohol-impaired drivers may be additionally impaired by drug use. When officers start looking for these cases they will frequently find them. Given this indicator, it is clear that agencies should send a DRE qualified officer to all serious injury crashes, vehicular assaults, and vehicular homicides. Using DREs to proactively investigate drug use by drivers instead of simply assessing and documenting overt drug impairment observed by less expert officers will help to raise the profile of the DUID issue.

Proven strategies for improving the quality of a DUI drug arrest involve encouraging agencies to adopt the DRE program, and to use it in conjunction with toxicological testing to develop sound DUID cases for prosecution, and using those officers expertise to train their peers.

ISSUE 4

Existing DRE programs are underutilized, understaffed, and not well coordinated

Finally, simply instituting a DRE program is not sufficient. Although the DRE program is the most effective tool currently available to law enforcement officers for the documentation of behavior and impairment in drug-impaired drivers in many states it is not adequately supported with training, administrative, or toxicological resources. DREs need to use their skills regularly to maintain proficiency, to receive training concerning changes in the program, and stay informed about emerging patterns of drug use in their communities. They need the opportunity to

testify regularly otherwise they lose confidence in their abilities to practice what they learned in training.

DRE utilization can be increased by use of state traffic safety funds for enforcement emphasis programs. Paying for salaries for multi-agency emphasis operations, and for overtime for inter-agency collaborations promotes the use of DREs, and the DREs act as ambassadors for the program—spreading the word about the extent of drug impaired driving and helping to make it a public safety priority.

To strengthen fledgling DRE programs, local DRE coordinators need to market their program to law enforcement agencies through roll-call training, participation in basic law enforcement academies, meeting with accident reconstruction technicians, and traffic detectives, creating newsletters, attending traffic safety conferences, and breath-test or other impaired driver training. They need to emphasize the DRE program as assisting the arresting officer rather than coming in and taking over the case.

Additionally the most successful DRE programs have the strong support of their State–Governors Highway Traffic Safety Offices, and officials in those agencies need to be educated about the DUID problem, and encouraged to support and fund DRE programs and DUID emphases.

Together these four issues present some of the major opportunities for agencies to expand, strengthen or consolidate their DUI-drugs enforcement efforts. There are certainly many other limitations beyond those discussed above in the process of detecting, identifying, arresting, prosecuting and sentencing drug-impaired drivers. The strategies which are the focus of this report are designed to point out that effective enforcement tools currently exist, and can be more widely implemented, better supported and more effectively utilized to improve the chances of drug impaired drivers having their first contact with the criminal justice system.

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Commentary on History of DWI Enforcement
What Does It Tell Us About DUID Enforcement?

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FIFTY YEARS SINCE THE BREATHALYZER

In 1952, Borkenstein announced the invention of the breathalyzer, the first practical device for police to use to collect evidential quality blood alcohol information on drivers arrested for DWI. For the first time, police officers could complete the investigation and arrest an impaired driver without sending urine or blood samples to an outside laboratory and waiting several days or more for the toxicology results to be returned. This increased the efficiency and lowered the cost of DWI enforcement, paving the way for the substantial growth in enforcement activity required to keep up with the expansion of traffic on the nation's highways.

Recent technological developments for collecting and analyzing drugs in saliva and urine are providing officers in the field and at the police station with the tools to detect substance abuse in individuals arrested for impaired driving. This is ushering in an age in enforcement of DUID laws similar to that produced half a century ago by the breathalyzer, a device that measured breath alcohol simply and reliably enough to be operated by officers and accepted by the courts as valid evidence in DWI prosecutions. Although the current DUID measurement methods are not yet accepted for evidential purposes by the courts, they give promise of doing so in the near future. Therefore, it is useful to consider lessons learned over the last half century in enforcing DWI laws with chemical test data.

THE SLOW PACE OF LEGISLATION

With the possibility of establishing a per se limit for substances other than alcohol, there has been considerable debate about the appropriate concentration levels in saliva, blood, or urine to define as the legal limit. In 1952, when the breathalyzer became available, a BAC of .15 was the level recognized by the American Medical Association (AMA) and the courts as establishing a presumption of intoxication under impaired driving laws. It was not until 1960 that the AMA lowered that recommendation to .10, and it required almost a quarter of a century for all the states to reduce their limits to .10. Then, finally, after another quarter of a century and the passage of congressional legislation to withhold state funds, the limit was lowered to .08 by all 50 states. The year was 2002. Thus, it required half a century to move from the level currently associated with "hard core" drinking (.15 BAC) to the current .08 limit, which is still substantially higher than that of most industrialized countries.

Moreover, the availability of an evidential-quality measuring device at the police station did not immediately bring about a movement for per se legislation, even though Norway had enacted a per se law in 1936. Although most states had enacted per se laws by 1990, Massachusetts still does not have such a law. Finally, the other key piece of legislation—

administrative license suspension (ALS)—that the availability of an evidential test device at the police station might have been expected to encourage was not adopted by the states until 30 to 40 years after the advent of the breathalyzer.

Thus, although scientific developments may ultimately lead to stronger legislation, experience with breath alcohol measurement suggests that it takes considerable time after the technology is available for it to be incorporated into an enforcement program. In this breath-testing to drug-testing analogy, the status of the knowledge of breath alcohol measurement in 1952 and our current knowledge of measures of drug use differ in significant ways. Alcohol is distributed relatively evenly throughout the body, and in the 1950s, its relationship to the BAC was known with substantially greater precision than is our current knowledge of the relationship of saliva-to-blood levels of most drugs. Despite this, for at least two decades following the passage of laws recognizing the breath-test technology, court cases were challenged based on the breath/blood partition. With the currently established differences in substances as measured in blood, breath, and urine based on the pharmokinetics of the substances as they pass through the body, it is likely that any test—perhaps even a blood test—will be open to frequent challenges in the courts and to greater differences between experts, leading to slow acceptance by the courts and substantial impediments in passing legislation.

THE UNITED STATES HAS DWI PER SE LAWS BUT NOT PER SE ENFORCEMENT

Although every state now has a law making a BAC of .08 illegal per se, the criminal justice system does not operate on a per se basis, which should be limited to only two findings: (*a*) Was the individual in charge of a vehicle? (*b*) Did that individual have a BAC equal to or greater than .08? The full application of this concept is limited to a few countries, such as Australia, where police officers can stop any car and demand a roadside breath test that, if positive, results in an immediate arrest and transport to the police station for a confirming test. The process specifically excludes consideration of whether the behavior of the accused indicated impairment. Under the 4th Amendment to the U.S. Constitution, stopping a vehicle is a "seizure" and obtaining a breath test is a "search." For both, the officer must have a specific reason for taking the action. This has generally been interpreted by the courts as preventing purely random testing, Australian style, which should be the fundamental basis of per se laws as they are intended to avoid legal arguments over behavior.

The Supreme Courts' 1990 Sitz decision provided for sobriety checkpoints, in which vehicles can be stopped at random under a limited set of conditions. Based on this decision, it would be possible to implement operations in the United States similar to random testing in Australia by using passive sensors (Voas and Layfield, 1983) that detect alcohol from in front of the face and are not considered a "search" under the 4th Amendment. Thus, the checkpoint system could provide for a "chemistry-based" (Voas and Lacey, 1990) enforcement system similar to Australia's random testing. However, despite the passage of 20 years since the first passive sensors became available in the United States, this technology has yet to be adopted by the police or accepted by courts for presentation at trials. The two basic methods of enforcing impaired-driving laws in the United States continue to depend upon the collection of visible evidence of intoxication. They are (*a*) the traditional patrol method, in which officers must detect aberrant driving to stop a vehicle and must have some behavioral evidence of impairment to require an evidential test; and (*b*) checkpoint enforcement, during which cars are stopped at

random, but the officers still must have some visual evidence of impairment to require an evidential test.

The requirement to collect behavioral evidence to justify an arrest and require the evidential test has become the crucial factor in reducing the effectiveness of per se laws. There is strong evidence that, at sobriety checkpoints where officers are dependent on brief interviews and observations of motorists to detect impairment, they miss approximately 50% of drivers who have BACs higher than the legal limit (Farmer, Wells, Ferguson, and Voas, 1999). In court, defense attorneys find it difficult to attack the chemical test data; instead, they attack the behavioral information that led to the arrest. This has required extensive training of officers so they can recognize signs of intoxication and conduct sobriety tests. Under "pure" per se laws, this type of evidence should not be required.

DRUG PER SE LAWS

Verstraete and Walsh (2005), in their paper presented at this session, distinguish between drug "impairment laws," which require a demonstration of driving impairment, and drug "per se laws," which require no evidence of impairment but only the presence of a drug in the body of the driver. However, most drug per se limits differ significantly from alcohol per se limits. Alcohol is a legal product; therefore, the limit must be justified by being related to impairment. Conversely, drugs are illicit, so any measurable amount is generally prohibited in zero-tolerance legislation. Thus, DUI enforcement must take advantage of the well-established relationship between BAC and impairment to establish an illegal limit for alcohol consumption. Drug impairment, however, is different. As concluded in the report of the Consensus Development Panel of experts convened in 1985, impairment levels for drugs cannot be determined because of the complexity of the concentration to impairment relationships. Nonetheless, enforcement of DUID has the benefit that certain substances are illegal, so zero-tolerance limits for illicit substances can be established.

The NSC/NHTSA 2004 Priorities report (Committee on Alcohol and Other Drugs of the National Safety Council, 2004) recommends that states pursue zero-tolerance legislation for DUID. However, it is unclear whether a true per se zero-tolerance enforcement program can be implemented. The prosecution still must establish probable cause for the arrest of an offender before the results from a chemical test can be admitted at the trial. Thus, police officers will face the same problem as for DWI prosecutions: they must present evidence of behavioral impairment at the roadside as justification for taking the driver into custody. When the evidence is based on the current SFSTs, the arrest will probably be found to justify the imposition of the evidential test, and most such cases will test positive for alcohol and be prosecuted for DWI. Conversely, a DUID prosecution will currently only be likely if the individual is obviously impaired but has a low BAC. Many individuals with near-zero drug levels will not be apprehended because they will exhibit too few observable indicators of drug use to justify arrest. Thus, although the nominal legal limit may be any positive amount of an illicit drug, functionally, DUID arrests, as with DWI arrests, will primarily occur at levels that produce substantial driver impairment, not at concentrations close to zero.

SIGNS OF DRUG-IMPAIRED DRIVING

Drug tests that can be administered in the police station or at the roadside increase the potential utility of drug per se laws. However, our experience with alcohol per se laws points to several problems that must be resolved before these laws are practical. Although the driving characteristics of individuals impaired by alcohol are fairly well known to police officers (NHTSA, 1999), there is no similar repertoire of behavioral symptoms for DUID. Further, such a list of symptoms, to the extent they could be developed, would probably be more varied and extensive than the list of alcohol behaviors. Therefore, this list probably would result in more false-positive stops and more difficulty in the training of officers. Although NHTSA (Logan, 2004) notes that the same cues that identify alcohol-impaired drivers will net drug-impaired drivers, it is probable that stopping potentially drug-impaired drivers will rely more heavily on enforcing moving traffic violations and checkpoints than is the case with DWI enforcement.

SIGNS OF DRUG USE

Developing observable evidence of drug impairment as the basis for demanding an evidential test also will be considerably more difficult than is currently the case for alcohol, for which there is a highly standardized test (Stuster, 2001). Although a series of observations and tests have been developed for use in the DRE program, those measures require special equipment and extensive training to be used effectively. Providing that level of training to all officers involved in traffic enforcement would be impracticable. Even extending the DRE to provide a sufficient number of officers to cover all the potential drug cases brought in by patrol officers would be prohibitively expensive. Conversely, most current state laws permit a second chemical test where a low- or zero-BAC result does not correspond to the apparent impairment of the driver. This authorization to make a second test allows the collection of a saliva, urine, or blood sample without direct evidence of behavioral impairment.

EVIDENTIAL TESTS FOR DRUGS

Establishing and protecting the validity of chemical tests for substances other than alcohol will take considerable time, just as it did for the breath test. The time of testing relative to the arrest will be more critical than is the case for alcohol because differing times are required to test the various types of samples (blood, saliva, and urine) that may be used for evidence. Even in the case of alcohol, where the time over which the body oxidizes the substance is well known, the NSC recommends against back-projection of the measured BAC to an earlier time of crash or arrest. The time that the drugs or their metabolites are in the body will be much less predictable and more dependent on the particular fluid used in the test. Most current onsite test devices only provide a preliminary screen for drugs, which must be verified by laboratory analysis and may require special handling (refrigeration), as well as the usual chain-of-custody procedures and potential failures to confirm the initial measurements in police station results. Experience with onsite alcohol tests clearly indicates that operators must be trained and certified and that equipment and handling procedures must be inspected by state authorities regularly.

Considerable interest has been shown in zero-tolerance laws that make it an offense to operate a vehicle with any illicit drugs in the body. The NHTSA–NSC report on priorities for DUID cases (Committee on Alcohol and Other Drugs of the National Safety Council, 2004, p. 14) recommends that states pursue zero-tolerance legislation. Sweden, Australia, and several U.S. states (Verstraete and Walsh, 2005) have enacted zero-tolerance laws for some illicit drugs. Conceptually, this avoids establishment of a drug level for impairment, which is likely to garner official support based on the national effort to suppress drug abuse. Because alcohol is a legal drug for adults, the history of zero-tolerance laws for alcohol is not directly applicable to drugs. Despite the fact that, since Prohibition, alcohol has always been illegal for underage youth, it was not until the minimum legal drinking age was raised to 21, and Congress threatened to sanction states that did not pass zero-tolerance laws for drivers younger than 21, that such laws were enacted in the United States.

An interesting anomaly of the zero-tolerance concept in DUID enforcement is the way in which drug possession is typically defined. Drug enforcement laws generally define possession based upon finding the substance on the person or the person's property, and the level of offense is defined in terms of the weight of the material collected. Tests for drugs in a biological sample from an individual are not generally accepted as possession by the courts. Conversely, in driving situations, it is the biological sample that defines the offense because it offers a measure of the level of impairment that defines the offense. Therefore, the drug must have been ingested to produce a behavioral effect and the measure of the biological sample must be great enough to cause impairment. Zero-tolerance DUID laws mix these two concepts. The offense is defined as possession based on the biological sample without reference to any amount that has been shown to be impairing. Many drivers who have no drugs in their possession may still have evidence of their use in their systems, so zero-tolerance DUID laws could become a powerful method of suppressing drug use among motorists. Conversely, courts hearing DUID cases may be reluctant to accept body fluid evidence without some reference to its significance for impairment.

POTENTIAL IMPACT OF ZERO-TOLERANCE LAWS ON THE DRE PROGRAM

Currently, the DREs perform two primary functions: (*a*) they detect physical and behavioral impairment due to drug consumption, which provides a basis for expert testimony in court; and (*b*) they identify the impairing substances, which assists laboratories in conducting chemical analyses of the biological samples provided by offenders. If states pass zero-tolerance laws for substances other than alcohol, then impairment will no longer be an issue and the capability to conduct drug-screening tests at police stations will reduce the need to identify the drug of abuse. This suggests that the role of the DRE will change unless states reject the zero-tolerance concept and enact drug-impaired driving laws.

A key issue for the DRE program will be whether the courts will accept drug-test evidence without behavioral evidence as justification for the arrest of the suspect. Currently, most state laws permit a second evidential test for drugs from a blood or urine sample if the suspect's BAC does not justify the apparent behavioral impairment documented at the roadside. In this case, the second chemical test has been justified based on the original behavioral evidence of alcohol impairment. A second test that is positive for illicit drugs will raise the issue of whether the case can be brought to court without specific behavioral evidence of impairment by drugs. If the courts, in adjudicating zero-tolerance cases for drugs, require evidence of drug

impairment as a precondition for administering a test for drugs (as is required for probable cause to test for alcohol), then the need for DREs will remain unchanged. Conversely, if the evidence for impairment that justified the original BAC test is accepted as meeting the 4th Amendment requirement for probable cause, then the current DRE role as testimony in court will be reduced.

The zero-tolerance concept should avoid the need for evidence of impairment as a precondition to acceptance of drug analysis data. Case law will need to be carefully monitored to determine whether there is a drift toward requiring evidence of impairment as has occurred in the case of alcohol per se laws. Nonetheless, the need for determination of impairment is likely to remain in connection with prosecuting drivers for impairment due to medicinal drugs. Although many individuals drive after consuming prescription and nonprescription drugs, we are probably years away from seeing state legislation making "driving under the influence of medications" an offense. Thus, the role of the DRE will need to be reviewed with the development of the new on-site drug-testing techniques and or court procedures.

OVERLAP BETWEEN ALCOHOL AND DRUG USE

Alcohol is by far the most frequently identified source of impairment in crash-involved drivers. It is well known that approximately half of the arrested or crash-involved drivers with drugs in their bodies also have been positive for alcohol. Terhune et al. (1992) analyzed blood samples from 1,882 fatally injured driver and found that 11.4% of the total were positive for both alcohol and drugs, whereas only 6.4% were positive for drugs alone. In general, such studies (also see Drummer, 1995, and Hold, de Boer, Zuidema, and Maes, 1996) have found that there are as many or more drivers with both drug and alcohol involvement as there are crash-involved drivers with drugs alone. This suggests that if DWI enforcement were fully effective, we would reduce the number of drugged drivers by half. Another important feature of this relationship, described by Zwiker, Preusser, and Compton (2005), is that drivers with a combination of alcohol and drugs in their systems are at greater risk of crash involvement than those at similar BACs who are not positive for another drug.

The importance of this relationship is clear: First, it demonstrates that DWI enforcement is taking substantial numbers of drug-impaired drivers off the road, particularly those that represent the greatest risk due to their combination of drinking and using drugs. Second, studies of drivers arrested under traditional DWI laws also have identified drivers impaired by drugs alone. This suggests the DWI enforcement procedures are identifying a substantial number of drugged-drinking and drug-only drivers. Changes to impaired-driving criminal justice procedures must consider carefully this overlap to assure that policy changes do not significantly affect the current partially successful system.

HOW IMPORTANT IS IT TO IDENTIFY DRUGGED DRIVERS?

Aside from the criticism that the current alcohol-oriented impaired-driving enforcement system misses drugged drivers, there is a concern that the criminal justice system fails to recognize drug involvement in drivers prosecuted for alcohol-impaired driving. This leads to a question: "Why is it important to identify drug use when the offender is being taken off the road and required, as a condition of probation, to be assessed for a drinking problem and attend treatment?" Three main issues arise. The first is that drug users will not be detected in such assessments and require

specialized treatment that they will not receive in the typical court-mandated alcohol treatment program. However, most alcohol treatment providers recognize that a large proportion of alcohol abusers also are other substance users and, thus, have been required to develop the capability to handle drug users.

The second reason for concern is that, if drugged drivers are recognized, the current belief is that they should be provided with the opportunity to attend drug court diversion programs. Although most DUID drivers will not be as addicted to drugs as those currently attending such courts, it is probable that the drug courts would be effective with many such offenders. However, a good alcohol-problem-assessment system will identify drug users and provide the court with the option to offer the drug court program. Finally a third issue is the need to examine drug users before allowing them to reinstate their licenses to ensure that they have overcome their problem. This issue could be handled by requiring that all reinstating impaired drivers be screened.

Although it is possible that the screening tests developed by the IACP for use by the police in identifying drug-impaired drivers could be added to the current SFST battery of three tests, a careful study of the added time required of officers will be necessary to determine whether such an extension of the roadside-testing time would be efficient in terms of total impaired-driving arrests. If court sentencing and probation procedures can be flexible, it should be more efficient to use postconviction assessment to identify drug-dependent offenders and steer them into drug court or to conventional alcohol-treatment providers with the capacity to assist drug users. Identifying drugged drivers who also are not drinking, and arresting and convicting them, will remain difficult. However, for the foreseeable future, most drugged drivers taken off the road will not be convicted of DUID because it will be far easier to convict them of DWI. We need to strengthen our traditional court assessment and treatment programs to ensure that they can effectively treat drug users.

IS THERE A CONFLICT BETWEEN DUI AND DUID ENFORCEMENT?

The NHTSA–NSC (2004) report on priorities and strategies for drug-impaired driving enforcement states that “Over reliance on portable breath-test devices, which may indicate an absence or low amounts of alcohol, may result in impaired drivers being released” (p.4). This concern with the possibility that the use of alcohol-detection devices may lead to overlooking drug-impaired drivers has discouraged the use of passive sensors and preliminary breath testers (PBTs) even though research overwhelmingly shows that these devices substantially increase the number of DWI arrests made by officers on patrol and at checkpoints. A series of studies conducted by researchers at the Insurance Institute for Highway Safety (Lund and Jones, 1987; Kiger, Lestina, and Lund, 1993; Lund, Kiger, Lestina, and Blackwell, 1991; Jones and Lund 1985; Ferguson, Wells, and Lund, 1995) has shown that use of passive sensors at checkpoints increases the number of DWI arrests by approximately 50%. Cleary and Rodgers (1986) reported that the distribution of PBTs to the Minnesota state police substantially increased their DWI arrests.

To date, there have been no studies on the extent to which the use of such alcohol-sensing devices result in the inappropriate release of drug-impaired drivers. It is possible that determining that an apparently impaired driver has a low or zero BAC in the field could be a basis for additional observations and tests leading to the development of probable cause to make

an arrest for DUID. However, where PBTs are available to officers in the field, using them before conducting a SFST is discouraged because it is believed it might bias the officer's judgment in scoring the SFSTs, and as noted, there also is the concern that it might cause the officer to overlook evidence of drug impairment. Thus, we have not fully determined the value of such technological aids to enforcement even though they have been available to the police for more than 30 years. This may be an ominous sign for the new drug-testing technologies. If the focus remains on observations of appearance and sobriety testing, the use of the new drug-screening tests may be discouraged.

THE ECONOMICS OF DWI–DUID ENFORCEMENT

Most police managers face a set of demands for action that overwhelm their available resources. This problem has recently been exacerbated by homeland security requirements that have drawn officer resources away from traditional public safety duties. All too often in the allocation of available resources, traffic enforcement receives relatively low priority. If apprehension of drug-impaired drivers is to be emphasized, it will have to come out of existing DWI enforcement capabilities. An important issue then is: "Can an enhanced drug enforcement effort be mounted without diminishing other key traffic enforcement activities directed at DWI and safety belt enforcement?" When considering this issue, it is important to consider the findings from the studies reported above, which indicate that half of the drugged drivers also are using alcohol. Consequently, our current DWI programs are probably identifying and taking off the road about 50% of the drug-impaired drivers. The proportion actually may be greater because in many departments, a zero BAC in an impaired driver leads to an examination by a DRE and possibly a DUID charge, so some drugs-only drivers are being apprehended under the current system.

Developing a new, enhanced DUID enforcement program will require substantial resources to pay for the new screening tests, which are likely to cost several dollars each, and follow-up laboratory confirmation analyses, which will run $30 to $50. In addition, if an in-station evidential analytic method becomes available, it will likely cost several thousand dollars and operators will have to be trained and certified. The greatest cost, however, will undoubtedly be in training officers who arrest DUID offenders. The 8- to 16-h training program on recognizing drug-impairment symptoms developed by the IACP may prove to be difficult to provide to all traffic officers. Experience with the effort to train all traffic officers on the current battery of three SFSTs tests provides an indication of the cost limitations inherent in attempting to provide such training nationwide. Despite the investment of considerable resources, most officers vary substantially in their exact application of the tests as designed. It can be argued that such an effort in DUID training may be justified even if one fatal crash is averted. Nonetheless, federal government resources for such an effort are unlikely, so inevitably, funds will be diverted from other enforcement activities within individual police departments. Therefore, we must be sensitive to the impact of diverting traditional DWI resources, which currently supports the apprehension of about half of the drugged drivers. Data from Terhune et al. (1992) suggest that one in five alcohol-involved drivers also use drugs; thus, for every five DWI offenders we fail to arrest, we also will miss one drugged driver.

LOOKING TO THE FUTURE

It has required a half century to develop the current DWI enforcement system based on chemical test criterion for intoxication. Although the new drug-detection technology can build on that base, experience suggests that it may take many years for a similar drug enforcement system to be established. It is useful, then, to consider what interim steps might be taken to strengthen drugged-driving enforcement. A major limitation in current DUID laws is the definition of the concentration limit to be prohibited and the constitutional need to demonstrate impairment before requiring a test. Although problems remain, these issues have been dealt with in DWI enforcement. It is tempting to propose that drug driving be initially handled as an aggravating factor for the DWI offense. Thus, if the DWI arrest is valid, the presence of a drug in the body of the driver could be the basis for additional sanctions. This could avoid the need to demonstrate drug impairment because the arrest would be based on alcohol impairment and the test would be justified based on the validity of the DWI arrest. Thus, a DWI arrest could provide the foundation for enforcing a zero-tolerance limit on drugs in a driver.

The enactment of laws making drug use an aggravating factor in a DWI offense would be consistent with the current trend to pass legislation that provides for additional penalties for a BAC of .15 or greater. Although zero-BAC drug users would not be subject to this law, it would affect the segment of the drugged-driving population most likely to be responsible for a crash: those who also are impaired by alcohol (Zwicker et al., 2005). Requiring a drug test for drivers arrested for DWI would provide the information for court use in assigning the appropriate treatment or diversion program. Finally, the introduction of drug enforcement in this mode would take the pressure off training police and prosecutors in the handling of DUID cases, reduce the resources necessary to enhance DUID enforcement, and could lead to greater effort to meld current alcohol- and drug-detection techniques into a system that enhances the effectiveness of both.

NOTE

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Appendixes

APPENDIX A

Workshop Schedule

Drugs in Traffic

Transportation Research Board
Alcohol, Drugs, and Transportation Committee

Kathryn Stewart, *Chair*

National Academy of Sciences–Jonsson Conference Center
Woods Hole, Massachusetts
June 20-21, 2005

Monday, June 20

7:30 – 8:30	Breakfast
8:30 – 9:00	**Introductions and overview of the agenda** Kathryn Stewart, Safety and Policy Analysis International
9:00 – 10:30	**Risks Posed by Drugs in Traffic** Moderator: Sue Ferguson, Insurance Institute for Highway Safety **Background presentations:** Doug Beirness, Traffic Injury Research Foundation, Canada Thomas Zwicker, Preusser Research Group, U.S. René Mathijssen, SWOV, The Netherlands
10:30 – 11:00	Break
11:00 – 12:00	**Discussants:** John Lacey, Pacific Institute for Research and Evaluation, U.S. Herb Moskowitz, California State University (Emeritus), U.S. Asbjørg Christophersen, Norwegian Institute of Public Health Ralph Hingson, National Institute on Alcohol Abuse and Alcoholism, U.S.
12:00 – 12:30	**General discussion**
12:30 – 1:30	Lunch
1:30 – 3:00	**Effects of Drugs** Moderator: Jim Hedlund, Highway Safety North

Background presentation
David Shinar, Ben Gurion University, Israel

Discussant:
Johannes G. Ramaekers, University of Maastricht, the Netherlands

General Discussion

3:00 – 3:30 Break

3:30 – 5:00 **Medicinal Drugs**
Moderator: Ruth Shults, Centers for Disease Control

Background Presentation
Johan De Gier, DGC, The Netherlands

Discussants:
Charles Mercier-Guyon, CERMT, France
Carl Soderstrom, Maryland Motor Vehicle Administration, U.S.

General Discussion

A reception and dinner at the conference center will follow shortly after the end of the discussion.

Tuesday, June 21

7:30 – 8:30 Breakfast

8:30 – 10:30 **The Legal Framework for Dealing with Drugs inTraffic**
Moderator: Barry Sweedler, Safety and Policy Analysis International

Background presentations
Mike Walsh, The Walsh Group, US,
Alain Verstraete, Ghent University, Belgium

Discussants:
Danielle Roeber, National Transportation Safety Board
Paul Boase, Transport Canada, Canada

10:30 - 10:45 Break

10:45 – 12:30 **Enforcement Issues**
Moderator: Allan Williams, Insurance Institute for Highway Safety

Background presentation:
Barry Logan, Washington State Patrol, U.S.

Discussants:
Philip Swann, VicRoads, Australia
Robert Voas, Pacific Institute for Research and Evaluation, U.S.

12:30 – 1:30 Lunch

1:30 – 3:00 **General discussion of issues and policy implications**

3:00 – 3:15 **Wrap-up**

WORKSHOP COSPONSORS

U.S. National Highway Traffic Safety Administration
U.S. National Institute on Drug Abuse
Transport Canada
International Council on Alcohol, Drugs and Traffic Safety

APPENDIX B

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