

TRANSPORTATION RESEARCH  
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# Alcohol and Other Drugs in Transportation

Research Needs  
for the Next Decade

Transportation Research Board  
National Research Council



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**ALCOHOL AND OTHER DRUGS IN TRANSPORTATION:  
RESEARCH NEEDS FOR THE NEXT DECADE**

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## FOREWORD

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In the last decade in the United States, more than a quarter of a million people have lost their lives in transportation crashes involving alcohol and other drugs. Although the vast majority of the alcohol- and other drug-related fatalities occurred on the highways, some of the most tragic and infamous accidents involved rail, mass transit, marine transportation, and aviation. Although deaths and injuries are of most immediate concern, we must also pay attention to the enormous property and environmental damage that can result from transportation accidents.

The past decade has also brought about significant progress in reducing the toll of transportation crashes due to abuse of alcohol and other drugs. For example, in 1982, 57 percent of all highway fatalities were alcohol-related. By 1992, that figure had dropped to 45.8 percent. In the railroad industry, 1.5 percent of workers tested after accidents in 1991 were positive for alcohol or other prohibited drugs, the lowest positive rate since testing began in 1986. In aviation, the percentage of fatal general aviation accidents involving alcohol dropped from 9.8 percent during the 1975 to 1981 period to 6.0 percent during the 1983 to 1988 period. The percentage of fatal scheduled commuter airline and unscheduled airtaxi accidents in which alcohol was involved also dropped significantly. There are many reasons for this improvement, including the development and implementation of programs at all levels of government, industry, and labor, which are encouraged and spurred on by citizen activists, public interest groups, and others.

One of the most important tools available, both to those who make policy and those who demand improvements, is solid research. Research allows us to implement countermeasures that have been shown to be effective. Those faced with advocating and implementing programs to further reduce the toll of alcohol- and other drug-related accidents will need to know what works. In the next decade, resources for dealing with these problems will be increasingly scarce, requiring careful selection of which programs to endorse. Good research, presented in an easily understood manner, will play a vital role. Resources for conducting research will also be scarce. This report outlines the research needs in the field of alcohol, other drugs, and transportation for the next decade and how the various public and private agencies conducting research in this field can work together to obtain the most effective and efficient research program possible.

It is hoped that this report will be a useful tool and provide guidance to those conducting research in this field. The committee hopes to periodically update this report so that the latest developments can be considered when research decisions are made.

Barry M. Sweedler  
Chairman

*Committee on Alcohol, Other Drugs and Transportation*

## ACKNOWLEDGEMENTS

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A sincerest thank you to the many people who participated in the workshop and contributed to the development, production, and publication of this Circular.

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Production of the final manuscript was graciously done by Karenina Newell-Okeke, Office of Safety Recommendations, National Transportation Safety Board, and Christopher Rollison, TRB. The cover graphic was developed by Terri Wayne, TRB.

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## EXECUTIVE SUMMARY

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This report summarizes ideas presented at a workshop organized by the Transportation Research Board of the National Research Council at the Beckman Center in Irvine, California, July 27-29, 1992. Fifty-one participants were invited to the workshop. The participants included representatives of the research community and the transportation industry. Also included were representatives of the government agencies that are funders and users of the research discussed. These agencies included the Department of Transportation's Office of Drug Enforcement and Program Compliance, the National Institute on Drug Abuse, the National Highway Traffic Safety Administration, the Office for Substance Abuse Prevention, the National Institute on Alcohol Abuse and Alcoholism, the Federal Highway Administration, and the National Transportation Safety Board.

The purpose of the workshop was to discuss the current state of the art in reducing the prevalence of alcohol and other drugs in transportation accidents in all modes, to identify gaps in knowledge, and to establish research needs and priorities for the next decade. This proposed research agenda is designed to provide information and guidance to the U.S. transportation industry, governments, institutions, safety advocates, and others to further reduce the role of alcohol and other drugs in transportation accidents.

Papers prepared and presented by researchers served to (a) review literature and (b) identify issues for research that served as basis for discussion and subsequent recommendations.

The information presented was broad and diverse. It was clear, however, that it would not be possible to address all the research ideas outlined in the workshop because not enough resources would be available. Therefore, a number of guiding principles evolved for ranking the proposed research initiatives:

1. The primary focus of the research should be on the reduction of deaths and injuries from alcohol- and drug-related accidents.

2. Alcohol, drugs, and transportation should be viewed in a broader context. In particular, the criminal justice approach has strongly dominated the research in this area at the expense of other approaches, notably the public health approach. The alcohol, drugs, and transportation issue needs to become part of the larger societal goals.

3. Full advantage should be taken of research that has already been carried out in the United States and abroad.

4. Researchers should collaborate more effectively across disciplines, funding agencies, states, and nations.

5. Researchers should attempt to use unifying and common methodologies to maximize comparability of data, minimize repetition of studies, and ensure that the research offers the greatest knowledge both nationally and internationally.

6. Long-term programs such as tobacco use, diet, exercise, and including drinking and driving, which have seen reductions in harm-producing behaviors, should be examined in order to learn from these successes.

7. Researchers should promote and disseminate research findings because much current information is not being used. Therefore, it is important that research be presented in a format accessible to a broader spectrum of constituencies.

The research agenda, as presented at the workshop, encompasses the three research "E's" of epidemiology (patterns and trends), experimentation (field and laboratory), and evaluation (intervention strategies).

### EPIDEMIOLOGY (PATTERNS AND TRENDS)

The epidemiologic approach necessitates an examination of trends and patterns in alcohol, drugs, and transportation, including attempts to determine causality.

#### Individual

The research ideas include both population-based and special group studies. Recommendations are made to continue monitoring alcohol- and drug-use trends in the changing U.S. population, general road users, and transportation workers. The special groups that are mentioned included drug-use of fatally and non-fatally injured drivers and pedestrians and crash rates of drug addicts and prescription-drug users.

#### Impairing Substances

The consensus was that alcohol would remain the major drug of choice and trends of alcohol and other drug use should continue to be monitored using cost-effective means.

#### Environment

##### *Physical*

Computerized technologies are being used in the development of intelligent vehicle highway systems

(IVHS). The use of alcohol and drugs and their effects will need to be addressed in the research and development of IVHS.

### *Social*

Drinking and driving historically has been perceived as a form of criminal behavior instead of a natural consequence of a driving and drinking society. More information is needed on the relationships among availability, pricing, and transportation planning for licensing of drinking premises to understand the interplay of these factors and drinking-driving behavior. Furthermore, the interaction between public agendas and institutional and governmental policy, how specific policies are disseminated and diffused in society, and the reasons for the recent reductions in drinking-driving behavior are all recommended for study.

## **EXPERIMENTAL (FIELD AND LABORATORY)**

### **Detection**

Detection research issues include biochemical studies of analytic markers or metabolite ratios, on-site testing for the workplace, and screening tests for "in vitro" adulterants used to obscure the presence of drugs in samples. In addition, alternative detection strategies, such as the Los Angeles Police Department's Drug Recognition Expert (DRE) Program, should be investigated.

### **Impairment/Performance**

The drugs of choice to be investigated are alcohol, marijuana, cocaine, and prescription drugs. Issues for alcohol include alcohol tolerance, low blood-alcohol levels, alcohol-drug combinations, hangover effects, alcohol-aging interaction, and alcohol effects on the young driver.

Marijuana research questions are on the effects of high THC-content marijuana, the duration of marijuana effects, the effects of marijuana on young (adolescent) drivers, and the relationship of blood/urine levels to performance effects.

Because little is known about cocaine and driving, it is important to study its effects on performance, with the first priority to define what variables should be measured.

Prescription drugs present a problem, particularly with the older population. Research ideas include

systematic evaluation of the effects of prescription and over-the-counter (OTC) medication, including acute dose studies with healthy volunteers to specify drug effects per se, acute and chronic dose studies with patients to clarify the net effect of drug-disorder interactions, and dosing regimens that represent typical therapeutic use.

More generally it is recommended that researchers determine the efficacy of developing a "per se" indication of impairment for drugs, as is available with alcohol, and establish an accepted format/design for measuring performance impairment. This should include single dose, multiple dose, and multiple drug studies.

Critical workplace needs are to pursue performance impairment tests, such as the Critical Tracking Test (CTT); link laboratory performance impairment results to field observational studies; and, most important, develop "fitness for duty" tests that are valid, cheap, quick, and transportable.

## **EVALUATION (INTERVENTION STRATEGIES)**

### **Education Research Agenda**

Further research is needed to assess the effects of advertising and health promotion campaigns on both alcohol consumption and drinking-driving behavior. Studies might focus on particular groups (e.g., youth) and on the types of public health approaches (e.g., counter-advertising versus media advocacy strategies).

### **Legal Control Research Agenda**

#### *Legislation*

It is recommended that researchers compare and evaluate selected legislative initiatives begun in the 1980s and currently in place in most states.

#### *Detection/Enforcement*

More knowledge is needed to identify the best strategies and procedures to detect and arrest impaired drivers and the amount of detection required to produce deterrence. For example, detection cues for .05 percent and .08 percent Blood-Alcohol-Content (BAC) and youthful drivers, optimal detection and arrest processing systems, and use of and training in methods for new technologies were mentioned. In addition, information on the different reasons for variance in arrest rates was also considered important.

*Workplace*

In the transportation workplace, it is important to determine the optimum random testing rate to maximize deterrent effect at minimal cost.

*Sanctioning*

It is recommended that various sanctions ranging from vehicle impoundment to mandatory treatment programs and variation in the severity of these sanctions be studied to determine optimal specific deterrence.

**Rehabilitation Research Agenda***Impaired Driving Remediation*

A more in-depth evaluation is recommended for remediation, which includes the expansion of options targeted toward specific sub-groups of offenders, improvement of methodology and reporting standards, and assessment tools. It is also suggested that impaired drivers may be frequently involved with a variety of systems such as health care and criminal justice. This needs to be investigated, and the inter-agency cooperation on research to design innovative and comprehensive approaches to intervention needs to be explored.

*Workplace*

It is recommended that researchers conduct

methodologically sound, comprehensive studies of return-to-duty success and long-term sobriety.

**Indirect Programs Research Agenda***Alcohol Policies/Programs*

Research recommendations extending beyond highway safety to look more broadly at alcohol control policies and programs include studies of underage drinking, patterns of alcohol use and sale, methods of sale, effectiveness of efforts to control availability (including price), and enforcement of alcohol control laws. In addition, more situational and contextual information is needed on the impact of availability and other control issues and on methods to increase the effectiveness when implementing innovative ideas and getting new legislation adopted.

*Transportation Policies/Programs*

Various research ideas to improve the safety of the transportation system include safer vehicles and roads. Graduated licensing, raising the driving age, provision of an alternative transportation subsidy at drinking establishments, and designated driver evaluation were all discussed.

## **ALCOHOL AND OTHER DRUGS IN TRANSPORTATION: RESEARCH NEEDS FOR THE NEXT DECADE**

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This report is the synthesis of ideas presented at a workshop organized by the Transportation Research Board of the National Research Council at the Beckman Center in Irvine, California, July 27-29, 1992. The 51 conference participants included representatives of the research community, the transportation industry, and the government agencies that are funders and users of the research discussed. These agencies included the Department of Transportation, Office of Drug Enforcement and Program Compliance; the National Institute on Drug Abuse; the Office for Substance Abuse Prevention; the National Institute on Alcohol Abuse and Alcoholism; the National Highway Traffic Safety Administration; the Federal Highway Administration; and the National Transportation Safety Board.

### **WORKSHOP PURPOSE**

The goals of the workshop were to (a) identify the extent and sources of progress in reducing the incidence of alcohol and other drugs in transportation accidents in all modes, gaps in the knowledge base, and opportunities and needs for future research; and (b) establish research priorities for the next decade. The proposed research agenda identified at the workshop is intended to provide guidance and data that can be used by the U.S. transportation industry; federal, state and local government agencies, including law enforcement, the judiciary, and the rehabilitation community; and safety advocates and others interested in further reducing the role of alcohol and other drugs in accidents.

This report is the product of the workshop. Research needs are identified and the coordination of this research among relevant private and public organizations and agencies that will support and/or conduct research in this field is discussed.

### **WORKSHOP ORGANIZATION**

The workshop was organized into six sessions:

- Overall trends in the coming decade,
- The transportation workplace,
- Effects of alcohol and other drugs on performance,
- Detection and enforcement,
- Deterrence, and

- Prevention.

Background papers, which reflected the current state of the art and outlined research issues to be addressed, were developed for each of the topic areas. The background papers are included in Appendixes A, B, C, D, E, and F. In addition, discussants for each topic area were asked to prepare comments on the background papers. Finally, open discussion introduced additional issues and research agendas.

This report presents a summary and synthesis of the issues and ideas discussed at the two-and-a-half-day workshop. The issues and research questions were purposefully crystallized into a research methods framework that transcends territorial boundaries for two major reasons. First, the information presented was broad and diverse. Numerous research needs were identified, from macro-level research programs of the relative interplay of countermeasure systems to specific micro-level analyses of particular interventions. It was evident, however, that sufficient resources are not available to address all these research ideas. Second, since many of the research needs are common to several groups/sectors (e.g., the transportation industry and criminal justice researchers), it is most reasonable that each group not fund and initiate their own similar and overlapping research independently.

For these reasons it was important to set out the following guiding principles for identifying and ranking the proposed research initiatives.

The first principle voiced by a number of participants is that the primary focus of the research should be on the reduction of deaths and injuries caused by alcohol and drug-related accidents. (It should be noted here that prevention of property damage and environmental catastrophe is also an important goal. It is assumed, however, that any efforts to reduce deaths and injuries would also have the effect of preventing these negative consequences.) Although this principle may seem obvious, some of the research ideas were either so broad or so narrow that the impact on deaths and injuries would be very limited. Hypothetically, one might argue that any question that advances knowledge is worth researching. However, the reality of limited resources available for research in the next decade will force researchers and funding agencies to look long and hard at what projects have the potential to provide the greatest benefit in relation to cost.

The second principle is that alcohol and drugs in

transportation should be viewed within a broader context. In particular, the criminal justice approach has strongly dominated the research on intervention strategies at the expense of other approaches, notably the public health approach. Concern about the link between alcohol and drugs in transportation should be integrated into and become a component of decision-making processes in other systems that could have an impact on alcohol, drugs, and transportation, such as alcohol and transportation regulation, transportation design, health education, and so on. It is important to point out that the focus on the criminal justice system resulted in part from the desire to avoid restricting the freedoms related to either drinking or driving. Instead, public policy attempted to separate the two activities. The consensus, however, was that no further net safety benefits could easily be realized without going beyond the criminal justice approach. Thus, alcohol and drugs in transportation must become a political, public, and economic issue.

The third principle that was emphasized by a number of participants is not to reinvent the wheel. Some of the research questions presented could be answered by simply reviewing the international literature on the topic. It is common that reviews of research topics include only American studies, although much of the research outside the United States is directly relevant and applicable in the United States. A number of the research questions posed already have been or are being addressed in other countries. Resources could be expended more fruitfully on research projects for which there are major gaps in knowledge or which are strongly culturally bound.

The fourth principle, related to the second and third, is to collaborate more effectively across disciplines, funding agencies, states, and nations. Again, the limited resources for the future should preclude territoriality. Piggy-backing research to meet multiple objectives is the ideal. As a number of researchers pointed out, there is a wealth of literature on, for example, community-based strategies, health promotion, and the dynamics of social change that has not yet been diffused into the traffic safety field. Furthermore, three separate federal agencies are charged with addressing various aspects of problems related to alcohol and drugs in transportation. The agencies, National Institute of Alcohol Abuse and Alcoholism, National Institute of Drug Abuse, and National Highway Traffic Safety Administration, are chipping away at the common problem (i.e., reducing alcohol- or drug-related traffic injuries and deaths). More consistent interagency communication and cooperative efforts on this problem are needed.

The fifth principle, which also relates to the previous two, is that research projects should attempt to use

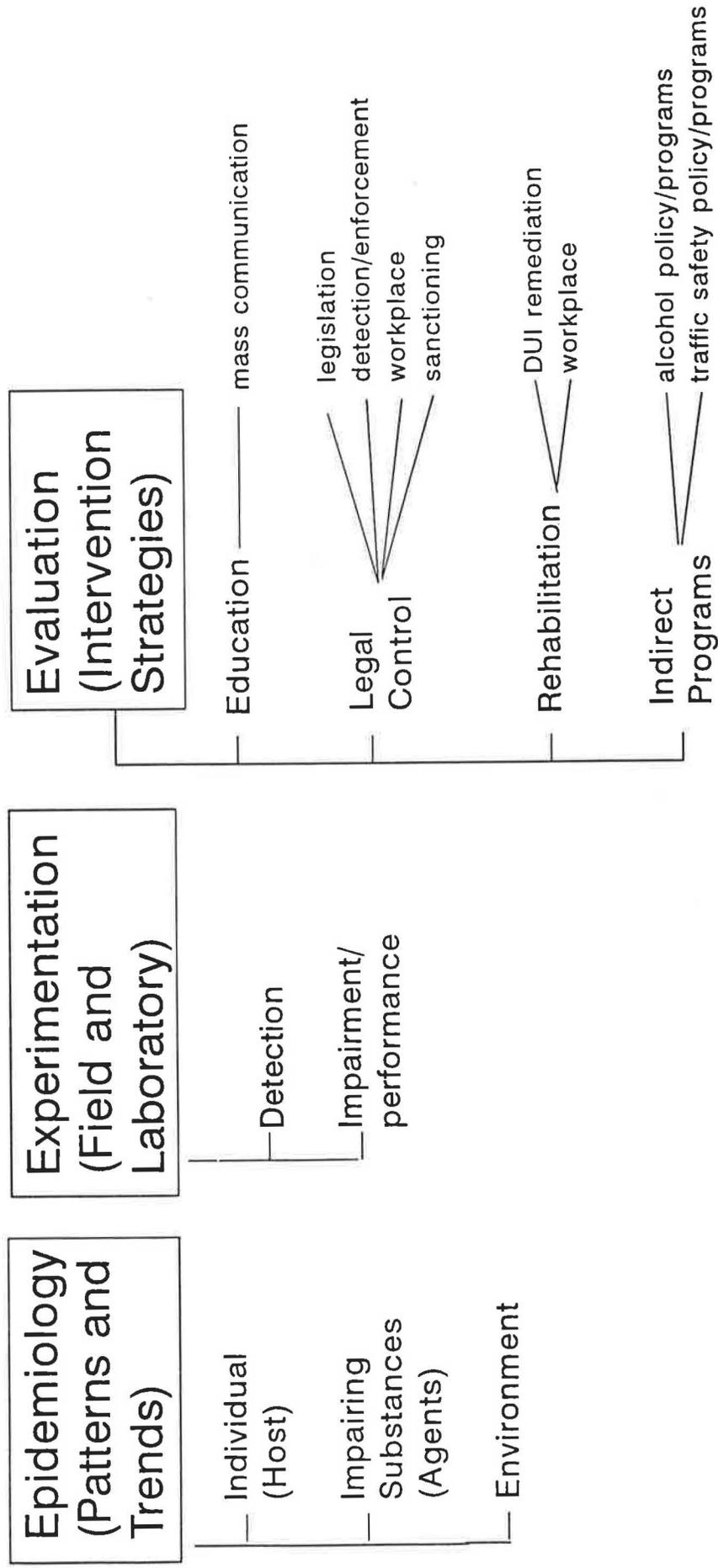
unifying and common methodologies and measures to maximize comparability of data, minimize repetition of studies, and ensure that the research offers the greatest knowledge both nationally and internationally. A recent workshop in Italy culminated with a book on methodology in drugs and traffic safety research that could provide guidelines on research methodology (see reference list).

The sixth principle is that much can be learned from a number of long-term programs on tobacco use, diet, exercise, and even drinking and driving, which have seen reductions in harm-producing behaviors. Researchers and policy-makers should learn from and build on these successes.

The seventh principle relates to finding more effective ways to disseminate and implement research findings. The current wealth of available information has not always been translated into interventions. In addition, some interventions that are promoted, such as driver education, are not justified on the basis of research findings. Therefore, it is important that research findings be disseminated and presented in formats that are easily accessible to a broader spectrum of constituencies.

The research agenda as presented at the workshop encompasses the three research "E's," epidemiology (patterns, trends, and etiology of behavior), experimentation (field and laboratories), and evaluation (intervention strategies). Figure 1 shows the specific topics within each research area. All the topics addressed in the workshop fall within this broad general picture. A fuller understanding of the problems of alcohol and drugs in transportation—both the overall magnitude and the contributory role various substances play in accidents, and the risks—can only be obtained through the pursuit of two complementary research approaches: epidemiology and experimentation. Epidemiological research examines the incidence and prevalence of substance use and abuse in various subpopulations to determine the magnitude of and factors related to the problem. Experimental research identifies the substances and the precise nature of the impairment. Epidemiology provides guidance to experimental research by identifying substances present in vehicle operators and pedestrians involved in accidents. Finally, experimental and epidemiological research provides the foundation for the development of intervention strategies. Fundamental to all intervention should be evaluations of its impact. Thus, the final research "E," evaluation, provides society with the best methods by which to reduce the problems associated with alcohol and other drugs in transportation.

FIGURE 1 Alcohol, drugs and transportation research agenda morbidity/mortality prevention.



## EPIDEMIOLOGY (PATTERNS AND TRENDS)

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Epidemiology focuses on factors that are especially pertinent to the occurrence of accidents. The approach is used to describe the frequency, distribution, and trends in alcohol and drugs in transportation, especially in large populations, and to organize the search for factors associated with increased incidence.

Accidents are caused by a combination of forces from at least three sources: (a) the individual (known as the host), (b) the impairing substance (the agent), and (c) the environment in which the host and agent are found together (Haddon 1964).

### ISSUES

The epidemiologic area was reflected in the presentations and discussion on the historical trend and overall trends in the coming decade. A number of changes occurred in the last 10 years that were not predicted. For example, legislative changes have occurred whereby in the United States the number of states with a 21-year minimum drinking age has increased from 17 to 50. The number of states with a BAC of .10 as a basis for a driving under the influence (DUI) arrest has increased from 25 to 47, and the number of states with administrative license revocation has increased from 6 to 32.

Changes have also occurred in trends. First, in 1981, there were approximately 25,000 alcohol-related fatal crashes; in 1991, that number was 19,900. This represented a decrease from 57 percent to 48 percent of total crashes involving alcohol. Furthermore, 10 years ago approximately 1.1 million arrests were made for impaired driving. This number increased and plateaued around 1.8 million for the past decade. Alcohol consumption has decreased from about 2.1 gallons of ethanol per capita to 1.9 gallons per capita.

An assessment of these historical trends suggested a number of guiding principles to steer the epidemiological research agenda.

The first principle is that research should be planned to anticipate future trends and not be based on the past or present. An added corollary was that this could mean discontinuation of old studies that are not currently relevant.

The second principle is that the world 10 years from now is likely to look rather different in terms of alcohol, drugs, and transportation in ways that are both predictable and unpredictable. As a consequence, research planning should be flexible. The research to be planned should be broad enough that it does not postulate a static set of questions or assumptions, or a specific future path. Instead, the research planning should accommodate a number of differing potential futures.

## EPIDEMIOLOGICAL RESEARCH AGENDA

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### THE INDIVIDUAL (HOST)

The research ideas included both general population-based and special group studies. Recommendations were made to continue monitoring alcohol and drug use trends of the changing U.S. population. In particular, it is expected that an increasing number of women drivers, the aging of the population, and the increasing numbers of immigrants will change the demographic profile of road users. In the next 30 years, it is predicted that there will be a 1 percent increase in the population under 50 and a 74 percent increase in the population over 50. As a consequence, it is expected that there will be a shift from recreational use of drugs to medicinal use of drugs. Moreover, increasing cultural diversity will introduce different cultural values toward substance use.

Information on the prevalence of alcohol and, in particular, drug use among the road-using population in the traffic flow was also identified as seriously lacking. In the transportation workplace, a desire was expressed for information on "real-world" drug and alcohol prevalence rates by transportation modes, including an assessment of different occupational groups. Little information is currently available on the drug use of fatally injured road users and consequently no case-control studies are available to determine driver risk for various drugs. Drug-use information on nonfatally injured road users is similarly lacking. There is also a paucity of data on the crash rates of individuals undergoing treatment for substance abuse, or on users of prescription drugs known to cause impairment. These groups could be at heightened crash risk. Finally, information is needed on the psychological factors related to substance use and driving and on the causes of drug-impaired driving.

Recommendations are as follows:

1. Continue to examine alcohol and drug use trends of the changing U.S. population, particularly with regard to women, the aging population, and immigrants.
2. Employ roadside surveys to determine alcohol and drug use among drivers in traffic flow.
3. Examine substance use in fatally injured drivers and pedestrians.
4. Use data derived from recommendations 2 and 3 to engage in case-control studies to determine which drugs at what concentrations are related to higher crash involvement in drivers.
5. In the transportation workplace establish "real-world" drug and alcohol prevalence rates for transportation modes, based on scientifically credible

research designs using multiple measures with representative employers. This includes assessing different occupational groups within each mode.

6. Examine substance use and abuse, driving records (i.e., previous impaired driving convictions), crash recidivism, and the like in crashed drivers and in injured drivers. Also examine injured pedestrians.

7. Survey driving records and self-reports of driving-related behavior of individuals undergoing treatment for substance abuse to obtain better crash-risk information. In particular, investigate which substances are related to higher crash risk.

8. Survey driving records and self-reports of driving-related behaviors of individuals using prescription psychotropic drugs.

9. Study the psychological determinants (e.g., attitudes, personality characteristics, etc.) of substance use and driving. The emphasis needs to be shifted to include the reasons people engage in drug use and combine it with driving.

10. Examine general deterrence, that is, who is deterred by threat of punishment and what other factors might deter them, to find some way to reach the hard to deter.

11. Examine the extent of recidivism both through self-reports and driving records of convicted impaired drivers.

12. Conduct intergenerational studies of DUI behavior to determine parental and family effects on transmission of values, role modeling, and the like.

### IMPAIRING SUBSTANCES (AGENTS)

Recent data suggest an overall decrease in alcohol consumption and a small shift away from spirits to beer and wine. There are predictions that with the aging population, illicit drug use will decrease and licit drug use will increase. These changes notwithstanding, it is reasonable to assume that there will continue to be substantial recreational use of alcohol and other substances in the future.

Consensus was that it would not be cost-effective to study the pattern and trends of all drugs because some drugs have waned in popularity and other drugs that may be popular 10 years from now may not even have been "designed."

Workshop participants recommended the continued monitoring, through different cost-effective means, of the trends of alcohol and other drug use, including new fad drugs.

## ENVIRONMENT

Environments may be physical, such as vehicles and roads, or social, such as families, cultures, norms, media, and so forth. Little is known about the environmental antecedents of drinking-driving behavior. For example, information is limited on the physical and social environments where drinking occurs among youth, and its impact on DUI. Issues that need to be reflected in environmental research should range from situational contexts of drinking to historical research profiling policy development.

### Physical

The consensus was that although computerized technology is being used in the development of intelligent vehicle highway systems (IVHS), few major changes are going to be seen in the next 10 years with vehicles and roadways. However, substance use should become incorporated as a component to be investigated in the research and development of IVHS.

Workshop participants recommended the integration of alcohol and drug use and abuse into the research and development of IVHS.

### Social

The social environment was viewed to be in need of much epidemiological research. For too long, drinking and driving has been viewed as criminal behavior instead of a natural consequence of a drinking and driving society. More information is needed on alcohol and transportation institutions, and the interplay of these factors with drinking-driving behavior.

Furthermore, consensus was that a much more complete understanding of the development, introduction, and implementation of public and institutional policies was needed. Wider use of other measurement methods was also required, in addition to conventional methods based on available records and population surveys. For example, only a few observational studies of drinking have appeared, most focusing on the effects of demographics, group size, crowdedness, and music volume on drinking rates, and in particular, on subsequent driving. Yet observational methods, focus groups, and the like can offer a wealth of information on patterns, trends, and relationships.

Recommendations are as follows:

1. Study trends and patterns of availability, transportation planning for licensing of drinking premises, and the like to understand the relationship with drinking-driving behavior.
2. Conduct observational studies of youth drinking, the locations in which drinking occurs, and the situational and contextual factors that contribute to or impede youth alcohol use, particularly in relation to drinking-driving behavior.
3. Study availability of alcohol to youth, including sources of alcohol, locations and patterns of youth drinking occasions, commercial and noncommercial providers of alcohol to youth, and dimensions of the social environment that support youth drinking.
4. Study the recent reductions in drinking-driving behavior to determine the factors involved in the reductions.
5. Engage in econometric analyses to quantify costs (and benefits) of drinking.
6. Examine attitudes toward drug use and testing.

## EXPERIMENTATION (FIELD AND LABORATORY)

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Experimental research focuses on determining the presence of a substance and the precise nature of the impairment, for example, discovering what psychomotor skills are affected, in what ways, by what particular doses of a substance. Both field and laboratory experiments define the behavioral effects of particular substances.

### ISSUES

Epidemiological data on crash-involved drivers and a few highly visible and catastrophic events in the transportation industry have generated new interest in the role substances play in performance and impairment. The introduction of transportation industry regulations governing the use of drugs has led to a massive drug testing system mandating 50,000 to 60,000 tests daily. In the workplace, drug testing serves three functions: (a) initial screening of job applicants to check fitness for duty, (b) random testing of staff to act as a deterrent, and (c) post-accident testing to determine the role of alcohol or other drugs. The simple detection of the presence of a drug poses less of a problem for testing than the determination of impairment.

Much discussion ensued concerning the practicality and methodology of fitness-for-duty determination, the generalizability of impairment measurements in the laboratory to conditions in the workplace, and the inclusion of additional drugs to the five already mandated for testing (cocaine, marijuana, opiates, amphetamines, and PCP). Central to the debate was whether the focus of the transportation industry should be on the simple detection of illegal substances in which impairment is presumptive, or whether the focus should be on fitness for duty. Performance was viewed as philosophically the most important criterion. However, inter- and intra-employee variability of performance, which could be caused by many factors independent of substances, makes this line of pursuit particularly problematic for management-employee relations. In addition, there seems to be a misrepresentation of what psychomotor tests measure, as performance goes beyond psychomotor skills to include such factors as judgment. Indeed, as one transportation representative stated, too much laboratory technology can be problematic because it gives a false sense of security to management that the problem is solved and lulls the management into not making decisions. Here, too, a number of general guiding principles emerged for experimental research on alcohol and other drugs in general.

The first is that experimental research should be related to the real world. As a number of transportation industry members and researchers stated, there is a need

to link laboratory results to field observational studies. For example, much experimental research on the effects of drugs on performance is based on single-dose models, with carefully titrated pure mixtures of drugs given to healthy volunteers with no other substances on board. These studies may not reflect actual driver and transportation operator realities, since these users are likely to use substances habitually and in combination, and may be impaired by other conditions, such as fatigue. Therefore, it is important for laboratory and applied researchers to collaborate.

The second principle, related to the first, is a call for the development of additional tests to better measure drug performance. Performance testing/fitness for duty is a complex issue involving many factors beyond psychomotor tasks, such as judgment and decision-making. It is important to make clear what these tests can and cannot do. For example, existing tests cannot measure the performance effects of cocaine. Thus, additional tests may need to be developed, which have good content, construct, and predictive validity.

A third principle is a call for more collaboration in the field. Currently, the research is being conducted by many different groups and is rather fragmented. Because of the almost universal nature of the physiological effects of alcohol and drug use on performance, this is one research area that is particularly conducive to international collaboration. This is especially important because it is impossible for one country to conduct the experimental research on every licit and illicit drug available. Collaborating internationally and with pharmaceutical industries may be a way to ensure that the proper experimental work is being carried out on the various drugs that are available.

A fourth related principle is that because a great deal of research has been carried out internationally in psychopharmacology, new research should only fill in the gaps in current knowledge. To this end, it was recommended that a review and synthesis of this large body of literature and identification of remaining major gaps in the body of information precede investment in new studies. A state-of-the-art review may ensure the greatest cost-benefit of research moneys spent.

A fifth principle is that the choice of drugs to investigate, both licit and illicit, should be based on prevalence of use and potential for impairment.

A sixth principle is that multiple-drug studies should follow single-drug studies because one cannot determine the significance of combinations without knowing effects of single drugs, and it is unlikely that two drugs in combination will cause impairment when neither drug used alone will cause impairment.

## EXPERIMENTAL RESEARCH AGENDA

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The two major issues for experimental research centered on the quick, simple, economical, and accurate detection of drugs in drivers and transportation operators and the relationship between performance/impairment and various drugs. For both the transportation industry and the criminal justice system, accuracy, defensibility, transportability (i.e., on-site testing), and simplicity of administration and interpretation (for transportation supervisors and/or police officers) were of prime importance.

### DETECTION

The detection of alcohol and drugs in drivers by both chemical and non-chemical means has always been of great interest in the criminal justice system. The development of the noninvasive breath analysis procedure for alcohol revolutionized the criminal justice approach to alcohol-impaired driving. The lack of similar noninvasive tests for other drugs has always been a hindrance to the detection and prosecution of drivers under the influence of drugs. Blood is still the most valuable specimen to determine level and recency of use and impairment, but the least available. Urine can only determine use or historical use, depending on the drug. Consequently, it is of limited value in the determination of impairment for many drugs. Saliva shows some potential for the detection of some drugs, but data are preliminary. Studies of analysis of hair samples are preliminary, and in any case can only yield information about history of use.

With the introduction of regulations on drug testing in the workplace and public concern over safety in public transportation, the transportation industries have become sensitive to alcohol and drug use by their operators and workers. The current system is under pressure from the industries to (a) allow on-site testing for economic reasons and for situations in which quick decisions by supervisors need to be made, (b) include more drugs, (c) lower the threshold rates, and (d) reduce the medical review of results. However, the unproven on-site testing technology and the ethical concerns of employers controlling testing maintain the current government policy regarding off-site testing.

Recommendations are as follows:

1. Identify analytic markers or metabolite ratios in body fluids to support determinations of recency of use.

2. Determine efficacy of on-site testing for the workplace. There is also a need to establish standards for the technology and acceptable procedures for implementation.

3. Develop a routine screening test to detect the presence of "in vitro" adulterants (substances that users add to samples in order to mask the presence of drugs). There is also a need to generate better tests for sample dilution based on temperature, specific gravity, and/or creatinine problems. Tougher consequences for such tampering are also needed.

4. Look at the potential for measures of long-term performance degradation to serve as indicators of drug use.

5. Develop other nonchemical detection methods using criteria such as attendance patterns, turnover, disciplinary action, medical costs, and frequency of claims, known to be strongly associated with substance use.

6. Examine the appropriateness of models such as the Los Angeles Police Department's Drug Recognition Expert (DRE) Program to be used by supervisors as an indication of drug impairment.

7. Evaluate drug testing process to determine how and why up to 20 percent of specimens are improperly collected.

### IMPAIRMENT/PERFORMANCE

Drugs, impairment, and performance were major issues of discussion and philosophical debate. Issues centered on how impairment should be measured, causes of performance impairment (not just by drugs but by tedium, fatigue, etc.), validity of current laboratory and field tests of performance and impairment, inability to perform daily fitness-for-duty tests on inaccessible transportation workers (e.g., truckers, mariners), inter- and intra-worker performance variability, and cost-efficiency of testing, to name a few. Recommendations included developing a better battery of performance tests, including such measurements as speech energy patterns, that could be used both by researchers in identifying various types of impairment and by supervisors in the workplace in making determinations of fitness for duty (speech-related testing could be carried out remotely over radio or telephone). Another recommendation was to develop nonimpairing pharmacological alternatives to increase vigilance (e.g., "stay-awake" pills).

The research ideas for which there was consensus focused on a number of drugs and issues. The suggested research approach was first to engage in laboratory studies to determine the pharmacokinetics, followed by driving simulator and on-the-road field studies. Although the impairment effects of alcohol have been well researched, a number of gaps in knowledge in the area merit investigation. Marijuana, cocaine, and prescription drugs should also be investigated because of their popularity and the general lack of knowledge of their impairing qualities.

Recommendations of the workshop participants follow.

1. Under alcohol, investigate the following:
  - a. Tolerance,
  - b. Low BACs with inexperienced, infrequent drinkers and chronic, heavy drinkers,
  - c. Alcohol-drug combinations,
  - d. Hangover effects,
  - e. Alcohol-aging interaction, and
  - f. Effects on the young driver.
2. For marijuana, examine the following:
  - a. The effects of high tetrahydrocannabinol (THC) content marijuana,
  - b. The duration of marijuana effects,
  - c. The effects on driving skills of high THC marijuana in combination with alcohol, and other popular drug combinations,
  - d. The effects on of marijuana on young (adolescent) drivers, and
  - e. The relationship of blood/urine levels to performance effects.
3. Under cocaine, study:
  - a. The effects on performance, with the first priority to define what variables should be measured, because current performance tests used for other drugs are not able to capture the type of impairment caused by cocaine.
4. For prescription drugs, examine the effects of prescription and over-the-counter (OTC) medication systematically, including the following:
  - a. Acute-dose studies with healthy volunteers to specify drug effects per se,
  - b. Acute- and chronic-dose studies with patients to clarify the net effect of drug-disorder interactions, and
  - c. Dosing regimens that represent typical therapeutic use.
5. Determine the efficacy of developing a "per se" indication of impairment for drugs other than alcohol. Establish an accepted format/design for measuring performance impairment and include single-dose, multiple-dose, and multiple-drug studies.
6. Pursue performance impairment tests, such as Critical Tracking Test (CTT), to determine if they may have value as (a) an independent performance impairment determination, or (b) a device to evaluate dose-related drug impairment levels.
7. Link laboratory performance impairment results to each other (e.g., divided attention tasks, critical tracking tasks), to simulators, and to field observational studies.
8. Develop "fitness-for-duty" tests that are valid, cheap, quick, and transportable.

## EVALUATION (INTERVENTION STRATEGIES)

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The identification, through epidemiological and experimental research, of behaviors and environments that increase risk of accidents normally leads to the development and implementation of policies, regulations, and programs. Evaluation should be integral to the development and implementation of any such strategy. Unfortunately, this is generally not the case. Often, when evaluation is included, it is considered as an afterthought. Evaluation is necessary to ensure that (a) the policy or program is having the intended effect, rather than no effect or a negative effect, (b) the policy or program offers the greatest cost-benefit, and (c) the integrity of a successful policy and program can be maintained and expanded.

Intervention strategies have been traditionally classified under the following approaches: education, legal control, rehabilitation, and indirect means.

### ISSUES

The presentations that were made and the discussions that ensued on intervention strategies clearly indicated that much of the intervention focus in the United States has been on the road-using, drinking driver and within the criminal justice system. Education and rehabilitation have also been used as means to reduce drinking-driving behavior, but much less successfully. The new intervention areas that have emerged most recently in the drinking-driving area are public health, alcohol policies, and transportation policies. Furthermore, a new group, transportation workers, and related to this group, drugs other than alcohol, also have surfaced as important new foci for intervention. The related research and knowledge base for these areas is less well developed than in the traditional educational, legal, and rehabilitative approaches to drinking-driving.

As with the other two research approaches, the discussions identified a number of principles to guide the evaluation research agenda.

The first principle is that evaluation should be built into the policy or program from the beginning. Although many ad hoc evaluations have been carried out on "natural experiments," it is preferable to have the evaluation planned from the beginning because more

and better data can usually be gathered.

A second principle is that evaluation ideally should not rely on only one measure of effectiveness. It is preferable to include both process and outcome measures and intermediate and criterion measures. This allows the researchers to not only speak to the success or failure of a particular intervention, but to articulate where, how, and why problems (if any) occurred and what improvements could be made.

A third principle is that in the drinking-driving intervention areas of education, legal control, and rehabilitation, additional research should be carried out only where there are real gaps in knowledge. Here, as in the psychopharmacology area, much international research has been carried out that provides sufficient information on countermeasure successes and failures. It is not necessary to implement and evaluate again countermeasures that have been proven unsuccessful.

A fourth principle expressed by a number of participants is the need for "synergism" of alcohol, drugs, and transportation intervention strategies. As one researcher put it, "future prevention research should examine the interaction and mutual reinforcement of, say, DUI enforcement and alcohol sales to minors or responsible beverage service, parents training and mobilization, and underage drinking.... To date, much of our research has focused on determining the effectiveness of a single isolated prevention strategy or countermeasure. This is necessary to determine the efficacy of that single strategy or countermeasure. However, there is reason to hypothesize that the combined effect of two or more strategies can exceed the sum of the two as separate strategies due to their mutual reinforcement."

The final principle is that some granting or funding system should be introduced to allow researchers to take advantage of natural experiments. It is often impossible to determine well in advance legislative and policy changes. Given the lead time required to apply for grants, it is generally very difficult to have funding in place for a prospective evaluation of a natural experiment. This means that much useful information will be lost, reducing our ability to determine which interventions are successful.

## EVALUATION RESEARCH AGENDA

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### EDUCATION

Traditionally, education encompasses specific education, such as school-based programs and driver education; mass communication, such as public information campaigns and advertising; and informal education, such as parental and peer dissemination of information and values.

Education research focused on the area of mass communication. Both public information campaigns and alcohol advertising were identified as areas limited in their knowledge base and in need of further research. Public information campaigns are competing with other social causes; thus, mass media coverage of drinking and driving news has decreased. Pro-drinking messages have increased in the form of advertising, promotions, paid placements, and public relations. Furthermore, alcohol advertising is not likely to be banned, although additional controls may be implemented, making the development of effective countermeasures an important avenue for intervention and study. One area that was mentioned in passing, but bore some merit, was the use of parents in education.

Recommendations on education are as follows:

1. Investigate organized mass communication campaigns on multiple variables, including media coverage, penetration, message, and impact on drinking-driving behavior.
2. Develop a better understanding of the effects of alcohol advertising (especially among youth).
3. Assess what controls on alcohol advertising can accomplish the objective of reducing drinking-driving behavior.
4. Evaluate counter-advertising and media advocacy campaigns related to alcohol and drugs in transportation.
5. Analyze changes in perception of risk and social disapproval in relation to public information campaigns.
6. Analyze individual versus collective messages of public information campaigns.
7. Develop and evaluate creative methods aimed specifically at using parents as the educators of their children on issues related to alcohol, drugs, and driving.

### LEGAL CONTROL

The legal control system is based on deterrence theory, which postulates that sure, swift, and severe punishment should inhibit individuals from engaging in a particular

sanctioned activity. Both the workplace environment and the system of traffic laws and enforcement function on the premise that the threat of detection and punishment should act as an effective deterrent. Major changes have occurred in traffic laws and enforcement over the last 10 years with regard to drinking and driving. As one presenter stated, "The 1980s can be characterized as a decade of 'tougher' DUI laws and sanctions as well as attempts to correct identified deficiencies in the processing of DUI offenders." During this time, the United States did see major reductions in alcohol-related traffic fatalities. The participants raised the issue, however, that despite the large amount of research that has been carried out on traffic laws and enforcement, in some cases there is still not enough information for governments and communities to make appropriate policy changes. Thus, the research questions that were introduced reflect the need to fill gaps in knowledge.

### LEGISLATION

In the 1980s, states introduced many and varied legislative changes. Yet the relative efficacy of some of these changes is unknown.

The recommendation of the workshop participants is to compare and evaluate selected legislative initiatives begun in the 1980s and currently in place in several states.

### DETECTION/ENFORCEMENT

Detection and enforcement were perceived as important components to deterrence. The research questions focused mainly on researching ways to improve and streamline detection of impaired drivers and enforcement of drinking-driving laws. Participants identified a number of barriers to arrests of impaired drivers. These related to police department attitudes toward the relative importance of impaired driving enforcement among their duties, paperwork required for arrests, long processing time, and shifts to community-based policing with a concomitant reduction in personnel deployed for traffic enforcement. One discussant suggested that detection was inefficient and costly. Therefore, the challenge was to make impaired drivers more detectable, using methods such as detection cues, passive breath testers, and external marking of vehicles driven by convicted offenders with stickers or

special license plates. In addition, some participants felt that the emphasis of research in the area of enforcement should be on the prevention of alcohol-related crashes instead of on the fine mechanics of enforcement. Both macro- and micro-level research projects were recommended.

A number of recommendations focused on increasing arrests and affecting other behaviors such as crashes:

1. Study the impact of the new community-based policing approach on drinking-driving arrests.

2. Determine how much "detection," and by what means, is required to produce deterrence.

3. Evaluate the effects of special license plates in increasing the detectability of reoffenses by convicted impaired drivers.

4. Assess alternative law enforcement strategies, such as detection cues and/or passive sensing devices, and "zero tolerance" laws for youth (which decrease the legal BAC for youth to any detectable amount of alcohol).

5. Examine the impact of checkpoints by developing and evaluating a model that describes the processes and mechanism by which checkpoints influence the behavior of drinking drivers and produce a reduction in alcohol-related crashes. This model should include input factors that determine the nature of the checkpoint operation, and output measures to evaluate the activity generated at a checkpoint, public information, perceived probability of arrest, reported changes in drinking-driving behavior, and reduced alcohol-related crashes.

6. Enforcement absorbs resources but also may increase revenues through fines. Research might examine the impact of self-sufficiency funding on participating departments. Impact should include not only overall enforcement levels, but effects on the characteristics and strategies of department-wide enforcement efforts and their impact on traffic safety.

7. Study the determinants of police impaired-driving investigation following a crash. Determine methods to increase DUI arrests of impaired crashed drivers.

8. Track arrest rates, state by state, over time; identify reasons for state-to-state variance.

9. Compare the characteristics of arrested drivers as a function of

- a. Type of arresting department;
- b. Division, assignment, mission, and training of arresting officer within department; and
- c. Type of police activity (e.g., impaired driving patrol, regular patrol, injury crash investigation, property damage crash investigation, sobriety checkpoint, saturation, stakeout).

10. Identify differences, particularly population

differences, between impaired drivers detected through checkpoints vs. those detected through regular patrols to determine net traffic safety impact.

11. Investigate the impact of driver's licenses with magnetic computer strips on the issuing of tickets by police officers.

12. Investigate the impact of citizen reporting of DUI programs.

13. Study the effect of increased impaired driving enforcement (particularly high visibility enforcement) on other alcohol problems, especially violence.

Additional recommendations focused on policing and processing methods and systems:

1. Develop and evaluate more effective social marketing and training techniques to ensure that new policies and technologies are accepted and implemented by police departments and staff.

2. Determine appropriate impaired driving detection cues for young drivers for .05 BAC and .08 BAC.

3. Examine the underlying determinants of conduct of checkpoints, saturation, and/or impaired driving patrols.

4. Examine the effects of operating environments in which regular patrols hand-off arrested drivers to arrest processing specialists.

5. Evaluate the application of new technologies in various enforcement environments. Study should distinguish current state-of-the-art equipment from earlier or first-generation equipment that may have been deployed in the past and may still be in use today.

## WORKPLACE

The primary issue for the workplace centered around the high cost of testing and the need to determine the minimum testing rate to achieve deterrence. There was also discussion of using detection methods other than testing, such as identification by peers.

Recommendations are as follows:

1. Determine the optimum random testing rate to maximize deterrent effect. This includes examining the optimum level for different occupations.

2. Examine and evaluate methods to encourage peer reporting.

3. Examine ways to encourage the use of technology, such as breath-testing equipment, "dipstick" alcohol test, and so forth, which could be used in transportation to detect alcohol.

## SANCTIONING

A major function of sanctions is to provide general and specific deterrence, yet the effects of some sanctions in use have not been examined.

Recommendations are as follows:

1. Develop sanctioning guidelines that link the seriousness of the offense with the severity of the sanction, and conduct a process evaluation.
2. Develop and evaluate a sliding scale for the imposition of fines that includes both the severity of the offense and the income level of the offender (like Sweden's day fine), and develop an effective collection mechanism.
3. Impound vehicles of those who drive with suspended licenses, and evaluate the effects.
4. Develop and evaluate combinations of treatment, licensing sanctions (such as graduated relicensing), special plate identification, and active probation with different offender types to determine the most effective program combinations.
5. Assess who is affected by license revocations and what is the most effective length of suspension.
6. Examine the relative effectiveness of different methods of license revocation.
7. Investigate the determinants for overcrowded courts and devise and evaluate more effective court handling of impaired driving cases.
8. Investigate the effects of other sanctions, such as victim restitution and community service.
9. Examine the effects of technological/driving restraint options, such as interlock devices.
10. Study the effects of insurance sanctions and social stigmatization.

## REHABILITATION

Questions in the area of rehabilitation, for both the workplace and drinking drivers, focused on developing better methodologies for, and measuring the effectiveness of, the varied program rehabilitation options.

## IMPAIRED DRIVING REMEDIATION

Despite the wealth of research that has been conducted on remediation programs, many questions are still unanswered because of poor assessment methods, poor methodology, weak evaluations, and little documentation of the decision points and processing within the

institutional system. However, in the drinking-driving arena, an even more fundamental question was raised that requires resolution. As one discussant stated, "Looking at macro-level effectiveness, what is the overall potential of individual reform measures?...to influence traffic safety." Some literature posits that even with 100 percent effectiveness of individual reform measures of all types, less than 5 percent of total alcohol-related crashes would be prevented over a one-year period because 95 percent of all alcohol-related crashes involve a driver with no impaired driving convictions. Other fatality data show that almost 35 percent of alcohol-related crashes involve a driver with a prior conviction. Whether these differences are due to reductions in plea bargaining in many states or to a proportional increase in crashes involving previous offenders is unclear. Thus, a thorough cost-benefit analysis of remediation should be undertaken to determine the overall impact on traffic safety.

On the micro-level, there were also comments on, as one discussant stated, "the lack of imagination given to treatment options for driving-while-intoxicated (DWI) offenders and a lack of consideration for individual differences." Other specific issues centered around the paucity of process evaluation, so that little information can be gleaned from the reports on implementation, program characteristics, and so on. Therefore, it is vital to engage in remediation research that is broad in vision, innovative, and will eliminate the programmatic and methodological problems of the past. One innovative technique that was mentioned is the use of biochemical markers for the monitoring and relicensing of habitual offenders.

Recommendations are as follows:

1. Conduct a cost-benefit analysis based on accurate and thorough record systems and an assessment of the various plea bargaining changes under various assumptions of effectiveness.
2. Continue research on the efficacy of matching offender characteristics to interventions. Identification of appropriate assessment materials should be an integral part of this research. Consider matching not only on alcohol problem indices but on other variables such as driving behavior, social, family, and life circumstances, sociodemographic factors (e.g., age, gender, etc.), and polydrug use.
3. Test the relative efficacy of programs combining rehabilitation strategies with technological/driving restraint options such as vehicle interlocks, home monitoring, and vehicle impoundment/plate confiscation, especially for habitual offenders.

4. Examine possible adaptations of European medical monitoring/relicensing programs for habitual offenders. This could include assessment of the utility of biochemical markers in the U.S. offender population.

5. Adapt and test promising approaches from the general alcohol treatment field for impaired driving offenders. Include options such as community reinforcement and family intervention that have been previously untested for impaired driving offenders.

6. Develop and test nontraditional options for underserved subgroups. Consider options that could become community based and that could create new support systems for alternative behaviors to drinking and driving for underserved high risk groups. Investigate the dissemination of such programs to similar but broader populations that potentially include undetected drinking drivers at high risk of accident involvement.

7. Identify mechanisms for expanding affordable and appropriately diverse options for remediation within various types of communities and for disseminating promising new options to diverse communities. Take into account demographics and social trends in the development of ranges of intervention options.

8. Exploit ongoing treatment research by explicitly examining impaired driving offenders as a subgroup of existing samples in alcohol treatment facilities.

9. Develop instruments with high criterion validity to set standards for assessment/screening based on research. Evaluate the differential validity of assessment devices.

10. Explore the interface between intervention and the legal/judicial system (e.g., the impact of length of time between arrest and the intervention referral by the courts) in terms of its effect on intervention efficacy. Evaluate programs designed to improve the interface (e.g., reduce arrest/referral delays).

11. Increase interagency cooperation and coordination of research on intervention and screening for impaired driving offenders. Examine the extent to which DUI offenders constitute a high-risk group that is frequently involved with a variety of systems, including the criminal justice system and the health care system. Facilitate interagency research to design and evaluate innovative approaches to intervention with this group.

12. Develop and evaluate intervention strategies for convicted impaired driving offenders that focus on changing the environment or the life circumstances of the offender in ways that would reduce the environmental causes and maintainers of drinking and driving.

13. Develop and evaluate intervention strategies for crashed drivers as new data are showing that crashed drivers are at increased risk of recrashing.

## WORKPLACE

Little information is available on the effectiveness of employee assistance programs, treatment programs, and the long-term maintenance of sobriety. This area was identified to be of prime importance.

The recommendations of the workshop participants is to conduct studies of return-to-duty success. Control for treatment type, degree of alcohol/drug problem, and the like. Identify relapse failure rates at six months, one year, and two years. Attempt to ascertain predictors of short-term and long-term success to assist with policy formulation.

## INDIRECT PROGRAMS

Indirect programs include any policies and programs that would reduce alcohol consumption through methods such as limits on availability, increases in road safety through driver licensing restrictions and vehicle and road engineering, and education on safety-related issues such as seat belts. Unfortunately, the general public and political system in the United States have not been inclined to accept controls in the alcohol and transportation arena. Consequently, there is a paucity of U.S. information on the effects of various control policies on impaired driving behavior.

## ALCOHOL POLICIES/PROGRAMS

Alcohol control policies is one area for which there are many options to be explored. As one resource paper author wrote, "The field of traffic safety research, which has concentrated on reducing the number of drinking-driving crashes, injuries, and fatalities has primarily emphasized driving decisions, (e.g., threat of enforcement, conviction, and sanction if one drinks and drives). There has not been an equal emphasis on drinking prior to (or even concomitant with) driving.... There is clear evidence...that strategies for alcohol problem prevention affect alcohol-involved traffic crashes. This has been shown in such alcohol policy areas as the minimum drinking age, changes in alcohol availability, alcohol prices, etc."

Areas identified to be in need of research centered on alcohol availability, including site of purchase and use, type of alcohol, price, dramshop liability, and server intervention programs. In addition, a number of social marketing issues and proposals regarding the dynamics of social change were mentioned.

Recommendations of the workshop participants are as follows:

1. Study the dynamics of social change. In particular, examine the introduction, dissemination, and diffusion in society of public, social, and institutional policies in the alcohol, transportation, and alcohol, drugs, and driving areas; the current status of impaired driving as a social problem; the competition of impaired driving with other causes; the diffusion and dissemination of specific policies in a community and across communities; the factors triggering an expanding agenda; the factors leading up to public interest and advocacy for legislative changes; and how legislation gets adopted.

2. Examine how multiple interventions interact with each other and with broader social conditions and movements.

3. Determine how communities can be mobilized to change institutional structures and practices around alcohol and vehicles.

4. Assess and evaluate methods to increase the odds that positive changes in public and institutional policies and practices are implemented.

5. Investigate the effect of changes at the local level of density and location of alcohol outlets on alcohol-involved traffic problems.

6. Examine the traffic safety impact in states that have undergone dramatic changes in the exposure of licensed establishments to legal liability during the past 20 years.

7. Study actual behavior of the specific licensed establishment managers and owners in response to their perceptions of the liability risks in their state.

8. Gather information about the relationship between liability as defined by statutory case law, the perceptions of owners and managers about the level of liability, and the actual changes in specific serving practices.

9. Study the effect of designated driver programs on drinking and driving and other health-related behaviors.

10. Evaluate the effects of the introduction of low- or no-alcohol beverages in the United States on the drinking environment and impaired driving.

11. Continue to evaluate the long-term effectiveness of warning labels on alcohol-beverage containers.

12. Study the effects of density of alcohol beverage outlets, controlling for alcohol price effects, local markets, and income effects on alcohol consumption, and determine the relative costs and benefits of the effects of changes in outlet densities upon alcohol consumption and problems.

13. Investigate "natural experiments" as they arise, such as increases in alcohol taxes. Include measures on the sensitivity of different drinkers and ages to price changes.

#### **TRAFFIC SAFETY POLICIES/PROGRAMS**

One area that has not been seriously explored in terms of alcohol, drugs, and transportation is traffic safety controls. However, as one discussant commented, it is important to look at "the other side of prevention—transportation—and get people out of cars." A limited number of policy and research initiatives were offered.

Recommendations are as follows:

1. Introduce and evaluate graduated, provisional, and probationary licensing systems.

2. Evaluate which drivers are and are not affected by provisional licensing programs.

3. Study the effects of increased gas taxes on traffic volume/exposure and crashes.

4. Investigate alternative transportation systems for licensed establishments, such as transportation subsidies.

5. Consider raising the driving age and evaluate the effects.

## CONCLUSIONS

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It is clear that within the research approaches of epidemiology, experimentation, and evaluation, there is yet much work to be done. It is also clear that, due to limited funding, not every research idea presented here can and will be carried out in the next decade. Now is the time to break through territorial barriers and start working in a synergistic and creative manner on projects and programs designed to answer multiple questions and on projects funded by multiple sources.

Unless funding agencies, industries, researchers, and communities start coordinating the efforts to fill in gaps in knowledge and include the broader range of issues that affect alcohol, drugs, and transportation problems, the research efforts will fail to answer urgent questions. If, however, these collaborative ideas are realized in the next decade, the United States will have developed powerful tools for reducing drug and alcohol problems in transportation.

## APPENDIX A

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### PROGRAM OUTLINE FOR THE WORKSHOP ON ALCOHOL AND OTHER DRUGS IN TRANSPORTATION: RESEARCH NEEDS FOR THE NEXT DECADE

National Academy of Sciences Beckman Center  
Irvine, California  
July 27-29, 1992

#### Sponsored by:

Transportation Research Board Committee A3B10  
Alcohol, Other Drugs, and Transportation  
National Research Council Committee on Drug Use in  
the Workplace  
National Institute on Drug Abuse  
National Highway Traffic Safety Administration  
Department of Transportation Office of Drug  
Enforcement and Program Compliance  
Office for Substance Abuse Prevention  
National Institute on Alcohol Abuse and Alcoholism

#### Monday, July 27, 1992

- 8:00 - 10:00 am Continental Breakfast and  
Workshop Registration
- 10:00 - 10:30 am **Welcome and Discussion of  
Workshop Format and Objectives**  
Barry M. Sweedler, Workshop  
Chairman  
Evelyn Vingilis, Ph.D., Workshop  
Coordinator
- 10:30 - 12:00 **Session 1 - Overall Trends in the  
Coming Decade**  
Presentation by:  
James Hedlund, Ph.D.  
Discussion by:  
M.W. Bud Perrine, Ph.D.  
Patricia F. Waller, Ph.D.
- 12:15 - 1:15 pm Buffet Luncheon
- 1:30 - 5:00 pm **Session 2 - Transportation  
Workplace**  
Presentation by:  
George M. Ellis  
Discussion by:  
J. Michael Walsh, Ph.D.  
Robert Knisely  
Steven W. Gust, Ph.D.  
Jacques Normand, Ph.D.

#### Tuesday, July 28, 1992

- 8:00 - 8:30 am Continental Breakfast
- 8:30 - 10:00 am **Session 3 - Effects of Alcohol and  
Other Drugs on Performance**  
Presentation by:  
Marcelline Burns, Ph.D.  
Discussion by:  
James F. O'Hanlon, Ph.D.  
Merritt Birky, Ph.D.  
Hans Laurell
- 10:00 - 10:30 am Break
- 10:30 - 12:30 pm **Session 4 - Detection &  
Enforcement**  
Presentation by:  
David F. Preusser, Ph.D.  
Discussion by:  
Adrian K. Lund, Ph.D.  
Robert B. Voas, Ph.D.  
A.J. McLean, Ph.D.  
James Hedlund, Ph.D.
- 12:45 - 1:45 pm Buffet Luncheon
- 2:00 - 5:00 pm **Session 5 - Deterrence**  
Presentation by:  
Elizabeth Wells-Parker, Ph.D.  
Carol L. Popkin  
Discussion by:  
Herbert Simpson, Ph.D.  
Kathryn Stewart  
Ralph Hingson, Ph.D.  
R. Jean Wilson, Ph.D.

#### Wednesday, July 29, 1992

- 8:00 - 8:30 am Continental Breakfast
- 8:30 - 11:00 am **Session 6 - Prevention**  
Presentation by:  
Harold D. Holder, Ph.D.  
Discussion by:  
H. Laurence Ross, Ph.D.  
Robert W. Denniston  
Alexander C. Wagenaar, Ph.D.
- 11:00 - 12:00 am **Concluding Discussion**

## APPENDIX B

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### ALCOHOL AND OTHER DRUGS IN TRANSPORTATION: RESEARCH NEEDS FOR THE NEXT DECADE

National Academy of Sciences Beckman Center  
Irvine, California  
July 27-29, 1992

#### TOPICS

**Overall trends in the coming decade:** Demographic, economic, technological, transportation. Includes discussion of epidemiology and data needs and availability.

**Effects of alcohol and other drugs on performance:** Including low blood-alcohol concentration (BAC) levels, hangover effects, prescription and nonprescription drugs, interactions of multiple drugs and drugs and alcohol. Implications for both commercial and private (including recreational) vehicle operators.

**Transportation workplace:** Detection of impaired operators (including company and government-mandated testing programs, training for workers and supervisors to

recognize problems), deterring impairment, rehabilitation and monitoring of operators detected abusing alcohol and drugs.

**Prevention:** Alcohol pricing and availability, enforcement of minimum drinking age, alcohol advertising and marketing, sales and service practices and policies, public information and education, alternative transportation and designated driver programs, provision of alcohol-free activities for youth, community mobilization.

**Detection and enforcement:** New detection technologies, including preliminary breath testing devices, passive sensors, etc., sobriety checkpoints, drug impairment recognition programs, patrol deployment, improved arrest and processing (including judicial) procedures, police attitudes and discretion.

**Deterrence:** Both specific and general, including licensing policies (provisional licensing, administrative license revocation), adjudication, sanctions (including jail, fines, vehicle impoundment), rehabilitation and monitoring (including medical testing), methods for screening and assessment of offenders for alcohol and other drug problems.

## APPENDIX C: LIST OF WORKSHOP PARTICIPANTS

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## APPENDIX D

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### APPENDIX D1

#### ALCOHOL RESEARCH FOR A DISTANT FUTURE

James Hedlund, Ph.D.

Carl E. Nash, Ph.D.

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This meeting was called to develop a research agenda for the 1990's on alcohol and other drugs in transportation. To do this we must pass beyond what we'd like to know today. The research conceptualized here may be funded by the mid-1990s, but won't be completed until later in the decade and will have little impact until the 21st century. So we must project into the future: what will the problems of impaired driving and other transportation impairment look like after the year 2000 and what will we need to know to address them?

Lest we think the issues we will face in 10 years are the same as today's, it's useful to recall the major changes that have occurred in the past 10 years. Here are some examples:

- Alcohol-involved traffic fatalities have dropped from 25,170 in 1982 to 19,900 in 1991. The proportion of all traffic fatalities involving alcohol has dropped from 57 percent to 48 percent.
- All states and the District of Columbia now have a minimum drinking age of 21, compared to only 26 states in 1982.
- 47 states and the District of Columbia now have illegal per se laws for alcohol, 43 with a blood-alcohol content (BAC) level of .10 and 5 with .08. In 1982, only 26 states had illegal per se laws: 25 at .10 and one at .13.
- 31 states and the District of Columbia have administrative license revocation laws for drivers who exceed the legal BAC limit. In 1982, only 6 states had these laws.
- 23 states and the District of Columbia have implemented the Drug Evaluation and Classification program, which trains police officers to recognize signs of impairment caused by drugs. In 1982, these techniques were just being developed in Los Angeles.
- Ten years ago, the "drug-free workplace" was only a concept, without widespread acceptance. Today, workplace drug testing is standard and alcohol testing will soon be included.

### What is the Problem?

Alcohol and drugs are antithetical to the safe operation of transportation equipment and systems. They impair a person's attention, reaction capability, judgment, and problem-solving capabilities, all of which are critical to the safe operation of a vehicle or control system. The problem involves three components coming together: (1) a *person*, who (2) takes in some *impairing substance*, and who then (3) participates in *transportation* in some manner that has the potential to produce property damage or injury (as a transportation industry employee or as a private citizen operating a motor vehicle or even walking).

Our tools to address safety issues of impairment also fall into three general categories: (1) *laws and their enforcement*, including publicity to encourage compliance with the law, (2) *education* to make people aware of the hazards posed by impairment, and (3) *technology* that can intervene to detect impairment, prevent an impaired person from operating transportation equipment, and compensate for errors made by impaired operators.

Problems with impairment and transportation can occur in both private life (driving automobiles, flying airplanes, or sailing boats) and in the workplace (driving trucks and buses, operating light and heavy rail equipment, piloting airliners, controlling air traffic, navigating ships, and more). Impairment also increases the possibility that pedestrians and passengers will be injured and killed in and around transportation vehicles.

Detection and control of impairment in the transportation industry is far easier than it is for private vehicle drivers. The basic principle of an alcohol- and drug-free workplace already has been established in public opinion, law, and business practice. The principle is enforced through workplace drug and alcohol testing, with failures punished by job-related sanctions. The primary workplace research area is thus quite specific: to develop effective and low-cost methods for drug and alcohol detection and testing. However, since impaired driving—mostly involving alcohol—produces over 90 percent of all transportation casualties involving impairment, that is the focus of these remarks. We also believe that is where the bulk of our research should be concentrated.

## Predictable Changes

Let's look at each of the six areas—three problem components and three solution types—in turn.

### *People*

We can estimate the demographic make-up of the population quite accurately for at least the next 20 years. There will be two important changes over this time: our population will be older and it will be more culturally diverse.

The peak of the baby boom generation—now in their early 30's—will be middle aged in 2010. Today's teenagers, who are the trough that followed, will be in their mid-30's by then. Senior citizens will continue to increase in numbers and will drive more miles.

Fatal crashes per capita disproportionately involve males from 15 to 30 years of age and over 70. Women have a similar pattern, but their involvement rates are nearly 60 percent lower than those of men in the critical 15- to 30-year old age range. The good news on alcohol is that the number of younger people will not increase much over the next 20 years, and that drunk driving is much less common among older drivers. On the other hand, older drivers are more likely to use, and perhaps be impaired by, prescription or non-prescription medications. This suggests an increased research focus on medications.

Minority populations will increase faster and be younger than the majority. In the 1990 census, minorities plus people of Hispanic origin were about a quarter of the U.S. population. This proportion is expected to grow by one to two percentage points per decade. Federal household survey statistics indicate that whites have generally higher rates of alcohol and drug use than blacks or Hispanics, but the differences are not substantial. Black males over 30 have moderately higher per capita crash fatality rates than white males, although their crash alcohol involvement is lower.

Measures to address alcohol and drug use in transportation must recognize this increasing diversity. Education, publicity, and even laws and sanctions must be relevant to different population groups. Some implications are obvious: messages in English are irrelevant for people who do not understand English. Others are more subtle: reward and punishment methods may have very different effects on people from different cultures.

### *Impairing substances*

Alcohol consumption per capita has decreased about 10 percent over the past decade. The mix of beverages has also changed: beer and wine make up a larger, and spirits a smaller, portion of the total. Use of other recreational drugs is much more volatile. Different drugs can spring into popularity quickly. A drug can be common in one area of the country and almost unknown in another. Prescription and non-prescription medication use patterns also can change quickly.

It is unlikely (but not unthinkable) that some or all drugs will be legalized in the next two decades or that there will be dramatic changes in the drinking habits of the general population. The most likely prediction is that recreational and medical use of legal and illegal impairing substances will continue at substantial levels. The traffic safety system must be prepared to cope with new impairing substances.

### *Transportation*

We can estimate what the motor vehicle fleet will be like ten years hence. Many new cars to be built in the year 2000 will be on platforms that are now on the drawing board or currently in production. Other changes, such as virtually complete adoption of air bags and anti-lock brakes, are all but certain. Dramatic changes in roadways are unlikely. More traffic on a slowly expanding road network will increase congestion.

Considering only changes in demographics, the number of licensed drivers, and fleet size projections, highway fatalities will increase by the turn of the next century<sup>1</sup>. Such projections are not based on increases in vehicle miles travelled (VMT) or fatality rates (per VMT). Historically, increases in VMT have tended to be offset by the fatality rate reduction.

If we consider the implementation of new standards and programs, such as the automatic frontal crash protection and side impact standards, reduced impaired driving, increased restraint use, and highway safety improvements, fatalities are likely to remain at or below their present level of just over 40,000. Of course, this number could fluctuate significantly because of economic or other external factors.

As we go into the 21st century, we anticipate that crash avoidance measures being developed in the Intelligent Vehicle/Highway System (IVHS) program will begin to demonstrate their promise. One might easily imagine that two or three decades from now

<sup>1</sup> Last year, NHTSA completed a study for the Office of Management and Budget that projected annual highway fatalities would be between 47,000 and 49,000 by the year 2000. A more recent extrapolation based on complete 1991 accident data projected year 2000 fatalities would be around 46,000.

new, state-of-the-art car could have sensors to determine its global position, its position within the travel lane, its proximity to other vehicles, and the condition of the driver (alert, impaired, drowsy,...). It could process this information with computer power that exceeds that of the best current personal computer. This car's ability to sense potential hazards and to develop crash avoidance strategies may rival that of its driver. In concert, the car and its driver might improve their crash avoidance capability dramatically, even when the driver is somewhat impaired. Can one imagine that the car itself might help to be the designated driver?

Nevertheless, the fundamental problem of impaired driving will remain unchanged. Vehicles will continue to require a driver to be in active control. Thus the goal is to prevent a person who is impaired by alcohol or other drugs from driving a motor vehicle, or otherwise participating in the transportation industry.

#### *Laws, Enforcement, and Sanctions*

Our society believes that we can control behavior through laws, with associated publicity, enforcement, and sanction. We certainly try to do so in transportation, where a wide variety of laws attempts to regulate private citizen and transportation employee behavior. Of course, these laws are balanced against the fundamental individual rights guaranteed in the Constitution, such as due process.

In the past decade the American public and the states have shown themselves willing to regulate more closely in the interest of public safety. Examples include the impaired driving laws cited earlier (BAC limits, administrative license revocation, minimum drinking age) as well as child seat, adult seatbelt, and motorcycle helmet use laws. The courts have upheld these laws. The Supreme Court has ruled that sobriety checkpoints are not an unreasonable violation of individual rights. Thus, there is strong support for laws directed at impaired driving.

Enforcement of these laws, however, is another matter. Police are faced with increasing demands on their services to address what many believe to be more serious societal ills than impaired driving. At the same time, overall police resources are shrinking as state and municipal budgets are squeezed. Court dockets are crowded; jails are full; many prosecutors, judges, and police officers treat impaired driving as a minor but burdensome annoyance instead of a major societal problem. The situation begs for research to identify how police and courts can use their resources more productively. The same issues apply to enforcement of substance-free workplaces: what is the most cost-effective method of drug and alcohol screening to

deter use by workers?

Research also should investigate technological advances that can assist enforcement. Some methods now exist but need to be evaluated, such as NHTSA's Drug Evaluation and Classification program to assist police in detecting impairment due to drugs. Other methods have not been developed such as a fast, cheap, non-intrusive method to detect drug presence in the workplace or at the roadside. Finally, we should explore the public acceptability of various automated enforcement methods. Photo radar and photo red light enforcement are used in other countries but have only limited use in America. Standardized driver's licenses with 'smart card' technology to carry driver identification and records would assist police and courts greatly but may meet opposition from those who fear it would become a national identity card.

#### *Education*

Formal and informal public education concerning traffic safety suffer from the same problems as enforcement: other demands are increasing at the same time that funds are decreasing. As an example, many high schools are dropping driver education courses or are charging substantial fees for them. Public information and education must compete with \$800 million per year of very compelling commercial advertising for alcohol and with peer pressures and life style demands, particularly for the attention of young people.

Employers may provide a new avenue for education. Employers are extremely conscious of increased health care costs and seek to reduce these costs. They understand that substance abuse contributes substantially to these costs as well as to workplace inefficiency. Some employers have begun to realize that traffic crashes and injuries, both on and off the job, are also very costly. Through a combination of alcohol and drug awareness activities and employee assistance programs, employers have many avenues to affect their employees.

#### *Technology*

New technology is difficult to predict. But some recent developments deserve noting in considering a research agenda. Examples include

- Vehicle interlocks that prevent a car from starting unless the driver's alcohol level falls below a pre-set limit;
- performance tests, now being developed for fitness-for-duty testing in many industries;
- biological markers that can measure whether a person has used alcohol recently.

## Unpredictable Changes

What will change in unpredictable ways are things that depend strongly on the beliefs, attitudes and behaviors of large segments of the population, on technological developments, and perhaps on international relations. You need only think about the last ten or twenty years to see how this is so. Personal computers have become extremely powerful, cheap, and ubiquitous at home and at work. More than half the population is wearing safety belts. People are not getting all of their entertainment at home: movie theaters are doing very well despite television, video, and predictions of their demise. Japanese companies are making about a quarter of our new cars, including some of the most interesting. After we wiped out small pox, conquered polio, and got control over bacterial infection, many people thought we were well on the way toward conquering all disease, but AIDS has become a major and uncontrolled threat to public health, and cancer and heart disease remain the major threats to the health of middle-aged and older people.

Strategic planning is a powerful technique for thinking about the future. It's a way of analyzing near-term actions based on their long-range implications; it's *not* a blueprint for actions for the next 10 or 20 years. It would make little sense, for example, to develop better drug recognition techniques if inexpensive, accurate, unobtrusive drug test equipment was soon to become widely available for most common drugs. Strategic planning ideas and tools can be useful in thinking about the future and in avoiding the trap of assuming that the future will look like the present.

Strategic planning addresses the uncertainties of the future by using scenarios: plausible stories about the future that capture the issues keeping us awake at night. If we are looking at the abuse of alcohol and drugs and its consequences, such as impaired driving, we might construct scenarios that will capture future possibilities that are not strictly predictable as extensions of what we know today.

For example, the division of society in which major segments of the population become even more concerned about health and safety might be accentuated. Religion or other belief systems may support this change. These people will drink less and may support more severe sanctions against anti-social acts fueled by impairment. On the job drug and alcohol testing may have a profound impact on demand for both. At the same time, other segments of the population could get more involved in drugs and alcohol and become an increasing threat on the highway.

Advances in the technology of drug making may result in a further expansion of the varieties of drugs

available and a reduction in their cost. Drugs that can be manufactured from more common domestic materials might kill the market for imported cocaine and heroin; but they would bring new problems, such as how to detect driver impairment from them. A drinkable drug alternative to alcohol is not unthinkable.

The distribution and retail marketing of drugs could also evolve, making them more available, less dangerous to buy, and cheaper. This might lead to some degree of actual or *de facto* legalization, or at least to broader drug use.

The kind of research that would make sense in the 90's might be much different depending on which of these scenarios more closely resembles the future. One would like to be able to do the research that would make sense in any reasonably likely scenario.

## Scenario Construction

There are a number of approaches to developing scenarios. The simplest is to identify the key issues that will face us and to look at the forces that will drive decisions concerning them. We should be acutely interested in those issues that are very important to us and that have highly unpredictable outcomes. Scenarios are built by considering the effect of different external forces that drive decisions on the issues.

There are more complex ways of developing scenarios that involve analytic techniques for identifying issues, driving forces, and potential developments. It takes hard work, insight, and the involvement of decision leaders to do a good job of scenario building.

To properly use scenarios, we should look for policies or decisions that work well in a variety of the most plausible scenarios. The value of good scenarios is that they give us future conditions against which to test our plans. They also give us indicators of trends as time passes. These trends may point toward one of our scenarios. If so, we can gain further insight from this scenario and adjust our plans to take advantage of it.

To show how this works, here are some ideas about issues that may be critical to impaired driving policies:

- Public attitudes toward alcohol, drugs, and their control may shift further as they have with auto safety and tobacco. Concerns over health, safety, and fitness are likely to continue and to carry over to alcohol and drug use. Changes in values and behavior concerning alcohol and drugs should carry over to impaired driving. It is uncertain, however, whether the message will get through to young males who remain the greatest threat to traffic safety. As we suggested earlier, however, the split within society of views on these issues may strengthen.

- There could be support for more government regulation of alcohol product offerings, advertising, sales outlets, prices. Nevertheless, if the government does make a serious attempt to reduce inappropriate or excessive alcohol consumption, demand and use could increasingly shift to illicit drugs.

- Technological developments may overwhelm attempts to control drugs or may enhance our ability to do so. The technologies of monitoring impairment and of performance testing will give us new tools for licensing, job-related tests, and non-punitive sentencing of drug and alcohol offenders. But technologies can be used to thwart attempts to control impairment in transportation just as radar detectors are used to foil speed enforcement technologies.

- Technological developments may obviate our current impaired driving situation. We could have an antidote (an amethystic agent) that would prepare one to drive home safely after drinking. The technology of the future automobile might significantly facilitate the ability of an impaired driver to drive safely.

- Government control of the growth, import, sale, and use of illicit drugs has been only moderately successful up to the present. The societal and economic costs of drugs and of government programs to control them has been very high. Currently we have a multibillion dollar, unregulated production, importation, and sale of illicit drugs; corruption of police and public officials; extensive drug use by minors; prenatal damage to significant numbers of babies from drugs, not to mention mistreatment of children by parents using alcohol and drugs. A few public leaders such as Baltimore's Mayor Kurt Schmoke have suggested a much wider ranging public debate on our national drug policies. Unfortunately, alcohol and drug policies may be driven by prejudice, politics, and economic interests, rather than by realistic analyses of societal needs.

- Traffic enforcement might continue to be a victim of shrinking police resources and competing demands for them. Safety education for young and novice drivers may be a similar casualty.

- Citizen activist groups such as Mothers Against Drunk Driving (MADD) and Reduce Impaired Driving (RID) may or may not continue effective advocacy of reduced impaired driving and public education on alcohol and traffic safety. Public consciousness of impaired driving may be crowded out by competing health issues such as AIDS, hand guns, and ozone depletion.

Certain forces are likely to continue to drive alcohol and drug issues as they have in the past:

- Economic forces from the very profitable alcohol business will continue to be an important factor in alcohol consumption.

- There are a number of citizens, religious groups, and secular organizations, some of which would like to reduce the availability and use of both alcohol and drugs, and some of which want to have and enforce stronger impaired driving statutes.

- Alcohol supports other industries such as sports, advertising, and broadcasting. The economic well-being of these industries often makes them allies of the alcohol industry in debates on the subject.

- Relations between the U.S. and countries that are major drug growers and producers will affect the supply and price of imported drugs.

### Alcohol and Drugs in the 21st Century

There almost certainly will be more choices of mind altering substances in the future. This will present us with a variety of new problems in traffic safety. Detection and control of impaired driving is more difficult with drugs than with alcohol. Thus, it would make sense to study the fundamentals of use and addiction patterns in the general population and look for policies to reduce demand. Our research today needs to take account of the possibility of major growth in the variety of drugs available and their use, and to look for strategies to reduce demand and deal with the consequences of drug use.

Alcohol products, their marketing, and markets will almost certainly evolve further. We already have wine coolers, prepackaged mixed drinks, and more. New types of social activities, such as the rave, will increase the possibilities for impaired driving. If these products and activities are profitable and expand markets rather than simply switching consumers from one product or social situation to another, they increase the potential for drunk driving. Yet there seems to be little public support for additional regulation of either alcohol products or marketing. Despite recent increases in alcohol taxes as a revenue source, there seems little support for further increases in alcohol taxes as a means to discourage consumption or to cover the social cost of harm from drinking.

Before the more scientific approach to auto safety of the last 25 years, most crashes were either considered acts of God or blamed on the "nut behind the wheel." There is a current tendency to define impaired driving and other types of alcohol and drug abuse the same way by blaming the "nut behind the bottle," not the marketing and social conditions that permit and

engender the behavior. Personal responsibility must be a part of any safety program, but we need to understand the environmental and other factors that encourage such behavior. We may not be able to change these forces, but research can illuminate the driving forces for alcohol and drug abuse, and may give us insight for other approaches to their control.

A cross cultural look, both within the U.S. and in comparison with other societies, might give some further insights into what we will need to know about alcohol and its abuse. Certain attitudes or behaviors involving use of drugs and alcohol that are found in small groups in society may become more widespread in the future, as often happens with popular culture. We may get insights into the nature and limits of alcohol abuse and impaired driving by looking at cultures that view alcohol use differently than we do.

Exploring these kinds of issues, forces, and scenarios can provide useful pictures of the future. This meeting easily can identify other issues and plausible scenarios, and can provide insights into their relative importance. A strategic planning process, including scenario development, would be an important early project for this decade's research agenda. Simply advocating that we now do the research that was left undone in the 1980's would be short-sighted at best. The 21st Century will demand more forward thinking, more creativity, and a more daring and thoughtful research agenda.

**APPENDIX D2  
DETECTION AND DETERRENCE OF DRUG AND  
ALCOHOL ABUSE IN THE TRANSPORTATION  
WORKPLACE**

George M. Ellis, Jr.

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**INTRODUCTION**

Although trends have concerned scientists and industry professionals for at least the past decade, only in the past few years has the extent of drug and alcohol abuse in the transportation industry caught the attention of both the federal government and the American public. Drug and alcohol abuse in transportation has triggered concerns about public safety, environmental protection, and economic impact. Use of these substances is no longer seen as an issue of personal choice or morality. But in spite of warnings, it has taken a few highly visible and catastrophic events to focus public and political attention on the problem.

Three Northwest Airline Pilots were convicted in

1990 for being under the influence of alcohol while flying a commercial airliner during an early morning flight. Ninety-one passengers were on board. The pilots were arrested after landing the flight safely. Tests showed blood alcohol concentrations ranging from 0.06 percent to 0.13 percent (the captain). All three pilots admitted drinking heavily the night before.<sup>1</sup>

In 1988, a Trans-Colorado Airlines Commuter operating as Continental Express crashed at Durango, Colorado, killing the two crew members and seven of the fifteen passengers on board. The National Transportation Safety Board (NTSB) found that the captain's use of "a bag" of cocaine the night before resulted in a degradation of performance which contributed to the cause of the accident.<sup>2</sup>

In 1987, a Conrail freight train improperly passed a stop signal at Chase, Maryland, and entered a main line where it was hit by an Amtrak passenger train at 120 miles per hour. The Amtrak engineer was one of the sixteen people killed. Over 170 people were injured. Both the Conrail engineer and brakeman were judged by the NTSB to be impaired at the time of the crash by their very recent use of marijuana.<sup>3</sup>

In 1989, a Exxon oil tanker ran aground in the Prince William Sound, Alaska. Over 250,000 barrels of oil were spilled causing extensive environmental damage. The ship's captain, who had a known alcohol problem, was judged by the NTSB to be impaired by alcohol at the time of the accident. He had left control of the ship to a junior officer at a critical time in the movement of the vessel.<sup>4</sup>

These catastrophic accidents, however dramatic, should merely draw attention to the very real problem employers face each day in deciding how to detect the impaired operator performing safety-sensitive functions and how to best create a workplace free from the effects of drug and alcohol abuse.<sup>5</sup> In this paper, these topics will be examined from the perspective of looking at research needs for the next decade based on an assessment of the current state of knowledge. Topics to be covered include both chemical and non-chemical based methods of detection and deterrence. In addition, the paper will examine other complementary research needs which may contribute directly or indirectly to these goals.

**STATEMENT OF THE PROBLEM**

Transportation workers provide their services in complex environments which may change instantaneously from highly tedious and monotonous to extremely stressful and dangerous. They may do so under conditions of

excessive fatigue or temperature, or under other adverse environmental conditions. Regardless of public policy or the public will, some operators will continue to use drugs and alcohol to either medicate or mediate their lives, putting at risk public safety.

It is the feeling of the American public, affirmed by our legal system, that employers of workers in safety sensitive positions have the right to a safe, drug-free workplace, and to protection from the economic and personnel costs associated with the substance abuser. In support of that right, transportation employers may elect or be required to conduct direct or indirect testing for drugs or alcohol<sup>6</sup> and/or to put in place other detection and deterrence programs, including education, prevention, or supervisor intervention. Over the next decade, decisions need to be made on where to place research emphasis to expand our knowledge of how to detect the impaired operator in the transportation workplace. Solutions need to be practical and demonstrate clear cost-benefit to employers.

#### **METHODS OF DETECTION AND DETERRENCE: CHEMICAL BASED**

The use of chemical tests to detect drug and alcohol use can be an effective deterrent against workplace substance abuse if properly applied and complimented with non-chemical deterrence programs. In the case of pre-employment, periodic, or random workplace chemical testing, it may be sufficient to know that the applicant or employee is a user of drugs or alcohol. In other cases, notably reasonable suspicion and post-accident testing, an indication of impairment or recency of use may prove important. In all cases, extending our knowledge of both the meaning of tests results and the scientific capability of chemical testing can only serve to improve the detection and deterrence ability for employers.

##### **The Chemical Analysis**

The human body excretes some drugs only in the unchanged (parent) form. For most drugs, however, the body will either excrete both the unchanged drug and one or more metabolites, or just the metabolites. In some cases, a metabolite may be unique to that drug. In others, a metabolite may be common to any one of several drugs which may make the identity of the administered drug difficult. Today's chemical-based methods of detection and deterrence seek unchanged drug and/or specific unique metabolites in the body's distribution or excretion systems, including in the blood,

urine, breath, saliva, and hair.

It is the consensus of scientists today that an effective analytical system for the detection of drugs of abuse in biological specimens should consist of: (a) a sensitive, drug-class-selective technique such as one of the immunoassays, employed as the initial screening process to identify negative specimens and to select presumptive positive specimens; and (b) a highly specific technique such as gas chromatography/mass spectrometry (GC/MS), used for confirmation of any presumptive positive results.<sup>7</sup>

##### *Immunoassay Screening*

Immunoassays are the required technology for initial drug screening for most federally regulated testing<sup>8</sup> and, in combination with GC/MS (gas chromatography/mass spectrometry) is the combination of choice by scientists for the testing of drugs of abuse<sup>9</sup>. Immunoassay techniques can be useful in the analysis of urine, blood, saliva, and hair, although not every type of immunoassay is equally capable in each of these mediums. There are three generally accepted immunoassay techniques commercially available today: radioimmunoassay (RIA), enzyme immunoassay (EIA), and fluorescence polarization immunoassay (FPIA).<sup>10</sup>

The immunoassays are not necessarily comparable. In some cases, there can be marked inconsistencies between the various immunoassays in their cross-reactivity with the same analytes. Variances in sensitivity to a specific analyte within a particular drug class may make a clear difference in the ability to detect a drug-using operator depending on the immunoassay which has been selected by the employer's laboratory.

As an illustration, the current principal RIA kit manufacturer provides separate methamphetamine and amphetamine specific assays. Depending on the choice of the assay, under certain circumstances, use of methamphetamine or amphetamine by an individual will remain undetected. The other two immunoassays detect both drugs in the same analysis.<sup>11</sup> All of the opiate immunoassays, on the other hand, are specific for both codeine and morphine. Codeine and morphine based drugs, heroin, and poppy seed use can be detected. However, RIA, EIA, and FPIA are all unable to effectively detect most of the synthetic narcotics. Hydrocodone, meperidine, methadone, oxycodone, and propoxyphene are essentially not detected with the opiate test.<sup>12</sup>

Another type of problem with the various immunoassays is that within large drug groups such as the barbiturates, the assay's capability to detect a specific drug may vary depending on the drug's cross-reactivity with the "anchor" analyte. With the barbiturates, all

three immunoassays are constructed around a drug which is no longer prescribed very often (secobarbital) and are not very sensitive to the more commonly used barbiturates (notably butalbital and phenobarbital). At low to moderate concentrations in urine, the drug(s) will often be missed.<sup>13</sup> Similarly, the benzodiazepine immunoassays have varying degrees of sensitivity to most of the newer more potent versions (including alprazolam, triazolam, and lorazepam). Differences in sensitivity for both parent drug and metabolites can severely limit the detectability of these drugs.<sup>14</sup>

Although it is recognized that reworking an immunoassay is time consuming and costly, the issues identified here are illustrative of some of those that are likely to continue to impact the ability to detect the impaired or drug using operator. Among employers, there is the reasonable assumption that the immunoassays are completely comparable and they can detect equally a much broader range of drugs than they do.

**Recommendations for Future Research:** Over the next decade, it would be beneficial to encourage manufacturers to update and upgrade their immunoassays to adequately and consistently detect a broader range of analytes than is currently true. Manufacturers should be encouraged to try to develop more flexible technologies capable of broadening the existing drug classes, such as the opiates, in order to detect additional drugs from the general class in a single test, such as some of the non-opiate narcotics. The development of immunoassay "cocktails" covering a broader spectrum of analytes should be encouraged. Additionally, manufacturers should work to increase the sensitivity of their assays to some of the more important analytes so that significantly impairing drugs will no longer be missed.

#### *Gas Chromatography/Mass Spectrometry*

The gas chromatograph using a mass spectrometer as a detector (GC/MS) has exceptional capabilities.<sup>15</sup> However, it has been shown that all drug confirmations performed by the GC/MS are not going to be unequivocally correct unless care is taken in selecting the analytical procedures to be used and the operating parameters for the method. Depending on what drugs are to be detected, and whether they are to be evaluated qualitatively or quantitatively, currently determines what methods of operation are to be used (full scan or selected ion monitoring, chemical ionization or electron impact, etc). While GC/MS provides the most specific technique available, it is also costly and still demands a high degree of technical expertise to operate and maintain the equipment and—most importantly—to

interpret the results.

Over the next decade, several areas of evolving hardware technology for confirmatory testing may prove worth watching.<sup>16</sup> These include MS/MS, GC/MS-MS, GC/Ion Trap MS, and HPLC (high pressure liquid chromatography)/MS.<sup>17</sup> Most of these will involve a significant financial investment by a laboratory, along with a commitment to a much more complex set of technologies. At the present time, most of them do not seem to offer a significant increase in analytical capability for the standard drugs of abuse.

**Recommendations for Future Research:** In the upcoming decade, increasing emphasis should be made on upgrading the hardware and software technology of standard GC/MS based confirmation systems. Areas of interest should include increasing the speed of the analysis, lessening the expertise needed to conduct the test, evaluating new robotics capabilities, and improving the hardware and software capability of the instrumentation to identify, confirm, and quantify with absolute certainty the drugs of interest. Attention should also be given, however, to the question of whether existing standard GC/MS hardware will continue to be adequate for the commercial drug testing laboratory, or are the new hardware combinations going to offer such a significant improvement in detection capacity as to warrant the substantial investment and the consequent increase in operational complexity.

#### **On-Site Testing**

Current regulations mandate that all drug testing conducted under federal authority be done at a specially certified laboratory.<sup>18</sup> Both the screening and confirmatory analyses must be done under the same roof under very strict scientific conditions established and monitored by the National Institute on Drug Abuse (NIDA).<sup>19</sup> This requirement is unlikely to be changed in the near future. In spite of the fact that most drug testing is laboratory based, the use by employers of on-site chemical testing (i.e., at the workplace or at a medical clinic) still occasionally occurs using urine, saliva, and breath. Because of limits in the technology involved, most on-site testing strategies should prudently limit themselves to initial screening-level tests only. Nonetheless, employers are still interested in lower cost alternatives to some of the higher costs of mandated laboratory-based analyses.

Currently, the commercial interest in on-site testing seems to be directed more towards the development of inexpensive, completely self-contained screening devices which can accurately detect the presence of the drug of interest or alcohol and not require expensive equipment,

trained personnel, or the significant mixing of any chemicals or reagents. Although they are often touted for pre-employment testing as well, their principal value may be for reasonable suspicion and post-accident testing situations in isolated locations, for emergency rooms, and/or for substance abuse treatment facilities.

In urine, self-contained screening tests for drugs have had a slow start and previous commercial efforts in the past decade have had problems with both false positives and false negatives. Recent efforts appear to be more successful and show greater promise for commercial application. Most of these applications are designed to be inexpensive and require little technical training to use. Currently, the better of these devices have a built-in quality control check and are often based on a latex agglutination immunological reaction.

In saliva, most current interest in a commercial application continues to be in the detection of ethyl alcohol. Like urine, previous attempts at a commercially marketed test devices have had problems with false positives and false negatives.<sup>20</sup> Some of the more recent commercial saliva alcohol testers appear to have resolved most of the technical problems of the earlier devices. Devices based on an enzyme reaction, offering a rough quantitative measure of blood alcohol concentration using a color bar "thermometer" approach, and with an attempt at an internal quality control measure would seem to hold the most interest. There have not been many saliva on-site test devices for drugs other than alcohol, in spite of the promise of the specimen type<sup>21</sup> (see also Section 3.4.4.).

With breath, there have been a proliferation of alcohol test devices that are applicable to on-site testing. Many of these operate on the principal of chemical oxidation and result in a color change which gives a qualitative result varying in accuracy depending on the quality of the device. Better quality hand-held devices offering accurate, quantitative readouts are available using electrochemical oxidation (fuel cell) and other technologies. Currently, proposed federal regulations for many transportation workers will mandate use of breath-alcohol testing devices in pre-employment, random, reasonable suspicion, and post-accident situations.<sup>22</sup>

**Recommendations for Future Research:** Over the next decade, policy attention should be given to consideration of on-site screening devices in urine, saliva, and breath as an alternative (backup) or emergency alcohol or drug screen for carefully limited types of testing situations. In addition to encouraging far more research in the validation of these commercial applications, efforts should be made to establish standards for their use. These should include, but not be

limited to, use of an approved or scientifically accepted technique (such as immunoassay for drugs), the requirement of at least a negative (and hopefully also a positive) control located on the device, sufficient research to establish capability at the established cutoff, a qualitative readout which does not require any real level of subjective interpretation, and stability of the readout for at least several weeks after collection under protected conditions.

### **Drug and Alcohol Levels and Impaired Performance**

There has been sufficient experimental data and scientific reports which suggest that drugs, alone or in combination, can significantly impair an individual's ability to perform safety-sensitive duties such as those which dominate the transportation workplace.<sup>23</sup> The challenge and the complexity of establishing impairment levels for individual drugs other than alcohol, however, is substantial. Concentrations of a drug and/or its metabolites in body fluids must be correlated to dose-related impairment of selected tasks in a laboratory setting. If possible, concentrations which show impairment in one body fluid, for example, will also need to be extrapolated to equivalent concentrations in other fluids.

One recent review attempted to summarize the research relating the presence and concentration of specific drugs with measures of performance.<sup>24</sup> The purpose was to evaluate the feasibility of using chemical testing in plasma/blood, urine, and/or saliva to determine when performance is impaired. Conclusions were drawn primarily from single dose studies in controlled laboratory environments. In the review, sufficient data was available to discuss only a very few drugs (marijuana, diazepam, secobarbital, diphenhydramine, and methaqualone).<sup>25</sup> An attempt was made by the authors to set conservative threshold drug concentrations to establish presumptive impairment levels for these drugs, similar to those already established for blood alcohol concentration (BAC). The concentrations provided in the review have not yet been generally accepted by the scientific community.

It is clear from a review of the research literature that many of the drugs of interest do not have completely developed pharmacokinetic or pharmacodynamic profiles. In many cases, there is insufficient existing data to establish plasma level vs. impairment curves, so only impairment duration calculations could be made. Extrapolations, interpolations, and logical extensions are often required to overcome what appears to be a very limited data base. Continuing to pursue this scientific problem over the next few years by post-study manipulation of data is

unlikely to be particularly useful.

**Recommendations for Future Research:** The principal scientific question is whether certain concentrations of drugs can be correlated with transportation workplace impairment as has been possible with alcohol. If this area is to be a productive avenue of research over the next decade, substantial resources have to be dedicated and specific research protocols have to be established to pursue these problems in a controlled laboratory situation with one or more drugs that are of interest. In order to do that, it may be necessary for a number of additional questions to be debated, including the type of tests necessary to measure impairment in the transportation workplace, drug and dose issues, specimen type availability, and the ability to extrapolate or interpolate from limited data.<sup>26</sup>

#### **The Search for Impairment Levels for Identifying the Impaired Operator: Specimens of Interest**

The most common method of detecting the impaired operator continues to be urine drug screening. It is generally concluded by the scientific community that urine tests reveal previous use of a particular drug (within certain timeframes), but cannot tell exact recency of use or how much drug was used. Other specimen types (blood, breath, saliva, hair) have varying degrees of potential for detecting the impaired worker or determining recency of use.

#### *Blood*

It is the consensus of scientists that all factors considered, blood remains the most valuable specimen available to determine impairment or intoxication, level of use, or recency of use. With blood, the presence (or absence) of parent drug and/or specific metabolites gives a much more useful picture for the interpreting scientist than is generally true for other specimen types. It is also the type of specimen which can best protect a donor from false charges of being impaired or under the influence. Regardless, because of its arguably invasive nature, blood will continue to be rarely taken as a specimen under most drug testing programs except in the occasional reasonable suspicion/reasonable cause or post-accident provisions of a few company policies.

Even with blood results, the interpreting expert may be still very limited and may only be able to give broad ranges of the meaning of a result. Research directly affirming the presence/absence of specific analytes at certain levels is far from absolute evidence about the behavioral effects of a drug on an individual. When drugs are used in combination or chronically, the interpretive picture is substantially muddled. This is true even for drugs with a reasonably developed research

literature, such as marijuana (see Section 3.5).

Blood alcohol concentration (BAC), however, has found forensic acceptance as a "per se" indicator of impairment and is certainly the most widely requested analysis in analytical toxicology. In spite of the lay community's confidence in the meaning of BAC, there are many factors which may color interpretations in both live donors and deceased subjects.<sup>27</sup> The literature is extensive, however, and the physiological and pharmacological factors which effect the correct interpretation of BAC are for the most part known. Although perfect consensus in the scientific community has been far from achieved, the debate may be made on the basis of the interpretation of reasonable evidence.

#### *Urine*

It is the consensus of scientists that the results from urine testing only indicate the presence of a drug and that the donor has been using or abusing that drug within some finite time frame before the collection. The time frame can be described in general terms based on previous research on the excretion patterns of known amounts of drug in the urine of human subjects. Principal among the problems with urine is that it is an excretion product and that target analytes may still appear for some time (days or even weeks) after last use, and that analyte concentrations are often easily affected by pH and the flow rate of urine. Tremendous variations of urinary concentration are possible because of fluid intake even when the supply of the drug to the kidney is relatively constant. Like the other specimen types, interpretations of urine results are made more complicated because it is sometimes impossible to be absolutely certain of the source of a positive test without substantiating information.<sup>28</sup>

Urine results are rarely useful in the determination of per se drug impairment and intoxication.<sup>29</sup> Very occasionally, the concentration in the urine is sufficiently high that some scientists may be willing to suggest a possible link to impairment based on urine results obtained in direct impairment studies.<sup>30</sup> It is sometimes slightly easier to relate concentration of certain target analytes in urine to dose and time intervals, and once this is done certain guarded statements might be made by a qualified expert.<sup>31</sup> But this can be dangerous ground given the current state of knowledge, and extreme caution with such interpretations is usually the most scientifically sound position.

Even the results of urine alcohol tests, where alcohol does have an impairment index (blood alcohol concentration equivalent), must be closely scrutinized based on the pooling of excreted alcohol in the bladder since the donor's last void. Unless precautions are taken, individual variations may give a slightly elevated

reading.<sup>32</sup>

### *Breath*

The principal application of breath testing has been in the identification and quantification of ethyl alcohol for the determination of blood alcohol concentration (BAC) equivalency. There is a substantial body of experimental and epidemiological research which has validated breath-alcohol testing with driver performance, impairment, and crash involvement.<sup>33</sup>

Like all indirect tests of blood alcohol concentration (BAC), breath testing relies on the principle of equilibrium between the concentration of alcohol in the blood and in the lung. The equilibrium between blood and breath occurs in the deepest part of the lung tissue (the alveoli) and the breath sample must be taken from this alveolar breath. For many years there has been an established blood/breath alcohol concentration ratio range in both the scientific and the forensic literature which defines the necessary equilibrium.<sup>34</sup> In addition, there has been some interest among forensic scientists in establishing a separate breath-alcohol concentration standard (BAC<sub>br</sub>). A breath sample is considered to be a generally non-invasive test and has a significant on-site detection capacity.<sup>35</sup>

Of the common drugs of abuse, marijuana has been mentioned as having potential for breath detection,<sup>36</sup> but little research has been completed. Because of the expected low levels involved, it is not expected that breath cannabinoid analysis will be of much interest in the future.

### *Saliva*

Saliva has been proposed as a suitable specimen for the detection of drugs of abuse since the 1970s and for ethyl alcohol since the 1930s. Today, saliva is seen as having good potential and value as a specimen in the detection of ethyl alcohol and many of the other drugs of abuse.<sup>37</sup> The physiological source of analytes detected in saliva varies depending on the drug. Although most drugs appear to be transferred to saliva by the blood, marijuana metabolites, for example, do not.<sup>38</sup> Instead, marijuana and its metabolites appear to be sequestered in the buccal cavity during smoking and can be detected directly.<sup>39</sup> Saliva has therefore been suggested as a valuable medium for the detection of very recent marijuana use in reasonable suspicion or post-accident situations.

There are noticeable between-drug variations in the length of time parent and/or metabolites are present in saliva and in the relative amounts of drug present in blood and/or urine.<sup>40</sup> To date, most drugs do not yet appear to be candidates for reasonable suspicion and

post-accident impairment determinations even though saliva is an ultrafiltrate of interstitial fluid and often will contain the free component of drugs.<sup>41</sup> However, because in some cases saliva analyte concentrations seem to correlate with levels in the blood, the result might be helpful in determining that use was recent.

One of the other advantages of saliva for the drugs of abuse is that it is a noninvasive and private collection, and it is a sample less vulnerable to adulteration. At the present time, use of saliva in a drug testing program is limited by our incomplete knowledge of the concentrations and length of time analytes remain in detectable amounts and the necessity to determine individual analytical laboratory protocols and cutoffs for the various drugs of interest.<sup>42</sup>

Saliva alcohol determinations have been given commercial application for a number of years. Although blood, breath, and urine are the most popular for alcohol analysis, saliva has been occasionally used as an alternative specimen. Unlike blood, saliva is considered noninvasive for alcohol testing. Saliva appears to have reasonable correlation with blood values for purposes of blood alcohol concentration estimations,<sup>43</sup> and the blood/saliva alcohol ratio may remain stable for many hours after last use.<sup>44</sup>

### *Hair*

Hair analysis has proven to be a useful tool with varying degrees of success in forensic toxicology, environmental toxicology, clinical pathology, and nutrition. There is little still known about the mechanisms by which drugs gain entry into the hair. It is known that drugs and other substances can obtain access both through absorption from the outside environment and through incorporation into the hair shaft from the blood supply. Drugs can enter the hair from outside exposure by way of aerosols, smoke, shampoos, cosmetics, dust, fumes, vapors, or from secretions from the two hair glands.

There are currently a number of analytical methods capable of detecting drugs of abuse in hair.<sup>45</sup> Analytical sample preparation practices, such as washing steps, have occasionally been found to lower drug concentration in a hair sample. Also, washing procedures may not remove all of the drug from environmentally contaminated hair, suggesting the possibility of false positives.<sup>46</sup> Preliminary research on drugs of abuse in hair has also demonstrated that there is generally a significant variance in concentration found in the various hair locations of an individual. Research has indicated that at least some hair samples (i.e., beard) may be capable of dose-related evidence of time and degree of exposure.<sup>47</sup>

Because of its vulnerability to outside contamination

and the variable concentrations found in different body locations, hair analysis may be of little use in telling the amount of drug used. However, research indicates that concentrations of some drugs can be found in hair after only one use, although the minimum dose that will produce a positive result is still unknown. There are some indicators that hair analysis techniques may eventually prove to be extremely sensitive to the presence of drugs in hair. At the present time, however, the application of hair analysis in any situation other than an experimental setting should be closely considered.<sup>48</sup>

### **The Search for Analyte Markers for Identifying the Impaired Operator**

It would be clearly impossible for employers to defend against the universe of possible substances of abuse through chemical detection means. There are simply too many drugs and too many possibilities, with science developing more abusable compounds every day. Therefore, chemical methods of detection and deterrence must target certain drug groups and certain specific drugs within that group in order to attempt to cover the most likely possibilities.

The two most important issues for the future, however, may be to hopefully determine the presence (or absence) of unchanged drug and/or metabolites which appear for only a short period after use, and to determine ratios of drug and/or metabolites which can only be reflective of very recent use. If the identification of such markers are possible, it would work towards assuring a scientifically credible chemical means to detect the impaired operator. Of the major drugs of abuse, the most research in these particular areas has been with marijuana and cocaine.<sup>49</sup> Based on the research literature, although there is reason to remain hopeful, data is insufficient at this time to establish clear predictors of recent use or impairment.

Ethyl alcohol has the capability of blood alcohol concentration (BAC), and has an extensive body of research literature which supports it as a determination of recency of use and for an "under the influence" determination.

Recommendations for Future Research: Over the next decade, continued research should support the existing drugs where potential still exists to establish analyte markers or ratios indicative of recent use (such as marijuana and cocaine), and to initiate study with the other principal drugs of abuse to determine if any real potential exists.

### **Future Challenges to Detecting the Impaired Operator: New Potential Abused Substances**

Ethyl alcohol and the current drugs of abuse (marijuana, cocaine, opiates, phencyclidine, amphetamines, barbiturates, benzodiazepines, and hallucinogens) are generally conceded to cover the most likely substances to be found in impairment situations. However, over the next decade, there may be a number of substances which may need to be addressed in order to protect the public from the impaired worker.

#### *Anabolic Steroids*

Use of anabolic steroids and related compounds, once only popular with body-builders, are reported to have become increasingly popular among a wide range of athletes of varying ages. Anabolic steroids are derivatives of testosterone, the natural male hormone. One of their first applications was an experimental use by Germans in World War II to increase aggressiveness in its troops. Since then they have been abused by world-class athletes in a number of countries in order to attempt to enhance performance. Recent media reports have indicated substantial abuse among high school and college age men and women athletes. Anecdotal reports have placed abuse in the transportation workplace among weightlifters and other part-time athletes.<sup>50</sup>

Recommendations for Future Research: Over the next decade, rates of use of anabolic steroids and other related compounds in the workplace should be carefully observed. The development of a rapid and sensitive screening capability which covers a broad number of these substances might prove to be an excellent proactive detection and deterrence step.

#### *Designer Drugs and the Opioid Peptides*

Although rates of use of some of the more esoteric and "designer"-type drugs are not high, attention should be kept on epidemiological trends. Certainly, the capability for abuse is significant,<sup>51</sup> and they pose problems in detection given current analytical strategies. Several drug families evoke special concern, including the phenylethylamines and various synthetic narcotics including the meperidine derivatives.<sup>52</sup>

The identification of opiate receptors in the early 1970s helped trigger the search for endogenous opiate-like substances found in the brain. In this early work, pentapeptides with morphine-like activity called enkephalins were isolated.<sup>53</sup> This was soon followed by the identification and isolation of larger polypeptides with greater activity (endorphins). At various times,

interest has been triggered in these compounds as agents to help resolve opiate addiction, to assist with problems of stress, to treat certain mental illnesses and disorders, and to remedy pain.

Certainly, the potential of this field will continue to be extraordinary. The principal scientific interest has been to find orally administered, stable opioid peptides of long duration which are going to be non-addicting. To date, it is probable that several thousand analogs have been synthesized. As yet, the hunt for a non-addicting opioid has been unsuccessful.<sup>54</sup> Instead, if these mistakes catch the interest of the drug use underground, we have created a whole generation of compounds which may contribute to the world's drug abuse problem and which may overwhelm our capability to rapidly and flexibly detect them. Areas of concern would be both in the misuse and abuse of the growing list of addicting synthetic compounds, but also in the development of triggering mechanisms which may cause the release and/or manipulation of the endogenous opioids already in the brain.

**Recommendations for Future Research:** Current chemical detection and confirmatory strategies reasonably target a limited number of specific drugs which are those most likely to be found in the target population. This approach will remain acceptable until drug using populations choose to select substances which avoid current chemical means of screening and confirmation. Some thought should be given to innovative and creative strategies of chemical detection which may allow better flexibility without sacrificing our current detection capability.

#### **Defending Against Sample Dilution, Adulteration, and Substitution**

The validity of urine drug testing results is necessarily predicated on the quality of the collection process, since the best opportunity for the impaired operator to defeat the test is at the point of sample collection. Because of issues of privacy, the majority of urine drug test collections today are monitored collections and are not directly observed, except under very specific circumstances. Even under close monitoring, there can be ample opportunity for the prepared donor to purposely dilute or to adulterate their samples and to defeat the test.

In general, methods have been classified as "in vivo" and as "in vitro" approaches.<sup>55</sup> With in vivo approaches, methods of masking drug use by purposely ingesting certain vitamins, herbs, special fluids (i.e., vinegar), or special masking "potions" have proven generally unsuccessful.<sup>56</sup> Nonetheless, underground sources still

persist in at least suggesting or advertising them.<sup>57</sup> Other in vivo approaches can be more successful.<sup>58</sup>

In vitro approaches offer the donor the most assured means to defeat a drug or alcohol urine test. The purposeful placement of various materials and fluids directly into the voided sample itself can have varying degrees of success and can be the most productive means to produce a negative test.<sup>59</sup>

**Recommendations for Future Research:** Future research needs in this area principally revolve around the need for better detection of sample adulteration and dilution. Current methods of detection are problematic and rely to some degree on luck. Extensive effort seems to be warranted to discover markers for adulteration or dilution which are not assay or method specific, but which can be used to routinely and accurately defeat attempts to compromise test program integrity. An inexpensive laboratory test which could detect a broad range of adulterating substances in urine and which is suitable for application in mass urine drug screening programs, would be an outstanding asset. Greater use of administrative sanctions applied by the employer and/or the appropriate legal system for the purposeful use of adulterants and diluents, are also strongly encouraged.

#### **METHODS OF DETECTION AND DETERRENCE: NON-CHEMICAL BASED**

The use of chemical means of detection and deterrence is seen to have value because it can sometimes provide objective, scientific measures of drug and alcohol use, and in some cases, of impairment. Reliance on only chemical means of detection can be dangerous, however, because no chemical detection method is invulnerable to being defeated by a knowledgeable employee wishing to escape detection. The use of non-chemical means of detection and deterrence have extreme value to employers, especially to supplement and/or compliment drug and alcohol testing programs.

#### **Education and Prevention Programs**

There are two general types of drug and alcohol abuse prevention programs: primary and secondary. In this context, primary prevention programs are those usually implemented before the onset of any problems and principally revolve around basic education on drugs and alcohol and on positive measures designed to enhance interpersonal relations, self-esteem, self-concept, values clarification, decision-making skills, and personal and social development as they relate to drug and alcohol abuse.

Theoretically, primary prevention programs are often

too late for implementation in today's workplace. In fact, primary drug and alcohol prevention programs seem to be best suited for children at the elementary school level where drugs and alcohol first start becoming prevalent.<sup>60</sup> It is the consensus of prevention professionals that basic drug and alcohol education alone is generally ineffective as a sole prevention strategy.

Secondary prevention programs usually focus on specific skills and strategies for employees and supervisors to deal with drugs and alcohol in the workplace. These programs often include a component on drug and alcohol behavioral indicators and training on recognizing signs and symptoms of use and abuse. However, basic education on drugs and alcohol and the development of interpersonal and decision-making skills may also have significant value in secondary workplace prevention programs.

The problem with implementing education and prevention programs in the workplace is that it is often difficult to gain a true evaluation of their long-term effectiveness. Certainly, pre and post testing can indicate what has been immediately learned. But whether an education or prevention program has any long-term impact or deterrent effect on a particular workplace is extremely difficult to quantify. Comparative evaluations or research on prevention strategies may never be of significant practical use because of the complexities of a specific workplace environment, changing personnel mixes, and evolving company cultures. The fact is, it may be sufficient to say that education and prevention programs can be effective if only because they call attention to the problem and management's interest in a drug-free workplace.<sup>61</sup>

### **Supervisor Training and Identification Programs**

Supervisor training programs are often an important part of good workplace secondary prevention programs. The typical supervisor training program today is intended to provide basic information on drug and alcohol abuse, to equip supervisors to recognize performance and behavioral indicators of employee problems in both an acute (crisis) situation and over a longer term degradation of performance, and to assist supervisors to act appropriately when confronted with an employee whose job performance or overt behavior may indicate use of alcohol or drugs.

A typical supervisor training package should at a minimum cover alcohol and drug information, including definitions, drug classifications, modes of administration, observable effects, and material indicators of the use of particular drugs. The package would also ordinarily include specific signs and symptoms of drug and alcohol

use, as well as impairment indicators. This information is usually presented in a didactic fashion and is designed to give supervisors specific knowledge which will contribute to a determination that reasonable cause testing or a fitness for duty examination is necessary.

For some employers, supervisor training is more advanced and will also teach skills on how to directly handle both the crisis intervention and the long-term degradation of performance situations. These knowledge and skills would ordinarily include training on how to handle the intervention/confrontation, as well as the process of problem identification and resolution (problem recognition, how to conduct the confrontation, supervisor do's and don'ts, recommended action, and proper documentation). Just as importantly, the supervisor could also be trained in how to directly handle the early identification of work performance problems, before an acute situation can build. This level of training requires an experiential, hands-on practicum where these skills can be practiced and refined. This level of supervisor training, when properly organized and competently taught, has been shown to be an effective detection and deterrent tool for the employer.

Although effective, these types of supervisor training programs have intentionally removed the supervisor from the role of diagnostician in the acute or reasonable suspicion situation. Instead, the supervisor is encouraged to leave every aspect of the impairment determination or the fitness for duty examination to an outside medical or diagnostic professional, such as found in an Employee Assistance Program.

Over the past decade, supervisor program content and training strategies have not changed much. The recent evolution of the DRE (Drug Recognition Expert) program in the law enforcement community, however, lends itself to a re-evaluation of current supervisor training methods to determine if parts of the DRE program could improve and upgrade existing training strategies. The DRE program, originally pioneered by the Los Angeles Police Department, has evolved into a product which has caught the interest of the National Highway Traffic Safety Administration (NHTSA). Its stated purpose is to apprehend and convict persons operating motor vehicles under the influence of drugs other than alcohol.<sup>62</sup> The program has quickly expanded by popular demand to other law enforcement jurisdictions throughout the country.

The DRE's Drug Evaluation and Classification Process is a standardized, systematic method of examining an individual. It is not a field test, but must be conducted in a controlled environment. The examination is broken down into twelve separate components.<sup>63</sup> The DRE program trains personnel in a

little over 110 hours<sup>64</sup> to determine whether a suspect is impaired; and, if so, whether the impairment is drug or medically related (illness or injury). If drug related, the DRE will then further determine what drug class category or combination of categories is the most likely cause(s) of the impairment.

Research results indicate that DREs, when properly trained, are often successful in correctly identifying drugs other than alcohol (94 percent of the time), identifying the proper drug class category when one drug was involved (79 percent of the time), and identifying all of the drug categories when multiple drugs were involved (50 percent of the time).<sup>65</sup> Part of the value of this examination is that once it is completed, toxicological tests can focus in on just one or more blood tests, with good specificity in which drugs are probably involved. Research indicates that the determinations are accurate even when alcohol has also been used by the suspect.

**Recommendations for Future Research:** It is clear that the use of a law enforcement tool like the Drug Recognition Expert (DRE) program could not be unilaterally applied to the training of workplace supervisors. The training is too long, requires too much practicum, and is far more indepth and technical than is reasonable to train supervisors. But the success of the DRE program gives evidence that perhaps existing supervisor training program content has been unnecessarily limited by a fear of supervisors fulfilling a diagnostic role. The DRE program should be looked at carefully over the next few years for several possible applications. First, what can be learned from the program which will reasonably improve the capability of the supervisor without over training him/her? Or, more likely, what can be learned from this program which can give occupational health clinics a better fitness-for-duty capacity. This would allow supervisors to fulfill their existing role but dramatically expand the quality of the medical fitness for duty determination, which now is inconsistent and often valueless.

### **Employee Assistance and Peer Intervention Programs**

One of the most valuable tools available to the employer to assist the impaired operator is an Employee Assistance Program (EAP). At its simplest, an EAP is a screening and referral program which can have a dramatic impact on the identification and resolution of employee and employee family problems. There are a number of ways in which an employee can access a company EAP: as a self-referral, as a medical referral, as a union referral, or as a supervisory referral. In most organizations employees are referred, directly or indirectly, by supervisors.<sup>66</sup> EAPs have consistently

demonstrated their value by assisting companies with the identification of drug and alcohol using employees, by providing cost-containment of employee benefits, and by facilitating the successful return of the rehabilitated employee back to the job. The EAP also has a role in monitoring the employee in aftercare programs and assisting with problems of relapse. EAPs are designed to determine the level of education, counseling, treatment, or rehabilitation needed, and make a referral into the proper program as necessary. Often EAPs are also significantly involved with company education and prevention efforts.

Another valuable detection and deterrence tool for employers are peer identification and intervention programs. Often these programs are organized by labor organizations to impact their fellow workers before they are intercepted by chemical tests or by supervisor intervention.<sup>67</sup> Usually these programs are designed to encourage anyone with a drug or alcohol problem to voluntarily seek help. The employee is then provided with EAP assistance or treatment and will not be fired. Whenever possible, the individual remains in service and is treated on an outpatient basis. Normally, the employee is confronted by a "team" consisting of two or more labor members, who will intervene with the individual who arrives at work under the influence or who consumes while on the job. The individual is counseled to stop using and to seek immediate assistance at the EAP. Discipline may be possible if the individual refuses to volunteer for help and is considered a safety problem. Discipline is not seen as punishment, but as a training and education process. Every effort is made by the company to accommodate the rehabilitation and return to work of the successfully rehabilitated employee.

Peer intervention programs are difficult to evaluate or duplicate identically in other locations, because they rely to no small degree on the corporate culture and the dedication of individual members. Nonetheless they can be extremely effective and are to be encouraged with resources and assets.

### **Performance Testing Strategies**

Chemical testing alone is not intended to provide daily protection against the employee who may not be fit-for-duty due to the effects of drugs or alcohol, or because of other factors (stress, fatigue, illness, etc.), alone or in combination. Historically, employers have had to rely on supervisory personnel to identify and confront employees who may not be capable of performing safety-sensitive functions at the required level of performance.

Supervisors usually have received only a few hours

of training in the recognition of signs and symptoms of impaired functioning and are often ill-prepared to identify impacted employees. The lack of indepth training may lead too often to a subjective determination, with no consistency between supervisors. Supervisors are also often poorly equipped to confront employees who may be defensive or argumentative, or might accuse the supervisor of discrimination or harassment because of the perceived subjectiveness of the determination. To that end, the concept of a daily objective performance test to determine fitness-for-duty has great appeal to employers.<sup>68</sup>

The determination of fitness-for-duty through some level of performance testing has proven to be an interesting scientific problem, and proposed or suggested approaches and systems have encompassed a most diverse set of test types.<sup>69</sup>

Certainly, there have been identified a wide variety of components of human performance from which to draw test types, including physical strength, sensory/perceptual ability, motor ability, psychomotor skills, learning, memory, and decision-making, among others. Fitness-for-duty tests must be sensitive to job performance impairment in one or preferably more of these components. Additionally, they must also involve a detection strategy that minimizes rejection of acceptable performance and maximizes rejection of unacceptable performance.<sup>70</sup> This detection strategy can be inherently complex, for example, due to individual variability and the fact that not all potential impairing factors impact performance in the same consistent downward direction (i.e., small amounts of cocaine or other stimulants may actually enhance performance).

One technology which may hold some promise for the identification and recognition of impairment of operators in the transportation workplace is critical tracking task (CTT), a test of visual-motor performance.<sup>71</sup> The science of CTT was developed in the early sixties to evaluate pilot and astronaut visual motor performance. Extensive research on humans and operator impairment has been completed over the last three decades in a number of areas, including measuring the effects of various environmental stressors (noise, space station confinement, ship motion, spacecraft re-entry, fatigue), other workload factors, and drugs and alcohol. Its principal capability appears to be in the evaluation of any effect which is related to the manner in which visually perceived information is reacted to by motor (eye, hand) actions.

Other promising products currently being marketed include those which use a computer software shell to embed two or more tests challenging cognitive and perceptual motor function. The tests are run singly but are integrated together within the software presentation

structure. Tests are selected based on the type of workplace or job type being screened, and should have a strong scientific background in discriminating levels of impairment in these kinds of job functions.

Interesting new work is also being conducted under the guidance of the U.S. Army Office of Military Performance Assessment Technology. These various studies, which essentially are precursors to more complex simulations of workplace performance measurement, have now become a tri-services project.<sup>72</sup> The work, which has been going on since 1983, attempts to model "real-world" military workplace environments in order to be better able to measure factors which affect performance. It is essentially synthetic work, with one or more carefully selected assessment instruments presented to the subject in sequence or simultaneously on a computer screen. The tasks may provide measures of time deadlines, divided attention functions, or other similar activities which taken together can provide a more accurate representation of real-world performance.<sup>73</sup> Although not intended to be directly applicable to fitness-for-duty, there may be lessons learned which could apply to various of the fitness-for-duty testing approaches. Even seemingly peripheral test batteries, such as those which constitute the Los Angeles Police Department's drug evaluation and classification program (see Section 4.2), may prove useful in evaluating future needs for fitness-for-duty test structures.

Recommendations for Future Research: Of course, the Army/tri-services project is not directly intended for commercial application and is still in its relative infancy. Still, impressive progress has been made to date with preliminary studies and computer software engineering. There may be a later application of some part of this technology as the next generation of performance testing available in the commercial marketplace. In the interim, studies should be undertaken which assess existing commercial and noncommercial performance testing methods for possible practical application in the transportation industry. At a minimum, criteria should be established and an evaluation made to assess test accuracy, consistency, and sensitivity to specific transportation industry job-performance impairment.

#### **METHODS OF DETECTION AND DETERRENCE: MISCELLANEOUS PROPOSED RESEARCH**

In the previous sections, chemical and non-chemical based methods of detection and deterrence have been seen as somewhat distinct from each other. However, there are several areas where the information required for employers to reinforce a safe, drug and alcohol free

workplace seem to apply to the development of strategies in both categories.

#### **Use of Random Testing as Deterrence**

No chemical test type has engendered more controversy than random testing. Labor unions, employee groups, and the public may in certain circumstances be willing to accept pre-employment, reasonable suspicion, and post-accident testing as necessary to maintain a drug and alcohol-free transportation workplace. Random testing, on the other hand, generates a significant amount of emotion and genuine concern about its purpose and effect on drug and alcohol use prevalence rates. Random testing manages the selection of employees for testing based on a certain pre-determined percentage of the target workforce, where testing is spread throughout a year and each member of the target population has a theoretically equal chance of being selected each time.

It has been forcefully argued by opponents that random testing is simply not necessary, since the specter of reasonable suspicion and post-accident chemical testing should by itself successfully deter employees who are continuing to use. That argument has tended to be more successful when applied against employees not performing safety-sensitive jobs. However, political and public opinion has often affirmed the need for random testing of employees performing safety-sensitive functions, such as is often the case in the transportation industry.

It is the argument of proponents that random testing is successful because each employee never knows if and when he/she will be tested, and for how many times during the year. The deterrent effect is then internally calculated by each employee based on their personal concern in being caught and thereby jeopardizing their employment.

With as much controversy as it generates, there has been almost no formal research either evaluating random testing as a deterrent for employees or establishing which rate of testing provides the maximum deterrent value. Random testing is simply assumed to be a deterrent, and random rates are often set arbitrarily by employers or by regulators.<sup>74</sup> Data that are generated usually come directly from workplace random testing programs already in place, without baseline or control data to establish deterrent effect. Proponents of current random testing programs point to low positive rates as evidence of deterrence (generally 1-3 percent in federally regulated transportation industries).<sup>75</sup> Opponents use that same data to claim that random testing is unnecessary because only such a small percentage of employees apparently use drugs.

Because of the costs involved, employers want to

know if random testing is providing any real cost-benefit to them and employees are wondering if this strategy is actually contributing to a drug and alcohol free workplace.

**Recommendations For Future Research:** Over the next decade, research in this area should focus on verifying the efficacy of random testing as a deterrent to drug and alcohol use by employees in the transportation industry. Controlled or quasi-experimental studies should be conducted which evaluate whether random testing has any direct effect on rates of use in an industry. Among the other questions which need to be answered are those relating to the direct effect of random rate on deterrent effect, on the real opportunity versus the perception of being caught on a random test, and whether a minimum/maximum effective random rate can be scientifically established.

#### **Prevalence Rates of Drug and Alcohol Abuse in the Transportation Workplace**

statements regarding the prevalence of drug and alcohol use in the transportation industry have traditionally been speculative or based on educated guesses. Companies have historically resisted scrutiny by researchers for a variety of reasons, including because of the direct and indirect impact on employees and on company operations. Instead, industry has traditionally relied on drug test statistics, anecdotal and case study data, self report data, and information extrapolated from other industries or sources. Accurate prevalence rates for the transportation industry, especially when done by category (maritime, aviation, rail, pipeline, ground transport, etc.), would be of tremendous importance in the design and structure of future transportation workplace programs.

**Recommendations for Future Research:** Over the next decade, attempts should be made to establish "real-world" drug and alcohol prevalence rates for transportation modes based on scientifically credible research designs utilizing multiple measures.

#### **NOTES AND REFERENCES**

1. (Cited by Sweedler 1991)
2. National Transportation Safety Board (NTSB) 1989.
3. (NTSB 1988)
4. (NTSB 1990)
5. In this paper, impairment is described as any process which adversely affects reasoning and judgement, mental performance (involving clarity and acuity), and/or physical performance (involving dexterity, reaction, and strength).
6. Most companies conduct tests in urine. Current

federal regulations and most knowledgeable company drug testing policies forbid the presence in urine of an illicit drug, an unauthorized controlled substance, and in some cases, ethyl alcohol above an established threshold. Use of the term "presence" purposefully avoids the complicated issue of on-the-job impairment determinations based on a urine test result. Correlation of urine test results with "under the influence" is considered a difficult scientific task by most experts (Baselt 1989).

7. Shaw and Ellis 1993; Shaw and Ellis 1985; Hawks 1986.

8. U.S. Department of Health and Human Services, 1988; U.S. Department of Transportation 1989.

9. Hoyt et al. 1987.

10. Immunoassays are based on the principle of competition between labeled and unlabeled antigen (drug) for binding sites on the antibody. Antibodies are substances that react with the drugs or drug metabolites that are being tested. The difference between the RIA, EIA and FPIA immunoassays is mainly in the indicator (label) that is used. EIA (or its most common commercial application, EMIT™) utilizes an enzyme as the label while RIA uses a radioactive material. FPIA (or its most common commercial application, TDx™) uses a fluorescein labeled ligand.

11. The Roche Abuscreen™ RIA amphetamine specific assay is essentially insensitive to d-methamphetamine and the Roche RIA methamphetamine assay is insensitive to d-amphetamine (Package Inserts, Roche Abuscreen RIA™, 1989 and 1992). Both are excellent assays, but if not run in tandem, each assay could miss certain illicit drugs and licit medications which may be contributing to a reasonable suspicion or post-accident situation. Theoretically, very recent methamphetamine use to the point of severe intoxication might go undetected by the RIA amphetamine assay if there was still insufficient metabolized amphetamine available in the sample (under 1,000 ng/ml in federal testing programs). In this hypothetical case, an employer would receive an RIA amphetamine result of negative, but a large concentration of methamphetamine would have been missed. That same sample analyzed by EIA or FPIA would likely have been strongly positive.

12. For all of the immunoassays, the opiate assay is based on any of the narcotic drugs in the phenanthrene series. The assays do not react or react to only a slight degree with any of the mentioned synthetic narcotics. These drugs are highly prescribed, and can be factors in reasonable suspicion and post-accident determinations.

13. The barbiturate assay is built around secobarbital for EIA, RIA, and FPIA. Secobarbital is rarely seen anymore as a prescription (Simonsen 1991) or as an

abused drug, and consequently using it as the target analyte appears increasingly less valuable since other far more common barbiturates do not cross-react well with this assay. Two commonly prescribed barbiturates, butalbital and phenobarbital, are noticeably less sensitive to EIA and RIA than to FPIA analysis. The relative lack of sensitivity is not as important when high doses of these drugs are present. However, in cases of multiple drug impairment or where a disease state (i.e., migraine or epilepsy) may have effected performance, failure to detect these drugs may be significant.

14. An illustration, the benzodiazepine assay is often constructed around oxazepam as the "anchor" analyte. Oxazepam is still a valuable base analyte since at least eight benzodiazepines, including diazepam, metabolize to this substance (Baselt 1984). However, identification of the source(s) of a benzodiazepine positive can become somewhat clouded. More importantly, various of the immunoassays have little sensitivity to the parent drug and/or major metabolites for several of the very potent short or intermediate acting benzodiazepines, including alprazolam, triazolam, and lorazepam (Jones and Singer 1989; Fraser et al. 1991; Fraser 1987; others). These drugs are prominently prescribed and have extensive potential for impairment (Simonsen 1991; Jones and Singer 1989). Yet they may go undetected in many reasonable suspicion or post-accident standard chemical tests.

15. Gas liquid chromatography (interchangeably referred to as gas chromatography or GC) is a form of chromatography which utilizes an inert gas, such as nitrogen or helium, as the moving phase to transport a vaporized sample of a drug through a glass or metal column (usually 10-15 meters in length and a few millimeters in diameter) containing specific packing material. Individual compounds are separated on the column according to their physical and/or chemical properties. The drug is identified and the concentration quantified by a detector as the analytes appear at the far end of the column.

The mass spectrometer is a highly sensitive and specific detector. When coupled with a gas chromatograph (GC/MS), it is capable of providing the most accurate procedure for the identification of drugs commercially available (Shaw and Ellis 1993; Hawks 1986; Shaw and Ellis 1985; Hoyt et al. 1987). Components separated by a gas chromatograph are introduced into the mass spectrometer where fragmentation of the chemical bonds of the molecule takes place. These electrically charged fragments (ions) differ from one another in intensity and result in fragmentation patterns which have specific characteristics for identification.

16. Perspectives of Dr. R. Foltz, personal

communication 1992.

17. Tandem mass spectrometry (MS/MS) couples two mass spectrometers together, so that one acts as a sample cleanup and the other as the analyzer. A sample can be directly introduced into the first MS, eliminating the sometimes lengthy chromatography step. While at the same time providing increased sensitivity, there appears to be some sacrifice of specificity. Generally, MS/MS doesn't appear to do as well at low end concentrations requiring good quantitative accuracy.

Another interesting use of MS as a mass analyzer occurs when a GC is coupled with two MS stages (GC/MS-MS). With this combination, the first MS acts to isolate the ions of the analyte(s) of interest from all others coeluting at the same time. The second MS then performs the more normal MS function of producing the "fingerprint" mass spectra for evaluation. GC/MS-MS seems to provide a noticeable improvement where it is necessary to demonstrate a better sensitivity with less interference (such as analyses required in the low picogram range). However, MS-MS does not guarantee better sensitivity for all drugs of interest. The combination is expensive and more complex to operate than standard GC/MS.

There has been increased scientific interest in the combination of gas chromatography and the ion trap mass spectrometer (GC/Ion Trap MS). The standard MS detector separates the ion beams into groups of ions based on the mass-to-charge ratio by means of a quadrupole filter, but in SIM mode discards much of the analytical signal. With the ion trap, all of the ions are retained and the ions are then selectively ejected in the detector during the mass scanning process. Compared with the quadrupole MS, the Ion Trap MS appears to have a slightly greater sensitivity, especially in full scan mode, but it does not have a strong advantage at this time over traditional GC/MS quadrupoles. The technology is advancing rapidly, however. With this approach, there are currently some very interesting developments coming from research laboratories that may have future commercial application.

High pressure liquid chromatography (HPLC) is a highly competent alternative to gas chromatography (GC) analysis. This technique is non-destructive and easily handles substances difficult to assay by GC because of sample destruction or decomposition at high temperatures. HPLC coupled with MS as its detector is currently undergoing a rapid development. With the success of the electrospray interface as its connector, it shows increasingly better promise as an analytical match for GC/MS.

18. U.S. Department of Health and Human Services, 1988; U.S. Department of Transportation 1989.

19. The National Laboratory Certification Program

(NLCP) was established in 1988.

20. Historically, the earliest saliva alcohol measurement methods had some problems when used in the field. Large volumes of saliva and the complete cooperation of the subject were needed. Enthusiasm for breath alcohol testing procedures, an equally noninvasive approach, relegated saliva testing to a back burner in the research community for many years. Commercial applications using saliva testing reappeared in the mid 1980's with the development of a dry reagent test strip technology using alcohol oxidase and with the field tests of commercially available versions. These commercial technologies were based often on the enzymatic oxidation method. With this relatively simple technology, color changes in the visible spectrum on a solid-state test strip could be compared against pre-determined color/saliva alcohol standards. These particular applications were hampered by a number of identified problems, including a high proportion of false positives in certain temperature conditions (NHTSA, 1986).

21. Schramm et al. 1992.

22. U.S. Department of Transportation, 1992. The special requirements of the proposed regulations will probably mandate a whole new generation of breath-alcohol testing devices.

23. Discussed in Sweedler, 1991; in Barnett and Willette 1989; and many others.

24. Barnett and Willette 1989. See also earlier work by Willette (NHTSA 1985).

25. For marijuana, diazepam, and secobarbital, Barnett and Willette relied heavily on the work of Chiang and Barnett 1984; Perez-Reyes 1982; Perez-Reyes personal communication; Peat and Jones, personal communication 1985; Moskowitz and Sharma 1979; and many others.

26. There are a number of questions which need to be discussed in the debate over future research in this area. Some of these are:

- Current laboratory models do not often capably represent the transportation workplace, and rarely measure performance in a number of factors at the same time, such as reasoning and judgement, mental performance (clarity and acuity), and physical performance (dexterity, reaction time, and strength). How many of these factors are really necessary in determining true performance impairment? Is a more complex model better or even necessary to judge impairment of safety sensitive functions?

- Additionally, it would also seem important to know what the effect is of multiple drug use and tolerance on impairment and detection capability? What is the effect of multiple dose use and tolerance (a more realistic scenario) as opposed to the typical existing single dose studies?

- Blood is normally the specimen of choice for

impairment and/or recency of use determinations (see Section 3.4.1). Since blood is usually not going to be available as a specimen for analysis because of its intrusiveness, can other types of specimens prove valuable to identify the impaired operator and under what conditions?

- It would seem necessary to correlate the pharmacokinetics of a drug (absorption, distribution, metabolism, and elimination/excretion) with the pharmacodynamics (the effect of the drug on the individual) in order to determine impairment. When will research data be available to make this possible for all of the drugs of interest? In the interim, are there dangers inherent in extrapolation and/or interpolation of existing data to the workplace population? How much data is necessary to collaborate impairment and generalize findings across workplace populations?

27. (Described in Caplan 1988, among others)

28. (Baselt 1984)

29. The best example is of the opiates, where the standard urine assay is specific only for codeine and morphine. A quantitative result of 300 ng/mL of morphine, for example, may be reflective of previous use of either codeine or morphine based drugs, heroin, or poppy seeds.

30. (Barnett and Willette 1989)

31. (Baselt 1989)

32. Baselt and Danhof 1988. As an example, collectors are recommended to have the suspected alcohol user completely void his/her bladder and provide an additional (second) sample 20-30 minutes later. The second specimen is probably a better sample to link to blood alcohol concentration equivalent. Examples of such a protocol may be found in Shaw and Ellis 1985; and in Caplan 1988.

33. For example, Borkenstein et al. 1972; Turner et al. 1985. Cited in Dubowski 1991.

34. Reviewed very capably by Mason and Dubowski 1988; and in Dubowski 1991.

35. There are five major techniques commonly employed to determine blood alcohol concentration (BAC) from the analysis of breath samples. They are the oxidation/photometric (color change), gas chromatography, infrared absorption, electrochemical oxidation (fuel cell), and semi-conductor technologies. Each of these techniques is capable of producing highly accurate measurements of BAC, and each has its own particular advantages and disadvantages (Mason and Dubowski 1988; Dubowski 1991). Since the early 1970's, the National Highway Traffic Safety Administration (NHTSA) has established standards for devices that purport to measure breath alcohol. In support of these

standards, NHTSA started regularly publishing lists of qualified products which meet federal standards as evidential-level devices. However, there is a great variety of non-evidential level devices which vary significantly in quality and accuracy.

36. (Hawks 1982)

37. A most comprehensive review has been provided by Schramm et al. 1992. See also an earlier review by Caddy 1984. Besides ethyl alcohol and the cannabinoids, research on saliva concentrations of drugs has been conducted at least to some degree in cocaine, phencyclidine, morphine, codeine, hydromorphone, methadone, amobarbital, hexobarbital, phenobarbital, methaqualone, diazepam, nordiazepam, and amphetamine.

38. Cited in Hawks 1982, based on personal communications with Perez-Reyes.

39. Although urine tests find principally the carboxyl metabolite (THC-COOH), research in saliva reveals at least three metabolites (THC, CBD, and hydroxy-THC) not normally found in substantial amounts in urine (Schramm et al. 1992). These may therefore appear directly either from marijuana smoke or from metabolism of the drug in the mouth. Importantly, it has been reported that ingestion of normal foods and liquids does not appear to impact the detection of marijuana metabolites in saliva (Thompson and Cone 1987; among others), although an alcohol rinse may be a risk.

40. (Schramm et al. 1992)

41. (Schramm et al. 1992)

42. (Schramm et al. 1992)

43. (See Coldwell and Smith 1959; and others)

44. (See Jones 1980; and others)

45. The most common commercially available test for the analysis of hair for drugs of abuse utilizes radioimmunoassay (RIA). TDx™, another immunoassay technique, has also been used. High performance liquid chromatography, gas chromatography, and gas chromatography/mass spectrometry have been successful for both screening and confirmatory procedures. Opiates, cocaine, PCP, marijuana, methamphetamine, and amphetamine have all been detected.

46. (Cone et al. 1991; Goldberger et al. 1991)

47. (Cone 1990)

48. Society of Forensic Toxicologists (SOFT), Proposed Revised Consensus Opinion, 1992. There has been previous criticism of hair analysis for drugs of abuse because of the lack of effective quality control procedures, limiting confidence in analytical findings. Even more significantly, because of the relative newness of this type of analysis, the most common evaluative techniques available commercially to employers are only now being linked to reliable confirmatory procedures.

Besides those previously mentioned, other limitations of hair analysis are that studies have involved a limited number of subjects, were not controlled, and relied too heavily on self-report data; there is little data available on the precision and accuracy of hair analysis; and there is relatively little clinical experience with hair analysis for the drugs of abuse (Harkey and Henderson, 1989, who provide a comprehensive overall review).

According to some reviewers, hair analysis may eventually prove useful to verify a history of drug use, to reaffirm past use beyond the window of urine or blood detection, to identify use of those drugs not normally tested for, to provide a "safety net" to guard against an error in testing, and to monitor compliance with an abatement program (Harkey and Henderson 1989). One of the exciting scientific possibilities of hair analysis is its potential to evaluate windows of use for a drug taken days and months previous since drugs in theory are retained "permanently" in the hair shaft as it grows out. However, many scientific issues still need resolution. A number of these issues were drawn directly from the consensus statement by a scientific committee brought together by the National Institute on Drug Abuse and the Society of Forensic Toxicologist's (SOFT) in May 1990. They include:

- What are the mechanisms of which drugs are incorporated into hair and what;
- Is the minimum dose required to produce a positive result?;
- To what degree does outside contaminants (i.e., marijuana, PCP, methamphetamine, or cocaine smoke) bind to the hair, thereby creating a situation equivalent to passive inhalation?;
- To what extent does hair treatments, shampoos, or analytical washing procedures remove already bound drug from a hair segment?
- To what degree does nutritional changes, disease, and other factors play a role in increased or decreased hair growth, thereby hurting the ability to "zero-in" on a targeted time-segment?
- To what degree does the various drugs diffuse or migrate along the hair shaft, thereby weakening the targeting capability?
- How much drug incorporation and retention in hair based on individual factors, including race, sex, age, or other differences?

49. Marijuana tests routinely can detect use of the drug, since the target analyte in urine, 11-nor-delta-9-tetrahydrocannabinol-9-carboxylic acid (THC-COOH), is easily identified by most chemical methods and usually exists in sufficient quantities after relatively recent use. It can also be detected in urine for many weeks after last use especially if the donor is a regular or frequent user (Ellis et al. 1985; Wall et al.

1983; Dackis et al. 1982). The presence of THC-COOH alone, then, is not of much use in detecting either the impaired worker or establishing recency of use with certainty. The metabolic parent, delta-9-tetrahydrocannabinol (THC), is responsible for the primary psychoactivity of the drug, but because it is so rapidly metabolized, it rarely is present for long in the urine. Presence of the parent THC in the blood of the infrequent user is usually reflective of recent use (Hunt and Jones 1980; Peat et al unpublished, cited in Peat 1989). Somewhat surprisingly for infrequent users, levels of THC-COOH may actually exceed that of THC for the first half-hour or so after last use (Hanson et al. 1987; Peat et al. unpublished, cited in Peat. 1989). The presence (or absence) of other metabolites (notably 11-hydroxy-THC) can be important in result interpretation especially if the history of marijuana use by the donor is known (Heustis et al. 1992A). Some research has suggested differences in the type of metabolites found in frequent users compared to light or infrequent users (Peat et al. unpublished, cited in Peat 1989; Alburges and Peat 1986). Other research has suggested that THC-COOH/THC ratios in plasma or blood may be useful in estimating time since last use (Hanson et al. 1983; Huestis et al. 1992B), but it is clear that a significant amount of information is necessary about the user (route of administration, analytical procedure used, type of user) before the ratios could be judged important (Wall et al. 1983; Peat, personal communication 1992).

Additionally, the concentrations and timing of various metabolites appears somewhat different than from smoking or intravenously administered doses (Wall et al. 1983). Neither passive inhalation or oral administration seems to cause either unique metabolites or metabolite ratios.

Most current cocaine use will involve one of two versions, either cocaine hydrochloride (the usual powder form which is most often snorted or injected) or crack cocaine (which is smoked). Current methods of chemical detection can choose to focus in on the presence of parent cocaine and two of its major metabolites, benzoylecgonine (BE) and ecgonine methyl ester (EME). To date, at least eleven metabolites of cocaine have been identified in the urine of a cocaine user (Zhang and Foltz 1990). One additional metabolite, cocaethylene, may be present when alcohol is used with cocaine (Hime et al. 1991; Hearn et al. 1991). This suggests that the metabolism of cocaine is more complex than previously suspected. In addition, there are questions about the stability of cocaine and its metabolites in vivo and in vitro, which appear dependent also on specimen pH (Baselt 1983; Levine and Smith 1990).

Research has generally suggested that use of cocaine

by any of the three principal administration methods (insufflation, injection, or smoking) produces drug and main metabolites (BE, EME) in roughly the same proportions. There is also data which suggests that additional metabolites may be present in the urine of smokers, perhaps due to the intake of cocaine pyrolysis products and their metabolism and/or excretion (Reported in Cook et al. 1985). Although cocaine metabolites are usually excreted out in detectable amounts up to 72 hours after last use, there are at least several cases where cocaine and/or BE positives have been reported in urine from 4-10 days (Cone and Weddington 1989; Hamilton et al. 1977). This last data suggests possible accumulation of the drug in body tissue after chronic use. The presence of parent cocaine in urine, therefore, may not necessarily be as useful as once thought to suggest very recent use of cocaine products.

Attempts have been made to prepare a predictive model of the excretion of cocaine and the principal cocaine metabolites in urine (Ambre 1985; Ambre et al. 1988; Ambre et al. 1991). Urine concentration ratios were preliminarily suggested as potentially useful predictors of time since last use. More recent kinetic models of cocaine and BE disposition continue to suggest that this may continue to be a productive avenue of research in both blood and urine, but more research is necessary.

Of the other drugs surveyed (amphetamines, barbiturates, benzodiazepines, the opiates, the hallucinogens, and PCP), there is little evidence yet available which would suggest strong markers helpful for identifying recent use. The only exception, of course, is that the presence of 6-monoacetylmorphine (6-MAM) in the opiate determination is an absolute indicator of recent heroin use. Unfortunately, the metabolite's absence in a suspect specimen does not rule out heroin. Interestingly, the apparent retention of 6-MAM in hair may make a verification of heroin use a much greater possibility.

50. Steroids can have a number of significant physiological and behavioral side effects. Adverse medical side effects include liver function damage and tumors, reproductive system problems, and possibly cancer (Strauss 1987; Haupt and Rovere 1984). People who take high doses of anabolic steroids may exhibit a variety of psychological and emotional changes. These range from feelings of well-being and euphoria to lack of energy, irritability and aggressiveness, manic behavior, symptoms of major depression, hallucinations, and paranoia (Strauss 1987; Haupt and Rovere 1984; Lamb 1984; Pope and Katz 1988). Fights and problems with interpersonal relations have been noted. Because of the large number of steroid compounds and similarity

between the compounds, detection and accurate identification is not a trivial problem (Chiong et al. 1992; Gaskell 1983).

51. Capable reviews of so-called "designer-drugs" and drug trends of the future have been provided by many, including Buchanan and Brown 1988; Shulgin 1975; and others.

52. Among the drugs that continue to be of potential interest to abusers include the phenylethylamines. These include derivatives of amphetamine and methamphetamine, as well as 3, 4 methylenedioxymphetamine (MDA), and 3, 4 methylenedioxymethamphetamine (MDMA; Ecstasy). All of these drugs have significant abuse potential, cause impairment, and in excessive dose or overdose situations, cause significant behavioral and medical problems. Most of these drugs may be picked up by current screening technologies, but because current confirmatory strategies generally ignore them, use of these drugs is generally going to be missed.

A number of synthetic narcotics substances appear to be of some concern because of their impairment capability and their difficulties for routine detection. As an example, the fentanyl derivatives have approximately 1,000 times the potency of heroin (Henderson et al. 1990). Their abuse potential is high among medical personnel (fentanyl is a commonly used general anesthesia) and among heroin-user type populations. The fentanyl family is a large and seemingly limitless one, possessing all of the pharmacological actions and effects of the better known narcotics. Because their chemical structures are quite different from the common narcotics, their ease of synthesis, and their ready availability, they are illustrative of the potential problems if drug use trends change to avoid routine detection strategies.

Another similar example can be found in the analogs of synthetic narcotic, meperidine. The meperidine derivatives are best known for the rash of moderate to severe Parkinsonism among addicts over a decade ago attributed to a batch of drugs contaminated with MPTP (1-methyl-4-phenyl-4-phenyl-1, 2, 3, 6-tetrahydropyridine; summarized in Buchanan and Brown 1988). However, as long ago as the mid-1970s, there were thousands of chemically modified meperidine structures available, some with potencies thousands of times that of morphine which could serve for heroin substitution and illicit drug usage (Shulgin 1975). Neither meperidine or any one of its analogs will screen positive on any of the assays in federal drug testing programs.

53. (Hughes et al. 1975)

54. (Rapaka et al. 1986)

55. (A comprehensive review is provided by Cody

1990)

56. (Cody 1990; Manno 1986; Schwartz et al. 1987; and others)

57. High Times Magazine (many issues); Hoffman 1987. Golden seal, cranberry juice, vinegar, and some specially manufactured commercial products have all been mentioned or advertised. Interestingly, the commercial products often offer a warranty of sorts—your money back if you offer proof that the product didn't work. Many of the underground commercial preparations are touted as necessary to protect against the specter of a false positive from over-the-counter products, although there is certainly no real illusion as to their real purpose.

58. A second *in vivo* approach focuses on flushing the system of drugs and/or metabolites through the use of some of the commercial masking products mentioned above or through the purposeful use of diuretics. At least one author has suggested that diuretics may have the capability to dilute the concentration of the analytes below the cutoff so that they are not detectable. Although prescription diuretics will clearly be the most effective, over-the-counter water loss pills or the simple ingestion of large amounts of fluid can have a mild diuretic effect. The best internal masking agent appears to be the ingestion of liquid, any liquid, in sufficient quantities to physiologically dilute the drug or alcohol concentration in the urine. This is best achieved when the concentration of the analyte of interest is going to be relatively close to the cutoff, although impressive dilution results have been reported from the ingestion of a liter of water (Laboratory of Pathology, unpublished).

A third *in vivo*-related approach may be direct sample substitution, where "clean" urine is intruded into the collection process by way of concealed sample bottle or bladder device such as a condom. This is a very common means to defeat a drug or alcohol test, and collections that are not directly observed are the most vulnerable to this approach. This approach is virtually undetectable by a laboratory if the replacement sample escapes the scrutiny of the collection agent.

59. Some of the common "household" materials used and for which there is research data include table salt, vinegar, ammonia, ascorbic acid, soap, detergent, bleach, Drano™, Vanish™, Visine™, Lime-a-Way™, and lemon juice (see Cody and Schwarzoff 1989; Kim and Cerceo 1976; Vu Duc 1985; Warner 1989; Pearson et al. 1989; Mikkelsen and Ash 1988; and others). There are a number of underground commercial products becoming available which are advertised to defeat one or more of the immunoassays. These substances are often very toxic and are usually advertised in underground press or passed on by word of mouth. In some cases, they have

a characteristic odor and can be detected upon collection. In others, they can be detected upon analysis if the laboratory is using a screening method other than the assay the product is designed to defeat (one well known product, for example, appears to contain a corrosive, likely butyraldehyde (butanol) or a similar substance. It also has a very characteristic odor in urine. The product clearly defeats EIA, but appears to cause multiple false positives with RIA). If the donor has judged the test requirements correctly, and the collection site and the laboratory are not vigilant, the adulterants can produce the desired false negative result.

60. U.S. Department of Education 1988; State of California Attorney General's Office 1991.

61. Naturally, this assumes a quality program which is developmentally appropriate, is of sound content, is employee-focused and relevant to the workplace, utilizes a broad methodology for teaching knowledge, skills, and concepts, and involves teachers or trainers who are knowledgeable and experienced.

62. (NHTSA 1989; U.S. Department of Justice 1989)

63. NHTSA 1989. The DRE examination includes the following components:

a. A breath alcohol test. This is done to determine whether alcohol is involved.

b. The interview of the arresting officer. Information is gathered from the arresting officer which may be used to craft the DRE's own interviews.

c. The preliminary examination. This is a structured series of questions, specific observations, and simple tests to help rule out injury or another condition not related to drugs. If injury or disease is suspected, the evaluation may be terminated here and professional medical attention sought.

d. The examination of the eyes. This examination looks for horizontal and vertical nystagmus, and includes a check for lack of visual convergence.

e. The divided attention psychophysical tests. These include classic roadside "drunk" tests including the walk and turn, the one leg stand, the Rumberg Balance test, and the finger to nose test.

f. The dark room examinations. These tests involve systematic checks of the size of the pupils, the reaction of the pupils to light, and evidence of ingestion of drugs by nose or mouth.

g. The vital signs examination. These are designed to be systematic tests of an individual's blood pressure, pulse rate, and temperature.

h. Examination of muscle rigidity. This test is a physical check of whether the muscles are hypertense.

- i. Examination for injection sites.
- j. Suspect's statements and other observations.

At this point, the DRE will ask the suspect specific questions which have been derived from the preliminary determinations made from the previous examinations.

k. Opinions of the DRE. Based on what has been learned up to this point, the DRE will be prepared to make and document his/her determinations.

l. The toxicological examination. The results of any chemical tests (preferably blood) that were administered are applied to the DRE's findings.

64. Officer T. Page, Los Angeles Police Department, personnel communication, 1992.

65. (NHTSA 1989)

66. (Scanlon 1986)

67. In this discussion, Operation Red Block, a successful peer intervention program in the railroad industry is used as the model. There are many other excellent examples.

68. To be useful, such an objective measure of impaired functioning would at least:

a. Provide an immediate and consistent measure of job performance capability before an employee goes on duty, not just subsequent to an incident or accident.

b. Be able to consistently measure impairment at expected thresholds.

c. Help identify more subtle forms of impairment where combinations of factors (i.e., an alcohol or drug induced hangover effect plus stress or fatigue) may produce additive or supra-additive impact on job performance, and which may be missed by routine chemical testing.

d. Be cost effective and cost beneficial and not detract from the effective and efficient operations of the company.

e. May be conducted with a minimum intrusiveness and impact on the rights of the individual employee.

f. May be conducted with a minimum capability of an impact by the test administrator on the results.

69. Two of the most common approaches are as follows:

a. Test Driven. A test or battery of tests which already has been developed for other purposes and which may be capable of discriminating fitness-for-

duty, are applied to various workplace settings and job types.

b. Job Task Driven. An evaluation of a work function or job type is conducted and tasks associated with the performance of a job are identified. A test or test battery is then devised to discriminate impaired performance in a fitness-for-duty determination.

70. (Allen et al. 1990)

71. As it is currently implemented as a commercial performance impairment testing device, an operator manipulates a control knob to correct increasingly unstable movement of a pointer on a computer screen. Eventually, the pointer becomes impossible to control and the operator fails. Success on the test is measured by the length of time the operator is able to retain control of the pointer compared against the operator's own pre-established baseline performance on the task. The operator is given several attempts (or trials) to pass the test.

72. Dr. Hegge, Office of Military Performance Assessment Technology, Walter Reed Army Institute of Research, personal communication, 1992.

73. To the person participating, the test(s) will ideally appear as a unified, integrated operating experience. This may include graphical displays such as maps and operating instruments. Depending on the type of work to be modeled, families of tasks can be constructed which are directly traceable back to the actual workplace. From the data gathered, risk assessment statements can be generated.

74. In the transportation industry, rates have generally ranged from 50 percent to 10 percent in past years, with 50 percent the current federal requirement for most Department of Transportation regulated employees.

75. Various reports have been generated which show some support for the suggested range of 1-3 percent positive tests. Among these are data provided by the American Trucking Association (Davis et al. 1991) of 1.95 percent random positives for its industry in 1990; by the Federal Railroad Administration of 0.9 percent positives among employees of Class I carriers in 1990-1991; and by the Federal Aviation Administration of 0.8 percent positives of its regulated employees in 1991. Some data also exists for the maritime industry of a 1.5 percent random positive rate in 1991-1992 (Ellis unpublished). The National Institute on Drug Abuse (NIDA) has also published data covering a broad range of industries in 1991-1992 consistent with a general range of 2-3 percent positives (NIDA 1992).

**APPENDIX D3  
ALCOHOL AND DRUG EFFECTS ON  
PERFORMANCE**

Marcelline Burns

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**BACKGROUND AND RATIONALE**

A number of difficult questions underlie the topic of performance impairment by alcohol and drugs. This paper can address only some of the questions and will do so with a relatively broad brush. Laboratory research typically is an activity of refining, controlling, and reducing measurement. Engaged with that focus, we may lose, or risk losing, sight of the context within which the data from experiments have meaning and consequence. The task before us as conference attendees, however, is to identify and define as precisely as possible appropriate research objectives concerning alcohol and other drugs in transportation. By definition, the task requires a real-world view of the problem.

What do we presently know about the effects of alcohol and other drugs on performance? That first question calls for an evaluation of the sum of information which has been obtained over the years from laboratory study, epidemiology, accident investigations, and case reports. The evaluation can be expected to reveal the major gaps in the body of information.

The primary question can be answered only in light of the evaluation. That is, in the interest of transportation safety, what additional information is needed? There are at least two corollaries to this inquiry, one of which concerns the why of research objectives. [In a time of multiple societal problem and ever-shrinking budgets, the "why" associated with research need is essential to an inevitable prioritizing process.] "What" and "why" are, of course, inextricably bound together and will be the focus of conference discussion.

A second corollary concerns who needs additional information about alcohol and drug effects on performance. Because this issue to some extent sets the stage for conference discussions, it merits discussion at this point in time.

**RESEARCH DIRECTIONS: WHO NEEDS IT?**

**Law Enforcement**

Police officers, from patrolman to watch commander to chief, need information about the effects of alcohol and other drugs. The relevance to traffic enforcement is

foremost and obvious, but the needs extend beyond traffic. Alcohol and drug problems currently impact virtually all areas of law enforcement and although some declines in drug use are evident, there is as yet no strong evidence that the contribution of drugs to crime will abate significantly within the decade.

Drug-related crimes cost American society about \$20 billion dollars in 1983 (NIDA 1991). In 1988 approximately 75 percent of arrestees in a 14-city study tested positive for drugs (Wish et al. 1989). More than one-in-three women jailed in 1989 were accused or convicted of drug offenses (BJS 1992). The probability is high that individuals who are arrested for robberies, burglaries, assaults, vehicle thefts, forgeries, counterfeiting, and prostitution, as well as for traffic violations and crashes, and those whose business is the sale of drugs, will test positive for drugs. In other words, police officers frequently confront and arrest drug-impaired suspects.

They need to know how drugs influence suspects. If they are to remove impaired drivers from the roadway and if they are to protect arrestee and bystanders, as well as themselves, they need to know which substances impair and which lead to violent and unpredictable behavior. They need to be able to recognize the signs and symptoms that signal drug presence. Street lore abounds within law enforcement and often is on-the-mark, valuable information, but it also can be misleading and it is almost always incomplete. Currently, however, it may be the primary source of information for an officer who is outside the ranks of Narcotics or Drug Recognition.

**The Criminal Justice System**

The drug-influenced arrestee eventually makes his/her way through the criminal justice system where the relationship of drug impairment to crime might be expected to be a key element in disposition of the charges. Often it is not. The principal players in the system (defendant, prosecutors, defense counsel, judges, juries) frequently do not understand the nature of drug impairment, the relationship of drug influence to crime, or the degree of risk created by a specific substance. An observer can only wonder how often the lack of drug research results in miscarriage of justice.

The court may rely on the testimony of expert witnesses, among whom the level of expertise varies widely. In the best of circumstances, an expert will draw from scientific data to accurately enlighten the court. Obviously, however, testimony can be only as accurate and complete as available data.

Given the socioeconomic milieu of drug use, what sanctions are appropriate and effective for drug-related crimes? In California 25 percent of first-time DUI offenders re-offend with 5 years (Peck 1991). The prevention of recidivism is one of the most important goals of the criminal justice system (Ross 1991). Realistically, courts which lack drug-specific information on which to base sanctions are unlikely to achieve that goal.

### The Workplace

During recent years, problems associated with impairment by drugs in the workplace have gained attention. The focus is appropriate and timely. Drug use is most prevalent among young adults ages 18-34 years, and that age group is a large segment of the working population. In 1988 nearly 17 percent of employed 18-to-25-year-olds had used marijuana within the last month, and 11 percent of 26-34 year olds had used it within the last year (NIDA 1991).

To date, the most common response by industry to the problem of drugs in the workplace has been a program of urine drug screening, which at best is a partial and controversial solution. Although a positive urine can reveal recent drug use and may serve a company's objectives at the pre-employment stage, it provides essentially no information about an individual's current performance and safety status. Managers, supervisors, and policymakers have considerably less need for information about an employee's drug-use history than for indicators of current impairment. They need data, methods, and programs to facilitate rapid, non-invasive evaluation in cases of suspected on-the-job impairment.

The transportation industry is particularly vulnerable to drug-use consequences which create risks that extend beyond the commercial vehicle operators. For example, in 1985 4500 people died in crashes involving tractor-trailers; only 17 percent of those fatalities were the drivers themselves (NHTSA 1985). Truck drivers are, of course, motivated by the economics of the industry to drive long, monotonous hours. The resulting fatigue and boredom may, in turn, motivate drug use. The drivers believe that at least 20 percent of their ranks drive under the influence, with marijuana, methamphetamine, or cocaine being the drugs-of-choice (Beilock 1989).

Truck drivers are a high risk group and their drug-related performance errors make headline news, as do those of airline cockpit crew, tanker captains, and railroad engineers. Because of those work environments, alcohol and drug use can have tragic consequences, but it is important to keep in mind the many less visible jobs

which are also incompatible with drug use. Moreover, the impairment issue extends to drugs other than alcohol, marijuana, and stimulants. Prescription and OTC medications almost certainly play a role, albeit ill-defined, in workplace risks.

At any one time, half the adult population takes medications, which range from vitamins and hormones to maintenance therapeutic agents and acute-care preparations (Faich 1986). Although true workplace prevalence rates are unknown, these numbers strongly suggest that substantial numbers of employees go about their jobs under the therapeutic effects of medication. Whether and to what degree safety is compromised because the medications impair performance is also largely unknown.

Calling attention to a workplace drug problem that may be overlooked by non-medical personnel, deHart (1990) noted that environment and work demands can potentiate the adverse effects of a medication. He illustrates the potential with two examples: heavy physical work can generate hypoglycemic reaction in an otherwise well-controlled diabetic. A patient who is taking a beta blocker to control hypertension may experience heat exhaustion in conditions of relatively mild thermal loading.

Because of the high costs of drug development, new medications reach the marketplace when there is virtually no information about associated risks for performance. The development process, from discovery to market, typically extends over more than 10 years at average total costs of \$100 million dollars (Tilson 1990). Although the process generates a great deal of data, little-to-none of it pertains to workplace safety. The kind of information, which the prescribing physician, patient, and responsible workplace parties need in order to make safety-consistent decisions, is typically not available until post-market experiences begin to accumulate.

Questions of workplace safety are complicated. There are potential but often unspecified, perhaps unrecognized, drug-disorder interactions. Decisions about the risks of a particular drug require that they be weighed against performance deficits associated with the disorder itself. For example, psychiatric distress can be impairing and as Potter (1990) points out, only the most severely affected men seek treatment (women are treated more often). Thus, employed men who are experiencing depression or manic-depressive illness are likely not to be treated. Potter believe the lack of treatment is a much greater problem for performance than the effects of drugs.

The individual who does seek treatment for psychiatric disorder may be prescribed an anxiolytic, antidepressant, antimanic, or antipanic drug, all of which

carry the potential for performance impairment, at least during the acute treatment phase. In a study with schizophrenic patients, Gerhard and Hobi (1987) found that performance impairment, which was measurable early in the course of treatment, abated as the patients reached a pharmacological steady state. Since there have been few studies over an extended period of treatment, however, the clinician typically prescribes treatment for his patient without data concerning chronic dose performance effects.

Evaluation of these issues of disorder and drug effects needs to take note of what may be an increase in the numbers of people for whom treatment with psychotropic drugs is indicated. Lifetime incidence of major psychiatric illness in the United States for individuals older than 60 years is lower than the incidence for ages 44-55 years (Robins et al. 1984). Although it is possible that the difference occurs because older people forget or deny such illness, it is also possible that the finding reflects a true cohort effect, demonstrating an increase in the prevalence of major psychiatric illness. Data from Canada showing higher suicide rates in younger populations appears to support the latter explanation (Gershon 1988).

Workplace issues are not limited to acute drug effects on performance but extend to drug seeking, chronic effects, and hangover/withdrawal effects. The problems are particularly acute in transportation-intensive industries but apply to other environments as well. The issues are enormously complex, and solutions which are both acceptable and effective remain elusive. Policies have undergone scrutiny and change in recent years, but significant progress in minimizing the adverse effects of drugs in the workplace awaits additional research.

#### **Legislators and Regulatory Agencies**

Reasoned and effective laws concerning alcohol and drugs require scientifically valid data about the effects of the substances. Also, the risks and costs associated with alcohol and other drugs is key information for the agencies which regulate their production and distribution. Either over- or understatement of risks due to a lack of research and a lack of data is a costly disservice to the public.

#### **Citizens**

Finally, parents, teachers, counsellors, youth leaders, and various other members of the community who serve as role models, sanction behaviors, and communicate norms need accurate information about drug effects. The Los Angeles Times recently reported that two local teenagers

died from the use of inhalants. They were not delinquents or chronic drug users. Apparently, they were "good" kids from an intact, middle-class family, who decided as a lark to get high. They turned to the most available source of an intoxicant, their homes. Their deaths illustrate the tragic consequences of parental ignorance that the propellants in common household products are sufficient for intoxication and death. In this connection, drug experts at all levels might ponder their responsibility to communicate their findings to a wider audience and to do so in language which the nondrug expert can readily comprehend.

### **RESEARCH DIRECTIONS: WHAT DO WE KNOW ALREADY?**

#### **The Literature**

A rather large, rather fragmentary literature documents the body of knowledge about alcohol and drugs. In large measure, the study of effects on performance has proceeded agency by agency, investigator by investigator in a reactive manner. As safety problems associated with the use of a substance have been recognized, research (typically lagging by some years) has accumulated around the substance and related issues. Proactive, systematic, and thorough study of a potentially impairing illicit drug or new therapeutic agent has not been the rule. Research has not been notably theory driven with an overriding, sustaining focus.

The literature encompasses several decades, several disciplines, many investigators, more than a single *raison d'être*, and many kinds of substances. It reflects medical, psychological, human factors, and traffic safety inquiry, economic issues, and health and safety concerns. If the questions posed here are to be productively addressed, part of the task at hand is to impose order which will permit evaluation of that body of knowledge. For these purposes, a traditional review, even if restricted to the most important books, papers, reports, and other documents, seems not the best way to proceed. A review would not necessarily reflect a consensus concerning importance, but it certainly would exhaust both the writer's and the readers' pre-conference time. The unwieldy base of information must be wrestled into a format which will facilitate organized discussion of broad issues.

Data appear to have accumulated largely as a function of perceived severity of safety, economic and social problems surrounding the various substances. Problem-severity has also served loosely as a criterion variable in the organization of the following sections. The discussion is restricted to those substances perceived

to be the cause of the most severe problems as a result either of extent of use and/or degree of performance impairment.

To some extent, the criterion fails where severe drug problems are specific to a time and place. Methamphetamine, which in 1988 contributed to less than 2 percent of emergency room cases nationwide, accounted for 27 percent of emergency room cases in San Diego (DAWN 1989). The large number of "meth" labs in San Diego County create a major problem, but it is restricted in area and therefore does not generate significant study. The magnitude of the Hawaiian "ice" (smokable methamphetamine) problem in Hawaii has not been duplicated elsewhere. Phencyclidine (PCP), the drug found most frequently in impaired drivers in Los Angeles in 1985 (Compton 1986), now is relatively rare in L.A. but remains a drug-of-choice in Washington, D.C. Despite differences by locale, however, there appears to be sufficient continuity and commonality for severity to serve as an organizing variable.

## The Substances

### *Alcohol*

Alcohol ranks at the top of the list of impairing substances in terms of extent of use, problem severity, accomplished research, and what is known about effects on performance. Because of the relationship of blood alcohol concentration (BAC) to impairment and the technology of breath sampling, the issues are less difficult than for some other substances.

Alcohol-and-driving is perceived as a problem of sufficient magnitude to generate research. Traffic safety problems directly and indirectly have given rise to a large proportion of the accomplished research. Further, the traffic safety literature is a primary source of data about the broader topic of alcohol effects on performance.

In 1989 there were 45,555 traffic fatalities in 40,718 fatal crashes. Even though more than 22,000 of the 1989 drivers, bicyclists, and pedestrians had been drinking, the statistics reflect a decrease over time in the role of alcohol. The proportion of fatalities in which the BAC of at least one driver or nonoccupant was 0.10 percent or higher decreased by 15.3 percent from 1982 to 1989 (FARS 1989).

Data obtained in many controlled laboratory studies of alcohol with human subjects demonstrate and define impairment of skills important to safe performance. The deficits are both statistically significant and practically relevant. Note, however, that much of the laboratory research was conducted as single-dose studies with subjects dosed to mean blood alcohol concentrations (BACs) of 0.10 percent or higher.

It is evident from more recent experiments, which have examined lower alcohol levels, that impairment of important skills also occurs at low BACs (Moskowitz and Robinson 1988; Moskowitz, Burns, and Williams 1985). This conclusion, which stands at odds with studies from much earlier times and with statutory BAC limits in more recent times, can be credited in part to more precise measurements of safety-critical skills. It reflects both advances in technology and the measurement sophistication of a maturing area of study.

It now is clear that performance changes begin with departure from zero BAC. The exact point on an ascending BAC curve at which the changes become significantly impairing is, within broad limits, a function of task demands, individual skill, and individual tolerance to alcohol. As a central nervous system depressant, alcohol acts on the brain and essentially all performance is susceptible to impairment at some BAC. However, there are wide differences between drinkers and skills and the BACs at which significant impairment occurs.

Coordination, balance, simple sensory functions, and a variety of overlearned, highly practiced skills are relatively resistant to alcohol, and the BAC at which they are affected reflects the individual's tolerance to alcohol. An inexperienced drinker may sway, stumble, fall, slur speech, etc. at low to moderate BACs. On the other hand, a chronic and/or heavy drinker is likely to exhibit none of these signs of alcohol influence until very high BACs (> 0.20 percent). This failure by the tolerant drinker to display obvious signs of intoxication may mistakenly be interpreted as evidence that performance is unimpaired, a mistake which undoubtedly contributes to the intractability of problems with chronic drinkers.

Perceptual, information processing, and attention processes are highly sensitive to alcohol, and it is these which are particularly critical to safe performance. Furthermore, there is a kind of unfortunate double liability. The alcohol consumer can observe his/her own stumbling, falling, or difficulty carrying out everyday tasks. These deficits may or may not contribute to an accident, depending on the activity and the environment, but the drinker can recognize them and adjust his activities. In contrast, the most introspective of drinkers likely will be unaware of those alcohol-related failures which are most critical to safety (e.g., his/her own misperceptions, failures to attend, and slowed central processes).

These general conclusions are based on the findings of many studies. Citations have been omitted for the most part since a few arbitrarily chosen references would not adequately represent the breadth of the underlying research. Moskowitz and Robinson (1988) provide a recent, comprehensive reference list, with studies conveniently categorized by task/skill in the body of the document.

### *Marijuana*

Although other substances are widely perceived as being more "dangerous," marijuana ranks just below alcohol on the basis of extent of use.

Marijuana remains the most commonly used illicit drug in the United States. A third of Americans—almost 66 million people—have tried it one or more times. Four million youth (12-17), 17 million young adults (18-25) and over 45 million adults age 26 and older have used marijuana.

In 1988, 5.9 percent (11.6 million) of the population age 12 and older were current marijuana users (that is, had used it in the past month). Of the 21.1 million people who had used marijuana in the previous year, almost one-third, or 6.6 million, used it once a week or more. (NIDA 1991)

A national survey of workers aged 19-27 years reported that rates of workplace marijuana use differ by occupation. The highest rate (17 percent) was reported for entertainment/recreation followed by 13 percent for construction, 11 percent for services, and 10 percent for manufacturing.

In a 1986 review of the epidemiology of road accidents involving marijuana, Simpson concluded that the "... literature relevant to marijuana and driving is fragmented and relatively sparse," (p. 28). He nonetheless states that the practice of driving after or during marijuana use is common among young adults. About one in six teenage drivers admits to driving after using marijuana. The difficulty of determining the contribution of marijuana to crashes is illustrated by his finding concerning the frequency of combining marijuana with alcohol. From a review of several major studies involving more than 2500 fatalities, he reports that when marijuana was present in the blood (7-10 percent of the fatally injured drivers), alcohol was also present about 80 percent of the time.

Lund et al. (1988) reported that cannabinoids were found in 15 percent of the blood or urine samples obtained from tractor-trailer drivers who participated voluntarily in a survey. However, what the relationship of their marijuana use and their driving skills might have been is not clear.

The issue of traffic risk is complicated by the fact that marijuana frequently is used with other drugs, and by the fact that it is not possible to relate the level of delta-9-tetrahydrocannabinol (THC) or its metabolite in body fluids to a degree of impairment. Although there is a correlation between plasma THC levels and effects when looking at group data, between-individual variation is great, and the predictive value of a single plasma level is very limited (Agurell and Hollister 1986).

The 1992 reports concerning marijuana are of the good news-bad news variety, which somewhat complicates the evaluation of what is known about its behavioral effects and risks to society. The downward trend in the number of users, as can be seen in the figure below, is a positive sign on numerous counts, including transportation concerns (Johnston et al. 1989).

**Figures.** Reports about the THC content of currently available marijuana falls on the negative side of the ledger. Marijuana is at least three times more potent than that available during the early 1970s. Growers have become increasingly sophisticated in the science of horticulture and can now produce material with high delta-9-THC content (El Sohly and Abel 1988).

There is evidence that users who smoke high potency marijuana do not titrate the amount obtained, as has been suggested, but actually do obtain more THC than if they were smoking less potent material. They do this even when their stated intent is to reach the same high (Perez-Reyes et al. 1982).

Given that THC content currently may be as high as 15 percent, it is highly questionable whether valid conclusions about its effects can be reached by extrapolation from laboratory experiments which used marijuana of 2 percent THC or less. There is no evidence to suggest that a linear function would adequately describe the drug effect curve.

There is considerable evidence that marijuana contributes to injuries and deaths, although with the interesting speculation that possibly it contributes less frequently to driving fatalities than to other kinds of fatal accidents. Maryland medical examiners found cannabinoids in 6 percent of victims from traffic crashes and in 10 percent of victims of other kinds of accidents (Isenschmid and Caplan 1988). In Los Angeles County coroner examinations, marijuana was detected in 19 percent of the samples (Budd et al. 1989).

Marijuana impairs a number of human skills. The effects of marijuana and alcohol, a common combination, are essentially additive although with distinct qualitative differences in the effects of the two substances. Since THC is not a CNS depressant, deficits are not attributable to a slowing of central processes, as with alcohol. They appear to be related to failures of attention and perception. The evidence suggests an intermittency of attention rather than, as with alcohol, generalized slowing and an inability to attend to multiple sources of information.

Laboratory study of marijuana is complicated by the interaction of the drug's effects with personality, situational, and social variables. Based largely on driving

simulator data, Smiley (1986) believes that marijuana impairs driving skills, but that drivers recognize their impairment and appropriately adjust their driving behavior to compensate. She also concedes that in emergency situations or where the task demands continuous attention, compensation is not possible.

As with alcohol, the large number of reports prohibits complete citations. A very limited, illustrative selection of marijuana-and-performance experiments includes work by Bird et al. (1980), Burns and Moskowitz (1981), Chesher et al. (1984, 1986), Casswell and Marks (1973), MacAvoy and Marks (1975), and Moskowitz (1985).

### *Cocaine*

If it goes well, I will write an essay on it (cocaine) and I expect it will win its place in therapeutics, by the side of morphium and superior to it. ...I take very small doses of it regularly against depression and against indigestion, and with the most brilliant success.

—Sigmund Freud (May 7, 1884)

The melancholy vanishes, the eyes shine, the wan mouth smiles. Almost manly vigor returns, or seems to return. At least faith, hope and love throng very eagerly to the danger; all that was lost is found. ...To one the drug may bring liveliness, to another languor, to another creative force, to another tireless energy, to another glamor, and to yet another lust.

—Crowley (1917)

Cocaine is a sympathomimetic local anesthetic, which has been used for thousands of years as a euphoriant and to combat fatigue. Freud's monograph, *Über Coca* (1884) coincided with a period of considerable interest in the drug, which then was followed by a period of little attention from either the scientific or popular press. It re-emerged as a recreational drug-of-choice during the 1970s but until very recently, it has been widely viewed as safe and nonaddicting (Grinspoon and Bakalar 1980).

Cocaine use peaked in 1985-86. Currently, in the U.S. population age 12 and older, 11.3 percent have used cocaine at least once, 3.1 percent used it during the past year, and 0.8 percent used it during the past month. It is most popular among 18-34 year olds, and among users in that age range, 35-40 percent have used it more than 100 times (NIDA 1990).

Although cocaine is reputed to have many effects, only five appear reliably: local anesthesia, increased pupil size, increased heart rate, increased blood pressure, and mood elevation. If a police officer observes that an arrestee's pupil size and vital signs are increased and outside the normal range, that alerts him to possible

stimulant influence. Although hyperactivity, agitation, and anxiety are frequently observed in the custodial setting, cocaine-related mood elevation or euphoria is not typically obvious in that setting. Strangely, moods also are not elevated, as measured with mood scales, at the dose levels and in the setting of laboratory studies (Burns 1991).

Heart rate and blood pressure changes possibly are related to cocaine fatalities. In the laboratory with subjects at rest, increases of 50 bpm and 20 mm Hg have been noted (Foltin et al. 1987, 1989). Since stress also increases heart rate and blood pressure, and since users take higher doses than those given to subjects, the cardiovascular effects together with the stress of physical exertion could explain some of the cocaine-related deaths of athletes. Also, because of the cardiovascular effects, the interaction of cocaine and the stress of high risk or emergency traffic events may be a dangerous combination.

Collecting cocaine blood level data, which could contribute to an understanding of its role in traffic crashes, is complicated by the enzymatic and spontaneous hydrolysis which results in rapid metabolization. The parent drug continues to metabolize in a blood sample unless the tube contains sufficient amounts of sodium fluoride or physostigmine (Jatlow 1988) or is frozen immediately. In illustration, blood samples obtained from drug-impaired drivers in a Los Angeles study were refrigerated but not frozen. Apparently, the preservatives were insufficient to stop degradation of the cocaine in the tube. The result was that the analysis found high levels of BE and only low or zero levels of cocaine (Compton 1986).

A Cocaine Bibliography (NIDA 1975) offered more than 100 pages of papers and books reporting anecdotal data, drug abuse trends, biochemical and pharmacological studies, and studies of addict populations. They did not address questions germane to skills performance. The consequences of cocaine use for traffic safety were considered only indirectly. That aspect of the literature has changed very little since 1975.

Williams et al. (1985) reported that cocaine was found in 11 percent, or 47, of the fatally injured young male drivers in California. It is important to note, however, that cocaine was the sole substance in only two drivers. Thirty-six had combined cocaine and alcohol, and seven had combined cocaine and some other drug.

Moskowitz and Burns (unpublished) carried out a laboratory study of the effects of 96 mg cocaine, with and without alcohol, with 16 healthy men, average age 24 years. Immediately after cocaine administration, performance on a battery of complex tasks was improved and the impairment from 0.05 percent BAC was almost completely counteracted. Enhanced performance persisted through a second test battery which began 2

hours post-dose.

Early data from the first experiment in a 2-year NIDA-funded study of cocaine essentially parallels the Moskowitz and Burns findings; that is, 96 mg cocaine enhances the performance of complex tasks by healthy male subjects (Burns 1991).

A more recently-completed experiment in the same project established laboratory times and usage as similar as possible to typical social conditions. Sessions were conducted at night and cocaine doses included 126 mg. Subjects "snorted" the cocaine as a series of three lines at 30 min intervals. They performed a battery of tests immediately after the last line, again near midnight, and again the following morning after sleeping overnight at the laboratory. Data analysis is in progress, and it appears that the findings are complex, reflecting differences by task and by test time. At this point, the only conclusion that can be offered with certainty is that the effects of cocaine are neither uniformly negative or positive.

#### *Narcotic Analgesics*

Although heroin use currently is receiving considerable attention, it is not because of performance issues but rather because of the HIV crisis. The practice of addicts gathering in shooting galleries to use drugs and share works is a common route of HIV infection. "Speed-balling," which is the combining of heroin and cocaine, is believed to be associated not only with HIV infection but also with bacterial endocarditis and hepatitis (NIDA 1991).

Household survey samples do not provide good heroin data since they exclude some of the populations among whom use is likely to be high (homeless, transient, imprisoned). The estimate that less than 1 percent of the population has ever used heroin is probably a significant underestimate (National Household Survey 1990). Using mathematical modeling, Brodsky (1985) estimated in 1982 that there were about 500,000 addicts in the U.S.

Whatever the actual size of the population, the lifestyle of active heroin addicts typically is incompatible with either employment or vehicle ownership. Thus, adverse effects on performance may not be a problem of great consequence. On the other hand, those addicted individuals who have entered methadone maintenance programs are able to be regularly employed and to be driving, and the effects of methadone on their performance is of considerable interest. In addition, the effects of codeine are pertinent, simply because it is so widely used as an analgesic.

The brief, following discussion is drawn largely from

a recent, very capable review by Chesher (1989). The original document is highly recommended both as a source of information about narcotic analgesics and for references to the literature.

Narcotic analgesics are either (a) the naturally occurring opioids (morphine, codeine) (b) semi-synthetic opioids (heroin, hydromorphone, oxycodone, dextromethorphan), or (c) synthetic opioids (meperidine, fentanyl, methadone, pentazocine, meptazinol). The first two categories are derived from the opium poppy. The synthetics are laboratory products.

Effects in common for the three categories include the modulation of pain, pupil constriction, euphoric/dysphoric moods, respiratory depression, gastrointestinal effects (chronic constipation), and tolerance/dependence. Tolerance develops to all effects except pupil constriction and the gastrointestinal action.

Although opioids have both CNS stimulant and depressant effects, therapeutic doses in humans are characteristically depressant. Effects depend on (a) the drug, specifically, its potency and the receptors on which it acts (b) the route of administration and (c) the drug history of the user.

For obvious reasons, study of the effects of heroin and morphine on performance have been rare. Two experiments can be cited as illustrative (although in this writer's view both the ethics of heroin administration to "ex-addict" prisoners and the sensitivity of pursuit rotor as a performance measure are open to question). Fraser et al. (1963) administered heroin to prisoners in a lengthy, complicated study of addiction. The investigators' interpretation of pursuit rotor data was that chronic heroin does not affect psychomotor performance. Bauer and Pearson (1956) reported no effects of morphine on a pursuit test.

Since methadone maintained patients are more likely to be driving and working than active heroin addicts, the studies by Moskowitz and Robinson (1985) and Robinson and Moskowitz (1985), as well as earlier work by Gordon (1970) are more relevant to safety issues. In the Moskowitz and Robinson research, methadone-maintained patients performed tests of driving-related skills. Compared to matched controls, they showed impairment only on a test which measures the rate of information processing. The investigators concluded that methadone-maintained patients should not be considered impaired in terms of their ability to perform complex tasks such as driving.

Chesher (1989) concludes that it is not possible to determine the role of narcotic analgesics in crashes. Based on his review of the evidence, he asserts that the risk of these drugs does not approach that associated

with alcohol.

### *Prescription Drugs*

Sedative, hypnotic, and anxiolytic drugs are prescribed to treat anxiety, insomnia, spasticity, convulsions, and alcohol withdrawal, as well as various other kinds of psychological and physical distress. These drugs offer the patient both potential benefits and possible adverse effects. Judged by the number of prescriptions and emergency room mentions, the benzodiazepines are perceived as being superior to barbiturate and non-barbiturate sedatives in terms of both benefit and liability. They currently are the most widely prescribed, and their trade names (e.g., Valium, Librium, Miltown) have become part of the average person's vocabulary.

In 1975, 90 percent of sedative, hypnotic, and anxiolytic prescriptions were for benzodiazepines. Since that time, the absolute numbers have declined, perhaps because the liabilities have received considerable publicity, including Congressional investigation, and physicians have begun to exercise more prescribing discretion. Still, 81 million prescriptions for benzodiazepines were filled in 1985 (FDA 1981, 1986). Diazepam (Valium) use declined, leaving alprazolam (Xanax) the most prescribed in 1988 (American Druggist 1989). Xanax has moved into a favored position with abusers, perhaps because it is more difficult to detect in blood or urine samples than is Valium.

In terms of safety issues, it is most important to note that most of these benzodiazepine prescriptions are not for hospitalized patients but for people who engage in their normal daily activities while taking the drugs. If the drugs do degrade performance, millions of people may be at increased risk as a direct result of their drug therapy.

A large number of laboratory and on-the-road studies, which were undertaken to examine the performance effects of the benzodiazepines, have reported that they cause significant impairment. Important as those findings are in terms of drug effect per se, their translation into real-world risk is less than straightforward.

Many experiments have examined a single therapeutic dose in comparison to placebo, possibly including a drug-plus-alcohol condition. Although the acute dose study provides important data, it is incomplete data. Patients rarely take a single therapeutic dose, and it is equally important to understand chronic dose effects. Do adverse effects diminish as blood levels reach steady state? Are blood levels of the drug's psychoactive metabolite increasing to a potentially impairing level?

The typical subject is a young, healthy adult, most often male, and as noted by Benjamin (1977), "If a

normal healthy subject is given a psychoactive drug, it would be surprising if his performance were not impaired." Patients for whom the drugs actually are prescribed are more likely to be middle-aged and female. Since the medical and emotional problems which prompted them to seek treatment may also impair performance, it is difficult to assign risk specifically to the drug.

Drug studies, including studies of the psychotropics, too often fail on two crucial counts: 1) The laboratory tests, which are used in an experiment and which are degraded by the drug, have neither theoretical nor demonstrated practical significance for safe driving or performance of other complex tasks, and 2) statistically significant performance changes are reported, but the magnitude of the change is small and may or may not make a practical difference in a real-world task.

It is clear from national surveys that anxiolytics/sedatives are used for other than medical reasons. Emergency room overdose cases often involve their combination with alcohol (NIDA 1991). In the illicit drug culture they are used by polydrug abusers, and extraordinarily high blood levels have been found. Although there is a lack of correspondence between plasma concentrations and performance, it seems reasonable to assume that the driver whose blood sample contained 2478 ng/ml diazepam or 3873 ng/ml chlordiazepoxide was "under the influence." Those levels were reported from the analysis of blood samples obtained from suspected drug-impaired drivers in Los Angeles (Burns 1985).

Published papers concerning the effects of therapeutic drugs are too numerous to cite here. The proceedings of the Second International Symposium on Medicinal Drugs and Driving Performance (1987, Maastricht, The Netherlands) and the "Medication-Induced Performance Decrements" issue of the *Journal of Occupational Medicine* (Vol 32, No 4, 1990) address the issues of prescription and OTC drugs and are valuable sources of information and references.

## **CONCLUSIONS-DISCUSSION: THE NEEDED RESEARCH**

### **Alcohol**

Although alcohol study exceeds the study of any other substance, gaps in the knowledge base remain. The following topics require further study in relation to performance:

- Tolerance;

- Low BACs;
- Inexperienced, infrequent drinkers;
- Chronic, heavy drinkers;
- Alcohol-drug combinations;
- Hangover effects;
- Alcohol-aging interaction; and
- Alcohol effects in the young driver.

The effects of many alcohol-drug combinations and alcohol-other variable interactions remain inadequately specified. It is not feasible to examine all doses, all combinations, and all interactions, but examination of basic, safety-critical skills should be systematically extended over a range of doses. Combinations would be examined over a range of both alcohol doses and doses from the several drug categories, which have the greatest potential for impairment. Systematic, as contrasted with scattered and incomplete, examination of key interacting variables (e.g., fatigue, circadian effects, sleep loss, age, health) should be undertaken.

### **Marijuana**

The 22nd Annual Report of the California Research Advisory Panel shows no active studies by California investigators of the effects of marijuana on performance. The state of research inactivity is strangely at odds with the continuing popularity of the drug. There is need for additional research, including the following:

- Examination of the effects of high THC content marijuana,
- Study of the duration of marijuana effects,
- Examination of the effects on driving skills of high THC marijuana in combination with alcohol and other popular drug combinations,
- Marijuana effects on young (adolescent) drivers, and
- Further study of the relationship of blood/urine levels to performance effects.

Hangover effects require further examination. There is some evidence that behavioral and subjective effects may persist for at least 9 hours (Chait et al. 1985). A report by Yesavage et al. (1985) that marijuana affects the complex skill aspects of pilot performance 24 hours after smoking generated considerable interest and controversy, but to date no replication has appeared in the literature.

Since marijuana remains a drug of choice for many teenagers, and since the introduction to marijuana

coincides with the acquisition of driving skills, it is a matter of considerable urgency to understand how marijuana effects, beginning driver skills, and the recklessness of immaturity interact. Admittedly, the study of alcohol and drugs with underage subjects is a difficult task, but one that could be addressed with innovative methods for gathering data.

### **Cocaine**

Cocaine effects on performance are not well understood. The task of first priority is to define the what and how of measurement. It appears that laboratory methods which served well for depressants, for example, do not measure the stimulant effects of interest.

A common observation is that cocaine-influenced individuals become aggressive, risk-taking drivers. Although difficult to operationalize in the laboratory, risk taking, aggression and judgment need to be measured in order to understand cocaine effects on performance. Within the constraints of laboratory ethics, research needs to examine not only the arousal and improved performance of low doses but the extent to which the user becomes overstimulated as blood levels increase.

If cocaine-related decrements can be demonstrated, then there will be a further need to attempt to specify the associated blood and urine levels. Although the attempt may fail, the effort must be made because of the potential importance of knowing the relationship between cocaine dose level, blood and urine levels of both cocaine and benzoylecognine, and the performance decrements. At the present time, fluid levels confirm recent use but provide almost no other useful information.

It may be found that cocaine alone at typical use levels does not produce significant performance deficits and that risk escalates only when it is used in combination with alcohol and other drugs. The combination of cocaine and alcohol is frequently observed in arrestees. Users explain that alcohol, diazepam, or some other depressant is used to "take the rough edges off the cocaine high."

A speedball, a dangerous combination of heroin and cocaine, is also frequently found among arrestees. Differences in duration of effects (heroin 4 hours, cocaine 90 mins) and differences in action (narcotic vs. stimulant) sometimes lead to inadvertent overdose. A user who repeatedly re-injects as the effects of cocaine dissipate, eventually accumulates multiple doses, and potentially fatal levels, of the longer-acting heroin.

### Narcotic Analgesics

There is no urgent need for additional research with the narcotic analgesics.

### Prescription Drugs

Defining research needs for medications is perhaps the most complex of the topics at hand. Issues of personal need and choice vs. heavy-handed regulation vs. unacceptable social costs and consequences will not be easily resolved.

Millions of people use drugs non-medically for relief of pain (whatever its nature) and for pleasure (however esoterically defined). The numbers and diversity of drugs, dosages, and combinations renders futile an attempt to estimate the potential for personal harm and social cost. Nor can research examine all questions and provide all answers concerning safety issues.

Given the numbers of potentially impairing drugs together with the new compounds that will be marketed, there is no obvious research agenda. The following are offered as a guidelines for whatever research objectives may be defined:

- Examine the effects of a prescription or OTC medication systematically, including:
  - Acute dose studies with healthy volunteers to specify drug effects per se,
  - Acute and chronic dose studies with patients to clarify the net effect of drug-disorder interactions, and
  - Examine dosing regimens that represent typical therapeutic use.

### MISCELLANY

The body of knowledge in 1992 about alcohol and drug effects on performance varies by substance from extensive and/or adequate to scattered and incomplete. In many areas, it has grown sporadically without design in response to a mixed bag of "needs to know."

The topic is complicated by numbers and diversity of substances and users, and by its dynamic character in the face of continually changing availability and personal choice. A consensus recommendation for research will not be easily reached. Perhaps the objective should be a direction and a strategy to facilitate more systematic research.

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#### APPENDIX D4 IMPAIRED DRIVING DETECTION AND ENFORCEMENT

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Enforcement of impaired driving laws is conducted by police officers who are members of municipal departments, state police agencies, highway patrols, sheriff's department and a variety of other police agencies. Collectively, these agencies have more than 500,000 sworn personnel and make approximately 1.8 million arrests each year for "driving under the influence" (FBI Uniform Crime Reporting estimates). Arrest rates have been relatively stable at this level during the 1985-90 period.

Many of these arrests are being made by officers assigned to police entities whose primary mission is traffic. The officers may be part of the highway patrol, other state police agencies dedicated to traffic, the traffic division of a municipal or county level department or a dedicated DWI Patrol. Such officers comprise only a portion of the total complement of sworn personnel. Regular or precinct patrol officers may or may not be conducting impaired driving enforcement depending on their training, their department's emphasis on impaired driving enforcement and the demands placed upon them for other types of police services.

The purpose of the present paper is to provide a framework for the discussion of research and development activities that may assist these officers in their efforts to enforce impaired driving laws. The paper provides a brief history of impaired driving enforcement, followed by current issues and suggested research topics. The reader is cautioned that a complete discussion of these issues would require several volumes and thus the present paper is only an overview as seen from the authors' perspective.

Throughout this paper, the term DWI encompasses driving while intoxicated; driving under the influence; operating while intoxicated; operating under the influence; and similar. It should be noted that this general use of the term DWI obscures important distinctions between each charge as defined uniquely in the laws of each state. The term DWID is used to

generally refer to similar charges involving drugs other than alcohol.

## HISTORY

### 1960s

Laws relating to DWI offenses have undergone considerable change during the past three decades. In the 1960s, the presumptive threshold for DWI, generally, was a Blood Alcohol Concentration (BAC) of 0.15 percent, with blood specimens as the common means for BAC determination. Typical sanctions involved monetary fines and license suspensions or revocations. While the possibility of jail terms existed, they were rarely imposed. A major milestone in combatting DWI behavior was the U.S. Department of Transportation's report to Congress on the nature and extent of alcohol involvement in the overall highway safety problem. By the close of the decade, breath testing was replacing blood for evidentiary purposes, presumptive thresholds were being reduced, usually to 0.10 percent BAC, and Federal funding was beginning to support research, development, demonstration, system support and other programs aimed at reducing the alcohol crash problem.

### 1970s

The 1970s began with the Alcohol Safety Action Projects (ASAPs). These were high-profile programs established in many communities across the country. They provided substantial funding for the development, implementation and evaluation of enforcement, adjudication, driver rehabilitation and public information countermeasures. They had a significant and long-term influence on impaired driving enforcement and related legislation.

In the late 1970s, a vocal public constituency regarding the alcohol crash problem began to emerge through organizations such as MADD and RID. Formed initially around individuals who had directly suffered the consequences of alcohol-related crashes, these groups called into question existing court and licensing agency practices in dealing with DWI offenders. Examples were cited of crash involved DWI drivers who had previous arrests but had not experienced license withdrawal or who were not charged as repeat offenders because of existing processing practices. Inadequate record systems, plea bargaining to non-alcohol related charges and referrals to treatment in lieu of adjudication and/or license withdrawal were among the practices criticized.

In this same time frame, there was a growing belief

that the only demonstrable impacts on the alcohol crash problem were being achieved by well publicized and intensive law enforcement efforts. A model emerged which suggested that reductions in alcohol-related crashes required deterring potential offenders from undertaking DWI behavior. Such "general" deterrence involved creating a plausible risk of being apprehended followed by the perception of certain and swift application of relatively severe sanctions.

By themselves, the specific treatments or sanctions applied to those actually apprehended would not solve the alcohol-related crash problem as the majority of the crash involved were previously unknown to the criminal justice system. The deterrence model, therefore, suggested that the primary goal of the arrest and adjudication system should be to support general deterrence by certainly and swiftly applying relatively severe sanctions. General deterrence would create the perception among drivers that they would be well advised not to attempt driving after drinking.

### 1980s

The 1980s can be characterized as a decade of "tougher" DWI laws and sanctions as well as attempts to correct identified deficiencies in the processing of DWI offenders. State laws began to appear which mandated the application of particular sanctions, guaranteed license withdrawal and eliminated or restricted plea bargaining. At the Federal level, H.R. 6170 (Barnes) became law in 1982. Among the provisions of this bill was authority given to the Secretary of Transportation to make basic and supplementary grants to the states. Grant eligibility requirements included: increased DWI enforcement efforts and publicizing such enforcement; adopting an illegal per se statute; mandatory jail or community service terms; and mandatory license withdrawal periods. Various innovations were introduced during the 1980s to further increase the certainty of penalties. Illegal per se statutes began to appear which simplified the elements of the offense which had to be proven. Administrative license revocation statutes were introduced to insure certain and swift license withdrawal. States also began to introduce new sanctions to broaden the penalties and treatments that could be applied. Some of these (e.g., restitution) were responsive to victims' rights, some (e.g., community service and house arrest) were alternatives or adjuncts to jail sentences, and others (e.g., ignition interlocks, vehicle confiscation and/or registration withdrawal) were attempts to specifically deal with repeat drinking and driving behavior.

Youth drinking and driving was a major issue during

the decade. In 1984, President Reagan signed legislation that would have withheld highway safety funds from states that did not set 21 as the minimum purchasing age for alcohol. By July of 1988, all 50 states had a 21 minimum purchasing age requirement. Some states also adopted low or "zero tolerance" presumptive BAC limits for drivers under the age of 21 and "use and lose" laws which linked drug and alcohol convictions, irrespective of motor vehicle involvement, to loss of the driver's license.

The 1980s were also a period of innovation for the detection and arrest of DWI offenders. Officers were routinely trained in DWI detection procedures, Horizontal Gaze Nystagmus (HGN) and other field sobriety tests. Preliminary breath testing devices were improved to the point where they could be placed in routine use. By the close of the decade, passive alcohol sensors had appeared and were being tested under both laboratory and field conditions.

Drug impaired driving enforcement also emerged as a major focus. Drug Recognition Experts (DREs) were trained based on program development work done in Los Angeles. Pilot DRE programs were begun in four states during 1987 and later extended to several additional states. The objective of these programs was to give departments the ability to enforce impaired driving laws in situations where the impairment was caused by drugs other than alcohol. Drinking and driving declined during the 1980s. Fewer alcohol related fatalities were reported by FARS and fewer drinking drivers were seen in roadside surveys (Lund and Wolfe 1989). The reasons for the decline likely involved some interaction of the initiatives described above plus changing social attitudes fostered by citizen pressure to deal with the problem.

## CURRENT ISSUES

### Current DWI Arrest Patterns

Nationally, the current total of about 1.8 million arrests computes to approximately 10 DWI arrests each year for every 1,000 licensed drivers (FBI, 1989 arrest estimates; FHWA, 1989 license estimates). These arrests are not distributed equally across the regions of the country. As shown in Table 1, arrest rates (per 1,000 licensed drivers) are highest in the west; substantially lower in the east and south.

Regional differences in per driver arrest rates suggest regional differences in enforcement practices. However, some or all of these differences could be due to regional variation in the underlying drinking and driving problem. That is, if eastern drivers drive less and/or drive less

after drinking, then lower arrest rates might be expected regardless of enforcement practices.

One measure of the underlying drinking and driving problem can be found in FARS. The second column of Table 1 shows arrest rates by Region computed on the basis of the number of fatally injured drinking drivers. For Region I, the entry (149.3) represents the sum of all 1989 New England arrests divided by the sum of the 1985-89 yearly average of all New England .05 percent + BAC driver fatalities (see Preusser et al. 1992). That is, in New England, there were 149.3 DWI arrests for each fatally injured drinking driver. The comparable ratios in Region IV Southeast and Region VI Southwest were 85.7 and 84.3, respectively. In Region IX, there were 230.8 arrests for every fatally injured drinking driver.

Arrest rates also vary substantially with respect to driver age (see also Voas and Williams 1986). Nationally, as shown in Figure 1, young drivers are greatly underrepresented in the arrest population. There are approximately three times the number of arrests for every fatally injured drinking driver age 25 and older as there are for every fatally injured drinking driver ages 16 and 17. A similar, though less striking, discrepancy exists for young drivers in the 18-20 and 21-24 age ranges. This pattern of results, i.e., low arrest ratios for 16 to 17 year olds, somewhat higher for 18-20 year-olds, much higher for drivers 25 and older, is remarkably similar across states and regions.

It is not known why DWI arrest rates relative to alcohol crash rates would be particularly low in the southeast and southwest. Low youth arrest rates, however, have been the subject of a recent NHTSA study (Preusser et al., 1992). It was suggested that youth do not follow the typical drinking and driving patterns of older drivers. Underage drinking is illegal and, to quote one officer, "drunk or sober, youth drive differently." Enforcement resources, targeted to the typical older driver, may not be well positioned with respect to place or time to find youth. When they do encounter a young driver, officers may not recognize youth impaired driving cues which likely differ from the detection cues used to find older impaired drivers. And, youth impaired driving typically involves lower BAC levels making arrest and prosecution more difficult.

### DWI Patrol Strategy

A DWI arrest can result from some patrol activity, a crash investigation, or some special operation such as a sobriety checkpoint or a "DWI saturation." It is felt that patrol activity, including DWI patrols, provide the

greatest number of arrests followed by crash investigations and special operations.

Surprisingly little is known about the efficiency of each of these arrest modes or the characteristics of those drivers found by each mode. Nevertheless, regardless of mode, DWI enforcement is often left to those officers who have traffic as their primary responsibility and/or are specifically assigned to DWI patrols. In general, on a per officer basis, state police and highway patrol agencies and the traffic divisions of county and municipal agencies conduct far more DWI enforcement than regular or precinct officers. In many large municipal departments, for instance, DWI arrests made by the regular or precinct officers are rare and arise only from an extreme set of circumstances.

Specialization of DWI enforcement among traffic and/or DWI officers likely has advantages. However, it also likely affects the selection of those drinking drivers that are arrested from among the many drinking drivers that could be arrested. DWI patrols, for instance, are rarely conducted during daylight hours. They are also less common on Sunday through Wednesday nights. In practice, DWI officers target their patrols to the times and places where they are most likely to find the "typical" drinking driver. This typical driver, however, only represents a subset of all drinking drivers. Similarly, highway patrol officers and officers assigned to municipal traffic divisions target their activities to highways and arterials. They are less likely to patrol residential neighborhoods. Regular patrol officers, who are in the neighborhoods at all hours of the day and night, may or may not be conducting DWI enforcement.

It is felt that there are differences in the characteristics of drinking drivers arrested by various types of patrols. There may also be differences in the arrest population derived from various arrest modes such as crash arrests versus patrol or pickup arrests versus sobriety checkpoint arrests. For example, 23 percent of drivers arrested at Charlottesville, VA checkpoints were under the age of 21 as compared with only 11 percent of drivers arrested by patrol activity during the same period (Voas, et al. 1985).

#### **DWI Detection and Arrest**

For patrols, DWI detection relies on officer experience, stopping many motorists for observed moving violations and/or a set of DWI detection cues developed some years ago by the National Highway Traffic Safety Administration. DWI investigation often relies on the Standardized Field Sobriety Test including Horizontal Gaze Nystagmus (HGN). Many of the officers familiar with HGN feel that it is the most important advance in

DWI enforcement in recent years. Some departments are using non-evidentiary preliminary breath testing devices as part of their investigation. Some are using in-car video cameras and/or cameras at the booking facility to document their investigation and arrest. Some have DRE programs which facilitate enforcement when the impairment is caused by drugs other than alcohol.

Virtually all of the above techniques can be used for crash investigations and checkpoints. However, particularly at checkpoints, it would appear that preliminary and passive breath testing devices are particularly useful. At checkpoints, the officer has less opportunity to observe on-road behavior and driver interviews tend to be brief because of the need to minimize the delay for nondrinking motorists. Parts of Australia have implemented random roadside breath testing (i.e., checkpoints) using preliminary devices. In this country, the use of passive sensors has been studied at checkpoints in Binghamton, NY (Wells et al. 1992) and Charlottesville, VA (Jones and Lund 1986). Such devices may also have a role in the enforcement of the low BAC laws for youth.

Most of the field sobriety techniques in current use were designed for the enforcement of .10 percent BAC laws. The new .08 percent laws may require some modification in these techniques though changes will likely be minimal. The new low BAC and zero tolerance laws for youth, however, pose a different set of problems. Active enforcement of these laws will likely require the development of different procedures.

#### **DWI Processing**

DWI is a serious offense. It can result in fines, jail, loss of license, a substantial increase in insurance premiums, and more. As such, prosecutors require that each element of the detection, investigation and arrest of the suspect be thoroughly documented. For the officer, each arrest requires both time and special skills to correctly perform and document each of these elements. Typically, a single DWI arrest requires 2 to 4 hours or more from the time that the impaired driver is detected until the time that the documentation is complete. It may also require additional time for attendance at hearings and/or court trials. And, from initial detection through adjudication, it requires special skills on the part of the officer.

Streamlining and reducing DWI paperwork and processing is likely possible in some jurisdictions. However, the seriousness of the charge and the need to establish each of its elements, limits the extent to which paperwork streamlining alone can reduce the processing burden.

It is felt that this processing burden fosters DWI

specialization both because of the time requirements and the skill requirements. In terms of time, officers whose primary mission is not traffic are reluctant to leave their patrol areas for the 2 to 4 hours required to deal with one arrest. Police supervisors may be equally reluctant to have the officers away from their areas particularly on Friday and Saturday night when demands for all types of police service tend to be high. These same officers may also be reluctant to work their way through all of the DWI forms and procedures. DWI and traffic officers, on the other hand, may see DWI enforcement as central to their primary mission and thus have a very different attitude relative to the processing burden. They also have a different skill level given that they likely have specialized training and routinely make DWI arrests.

Some departments are reducing the processing burden for regular patrols by providing backup from DWI specialists. Phoenix has DWI vans that travel to the arrest location and take custody of the suspect for all processing beyond the moment of arrest. Various other types of "hand-off" procedures are being used in Denver, other Colorado communities and communities in other states. Some of these procedures have the capability of returning the regular officer to his or her patrol area in 30 minutes or less.

## RESEARCH NEEDS

The following paragraphs research topics that could be meaningfully pursued in the near future. The topics presented are not all inclusive nor are they presented in sufficient detail for work to begin. Rather, the list is intended as a "straw person" starting point for a more comprehensive discussion. Also, the list is limited to DWI enforcement despite the fact that alcohol availability, DWI adjudication, DWI sanctioning, DWI rehabilitation, and other variables, are all integral and interactive parts of a total system.

### Impaired Driver Detection—Patrol

Most impaired drivers are detected through patrol activity. Existing detection cues concentrate on finding the "typical" impaired driver at a BAC level of .10 percent or higher. Research is needed to respond to emerging trends toward lower BAC limits for all drivers and "zero tolerance" for youth. Research is also needed for the detection of drinking drivers (e.g., youth) who do not follow the "typical" patterns. The following efforts could be considered:

1. DWI detection cues appropriate for .05 percent BAC (impaired laws in several states); .08 percent BAC; as compared with .10 percent BAC.
2. DWI detection cues for youth.
3. Enforcement strategies, possibly to include detection cues and/or passive sensing devices, for the youth "zero tolerance" laws.

### Impaired Driver Detection—Crash

The first priority at a crash scene is to help those who may be injured. Next, there are other priorities such as clearing the roadway, interviewing drivers and witnesses, and preparing reports. It may be difficult for the officer to pursue a DWI investigation even when impaired driving may be suspected as a cause of the crash. This is particularly the case when the suspected driver has been injured. A DWI arrest following a crash would have both criminal and civil liability implications. Research is needed to study DWI crash investigation guidelines and procedures as well as locally developed working relationships between the police and emergency room personnel for driver BAC determination.

4. When, how and with what procedures should an officer pursue a DWI investigation following a crash. How are such investigation currently being pursued and under what guidelines. Should legislative initiatives be taken.

### Impaired Driver Detection—Checkpoints

Checkpoint proponents claim that they are highly visible activities contributing to general deterrence; provide younger officers with the opportunity to work closely with experienced DWI officers; and apprehend drivers that might otherwise go undetected with traditional on-road DWI detection methods. Opponents claim that they delay travel for the nondrinking driver; are very labor intensive; and, per person hour, do not produce as many DWI arrests as saturation patrols or DWI patrols. Current NHTSA research is examining specific checkpoint programs. Nonetheless, and as a practical matter, departments will continue to make choices between checkpoints and patrols based on their perception of the relative merits of each and the importance of those aspects of DWI enforcement that each is designed to maximize. It would be of interest to examine these choices across a range of departments and a range of operating environments.

5. What are the underlying factors that cause some

departments to conduct checkpoints and others to rely solely on saturations and/or DWI patrols. The study should be conducted across a range of departments; in a range of operating environments; in states that allow checkpoints.

### **DWI Arrest and Processing**

Current DWI processing procedures from arrest through adjudication can be as much a deterrent to officers as they are to offenders. This is particularly true for regular or precinct officers who view DWI as only one part of their overall mission. Streamlining and paperwork reduction in coordination with the prosecutor may be part of the answer. Regular patrol hand-offs to DWI specialists may be another part.

6. Develop model DWI processing systems appropriate to various legislative environments including: Administrative License Revocation; guidelines for hearing and court appearances; step by step paperwork; and required and/or desirable legislative initiatives.

7. Examine the circumstances and operating environments where regular patrol hand-off of DWI arrested drivers to DWI processing specialists may be advantageous. Recommend model hand-off strategies as appropriate.

### **Funding for DWI Enforcement**

For most agencies, DWI enforcement is one of many enforcement missions and is primarily funded with general department budgets. There is current interest in providing DWI enforcement with some form of self-sufficient funding mechanism derived from the fines paid by DWI convicted drivers. Such interest has found support in the "410" incentive grant eligibility formula. Currently, very different self-sufficiency funding mechanisms are in place or are being developed (e.g., Colorado Law Enforcement Assistance Fund versus New York Stop DWI). These different mechanisms may serve different objectives and have very different effects on participating departments.

8. Study existing and developing DWI self-sufficiency funding mechanisms in terms of their impact on participating departments. Impact should consider not only overall enforcement levels, but effects on the characteristics and strategies of department wide enforcement efforts including who is being arrested when and where and by which officers.

### **Arrest Population**

State police, sheriff's department, municipal traffic division and precinct officers each patrol characteristically different roadways. They also, typically, have different patrol missions. Presumably, these differences should lead to a different mix of DWI arrested drivers from among the entire population of all drinking drivers. Differences in the arrest population may also occur across the various arrest modes (patrol, crash and special operations). It would be of interest to determine who is being arrested as a function of arresting department, arresting officer and arrest mode.

9. Compare the characteristics of DWI arrested drivers as a function of:

- Type of arresting department;
- Division/assignment/mission/train department;
- Type of police activity (e.g., DWI patrol, regular patrol, injury crash investigation, property damage crash investigation, sobriety checkpoint, saturation, stakeout).

Identify differences and, as appropriate, recommend strategies and/or training needs.

### **Recent Legislative Innovation**

A variety of legislative innovations are currently being adopted and/or considered by the states. Administrative License Revocation, .08 percent presumptive BAC limit, low BAC limits for youth and "use and lose" are the most prominent. Evaluations of these initiatives have been largely limited to one or a few states and/or the initial implementation periods. A more comprehensive consideration of these laws will be possible in the near future.

10. Compare and evaluate selected legislative initiatives begun in the 1980's and currently in place in several states.

### **Recent Technological Innovation**

A variety of technological innovations are currently in use or are being considered by various police agencies. These include in-car video cameras, passive alcohol sensors and drug testing.

11. Evaluate the application of new technologies in various enforcement environments. Study should distinguish current "state of the art" equipment from earlier or first generation equipment that may have been deployed in the past and may still be in use today.

### Statewide Systems

Earlier in this paper, it was suggested that the DWI arrest rate across states and regions was variable. High arrest rates were found in California, Colorado and other western states. Arrest rates in the south and southwest were particularly low in relation to the underlying drinking and driving problem as measured by fatally injured drivers. Arrest data were based on the FBI Uniform Crime Reporting System which relies on the voluntary cooperation of police agencies, not all of which participate. Thus, state to state variance based on these data must be viewed with some caution. Nevertheless, it appears that major arrest rate differences do exist. These differences may be the result of resource allocation, legislation, cultural differences or any number of other factors.

12. Track arrest rates, state by state, overtime; identify reasons for state to state variance; and, if appropriate, recommend actions that states can take to increase rates.

This concludes the list of possible research topics for the near future. As mentioned above, the list is not all-inclusive nor is it sufficiently detailed to permit actual research activities to begin. Rather, the objective was to suggest a starting point for a more comprehensive discussion.

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### APPENDIX D5A

#### DETERRENCE AND REHABILITATION:

#### SECTION 1 - DETERRENCE

Carol Lederhaus Popkin

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### INTRODUCTION

The goal of most DWI programs has been to prevent drinking driving behavior. Deterrence theory is predicated on the belief that a behavior can be prevented by the threat of punishment. According to this theory, the effectiveness of the perceived threat depends on the perceived certainty, celerity, and severity of the punishment. The effect of deterrence may be specific or general.

Specific deterrence seeks through punishments, education and treatment to influence the drinking driver who has already been apprehended to refrain from drinking and driving in the future. Roadside surveys indicate that most drinking drivers have low BACs (Lund and Wolfe 1988). In contrast, a significant portion of fatally injured drivers have high BACs (Simpson and Mayhew 1991). Research has shown that drivers fatally injured in alcohol related (A/R) crashes are more likely to have a history of previous DWI convictions (Brewer et al. 1991). Simon (1992) reports that recent studies of DWI recidivism conducted in Minnesota indicate that an increasing proportion of drivers arrested for DWI are recidivists. Furthermore, Minnesota has also experienced an increase in the percentage of drinking drivers

involved in fatal accidents who have had one or more prior alcohol-related incidents on their driver history records. Given the growing proportion of previously convicted DWI offenders in the fatally injured driver population and the increasing proportion of recidivists among those arrested for DWI, increasing attention should be focused on specific deterrence.

Unlike specific deterrence, general deterrence strives to influence all drivers, especially those who drink and drive who have not yet been apprehended for DWI. Because of the potential to influence a much greater number of people, the general deterrence value of various countermeasures and sanctions has been evaluated most often.

Most sanctions/countermeasures have a dual deterrent function; e.g., an effective specific deterrent may serve as a powerful general deterrent. For example, loss of a license may be a strong specific deterrent to those who have experienced this sanction, and at the same time it may be a powerful general deterrent to those who consider it a consequence of drinking, driving and getting caught.

Numerous evaluations have been made of the impact of various sanctions (Voas 1986; Nichols and Ross 1989). However, it has been challenging to determine the deterrent value of individual sanctions because they are frequently implemented as part of a comprehensive set of countermeasures so that their individual contribution is difficult, if not impossible, to assess. Moreover, many evaluations have been handicapped by a lack of agreement on appropriate criteria for measuring effectiveness.

Evaluation of sanctions has further been complicated by the uniqueness of the settings in which they have been employed. The philosophy of the citizens of a state or jurisdiction shapes its public policy/law making. This means that the entire milieu in which sanctions and countermeasures are evaluated may differ not only state by state but also county by county and court by court. The variations are numerous, and interpretations of the successfulness of a particular program as well as its transferability to other jurisdictions must be carefully considered. Researchers must endeavor to untangle the complexities of laws, enforcement practices, impositions of sanctions, etc. before they suggest that a particular sanction has had a deterrence effect.

Finally, as researchers and policy makers consider the combinations of sanctions that may have the optimal effect on the drinking driver problem, they must not lose sight of the fact that formal sanctions have been evaluated with little or no consideration given to the particular population or subgroup on which they have been imposed, or to the effect of informal sanctions,

such as social disapproval, or peer pressure, imposed on people who drink and drive.

## STATE OF KNOWLEDGE

### Licensing Policies

Licensing policies have traditionally sought to reduce the crash risk inherent to or posed by certain segments of the driving population. Policies have been used to limit the driving of younger drivers, medically impaired drivers, and other high risk groups. The past decade has witnessed increased emphasis on the use of driving restrictions as a sanction for DWI, and most states have adopted mandatory license suspension/revocation policies. Since the anticipated social and economic consequences of this sanction may be the greatest perceived cost of a DWI arrest, it is not surprising that this sanction appears to be one of the most effective DWI deterrents.

#### *Provisional/Graduated Licenses for Novice and Youthful Drivers*

It is a well established fact that persons in their teens through their early twenties have more crashes and more traffic related convictions than the rest of the driving population (Evans 1988; Maleck and Hummer 1986). In addition, data from the Fatal Accident Reporting System (FARS) indicate that drivers between the ages of 16 and 24 have the highest rates (per mile travelled and per licensed driver) of fatal accidents after drinking (Fell, 1984). For this reason, all the states in the U.S. and many countries have implemented special policies for dealing with younger drivers. These may include provisional licensing, curfew laws, and lower BAC levels for these drivers. Provisional licensing programs, in effect, acknowledge that young drivers are at greater risk to themselves and others and seek to lower this risk by modifying the circumstances under which they may drive. These modifications include

- Additional parent/adult supervised driving practice.
- Longer waiting period after failing the driving test.
- Use of curfews to restrict driving times.
- Restrictions on transport of passengers.
- Restrictions on the use of alcohol.
- Use of special license plates for families with provisional licensees.
- More comprehensive testing.

- Activation of post licensing control sanctions at lower number of traffic violation points.
- Special driving skills courses.
- Restrictions on speeds driven.
- Restrictions on the engine size of vehicle driven.

Some programs have motivated younger drivers to drive safely with gradual reduction of restrictions when certain driving performance indicators are realized; e.g., a violation-free period, completion of special skills tests. The idea of requiring a period of violation-free driving in order to qualify for a regular license appears to have merit in that it creates an incentive to drive within the law and avoid traffic violations that could lengthen the provisional period. Several studies have reported reductions in crashes and convictions for more serious moving violations among younger drivers as a result of provisional licensing programs/curfews (McKnight et al. 1983, 1990; Preusser et al. 1983; Williams 1987). McKnight (1986) suggests that provisional licensing schemes must require restrictions that are distasteful to drivers in order to be effective. Without restrictions such as curfews and mandatory driver improvement action following any violation, a provisional driver has little motivation to obtain a regular license.

**Driving Curfews to Deter Drinking and Driving by Young Offenders.** Curfew laws limiting the hours during which youthful drivers may operate a vehicle have been passed in 11 states, generally in response to the proportion of younger driver fatal crashes which occur at night. Curfews are beneficial in that they may reduce sleep deprivation (shown to increase crash risk in young people even at low BAC levels), and reduce the driving of younger persons at the times of greatest risk. Unfortunately, the evaluations of their effectiveness have produced inconsistent results. Preusser, et al. (1984) reported that after the imposition of restricted hours in New York and Pennsylvania, this age group experienced dramatic reductions in crashes. He also cited additional data from Louisiana and Maryland that supported the efficacy of restricted driving hours for youth.

In contrast, McKnight et al. (1983, 1990) evaluated Maryland's provisional licensing law, implemented in the early 1980's, and found that the law, which basically has a nighttime driving curfew for young people, led to a 5 percent reduction in accidents and a 10 percent reduction in convictions among the 16-17 year olds, the age group affected by the law. However, no effect on nighttime crashes was detected. They attributed this to the relatively small number of accidents occurring at night and also speculated that those who drive at late night hours are not readily deterred by a curfew. They

attributed some of the reductions in nighttime crashes reported by Preusser to a long-term downward trend in nighttime crashes by 16 year olds.

**Lower BAC Limits.** Because younger people are over-involved in crashes, even at very low BAC levels, eight states have moved to adopt lower legal BAC limits for young people. In most of these states, license revocation is either discretionary or an automatic penalty for any arrest with a BAC in the lower limit. Studies of lower BAC limits both in the U.S. and in Australia (Hingson et al. 1989; Hingson et al. 1991; Drummond et al. 1987; Smith 1986) indicate that such limits appear to have a positive impact on reducing teenage involvement in nighttime fatal crashes. Hingson also found that Maine youth who were aware of these provisions of the law reported that they were less apt to drink and drive.

**Other Restrictions.** Several other states have experimented with license revocations and sanctions against youth for alcohol and other drug offenses that were not in conjunction with driving. These types of penalties may be imposed for offenses ranging from underage alcohol purchase to fraudulent use of an identification card to purchase alcohol. Most of these restrictions have been implemented as part of a comprehensive youth-oriented legislative package, thus making their individual deterrent value difficult to evaluate.

#### *A Model Graduated Program*

To date, probably the most comprehensive graduated licensing program designed was the graduated licensing system in Victoria, Australia (Boughton et al. 1987). This system, which is applied to all newly licensed drivers regardless of age, is rather complex and contains different restrictions and requirements for various ages. A learner's permit may be obtained starting at age 16. The permit must be held for at least 12 months before the next probationary stage is reached, but the applicant must be at least 18 years of age to receive a full license. The probationary phase lasts for 3 years and successful completion of a special hazard perception test is required for a permit holder to graduate to full licensure. Two specific restrictions, a zero BAC requirement and a restriction on the power of the vehicle that can be operated, are applied during the probationary phase. Passenger restrictions are imposed during the learner's phase and in cases where the probationary drivers are convicted of a serious offense during the first 12 months. A unique feature of Victoria's system is that drivers under the graduated licensing system must display special plates on their

vehicles. Several modifications have been made in the program and evaluations are incomplete.

In summary, some highway safety benefits have been reported in states and countries employing provisional licensing programs. These may be beneficial because they offer new drivers an opportunity to gain driving experience under conditions that minimize their risk to themselves and others and serve to penalize poor driving behaviors. However, not all provisional license programs have affected nighttime single vehicle and A/R crashes. Inability to affect A/R crashes may indicate that some programs are not comprehensive enough to show an effect, or are ineffective in deterring high risk teenage drivers, or have not achieved a high perception of risk of detection because they are difficult to enforce, or have not been adequately publicized. More information is needed about the drivers affected by provisional licensing programs and those who are not. Further evaluation of the effects of these laws is needed. In addition, evaluations should consider the broader effects of these programs on other aspects of the drinking driver system, e.g., how will enforcement and adjudication be affected?

#### *Licensing Penalties*

All states provide some type of licensing sanction for drivers who violate drinking driver laws. In general, the apprehended drinking driver may be subject to two different types of licensing actions—those judicially imposed and those administratively imposed. Judicially imposed licensing actions are the result of a trial and the imposition of a series of sanctions upon determination of guilt. The length of time between arrest and disposition of a court case routinely takes 2 to 6 months. Judicially imposed licensing sanctions usually follow legislated directives, but may be moderated to some extent depending upon the discretion of the court. Such moderations include the suspension of licensing sanctions if certain other criteria are met, and the granting of a hardship license.

The failure of traffic courts to uniformly impose license sanctions was partially responsible for the adoption of administrative per se laws. As of 1990 there were 28 states with administrative license revocation (ALR) laws (Williams 1991). The administratively imposed license revocation is usually applied when an individual refuses or fails a chemical test. Usually the license is revoked for a period of 10 to 90 days. Only the accuracy of the chemical test and whether or not the officer had probable cause to stop may be challenged by the individual. Thus, the failure or refusal triggers the licensing action, regardless of determination of criminal guilt. Individuals who have an administrative revocation usually have a set period of time in which to request a

hearing to appeal the removal. Some states require that the hearing be held within a specified period of time; others do not. Laws differ as to whether or not the licensing action is stayed pending the results of the hearing.

Because many of these laws were enacted as part of comprehensive legislative packages, evaluations of their effectiveness have been difficult to conduct. In general, ALRs have been followed by significant increases in the number of offenders receiving licensing actions and by small, but significant reductions in A/R fatal crashes. Several studies have demonstrated the ability of ALR laws to reduce alcohol related crashes or their surrogates (Ross 1987; Blomberg et al. 1987; Klein 1989; Zador et al. 1989). In addition to their general deterrent effectiveness, ALR laws appear to have a beneficial specific deterrent effect. Stewart et al. (1988) studied the specific deterrent effect of ALR in three states and found a reduction in DWI recidivism in two of the three states and a reduction in DWLR in the other. These effects endured well beyond the period of suspension. However, it is unclear whether this is a residual effect or if the offenders never applied for relicensure.

In summary, evaluations of removal or suspension of the driving privilege (Votey and Shapiro 1983, 1985) indicate that it may be the most effective sanction yet tried and that its effect endures well beyond the period of revocation. This appears to be true even though there is substantial evidence indicating that 25 to 75 percent of suspended drivers continue to drive during their period of suspension (Hagen 1977; Peck et al. 1985; Ross and Gonzales 1988). Peck (1991) evaluated the deterrent effects of DUI sanctions and reported that driver license suspension/revocation reduces crashes and DUI offenses by 30-50 percent during the period of suspension.

**Limited Licenses.** A hardship license is often granted to offenders so that they are able to continue to drive to work, while at the same time limiting their recreational driving. Few studies of deterrence effect of this 'softer' license sanction exist, but it seems reasonable to assume that its use mitigates to some extent the deterrent value of license sanctions. Nichols and Ross (1989) suggest that limited licenses do not work as well as those that are coupled with at least a month of hard license suspension.

In summary, license suspension appears to be an effective general and specific deterrent. If one believes the deterrence model, then it would appear that the ALR laws should be most effective in deterring DWI and preventing A/R crashes. While most of the studies of the effectiveness of suspension on specific deterrence have been based on judicial suspension, there is reason

to believe that the specific deterrent effects of ALR would be as great or greater. However, the components of these laws vary considerably from state to state, particularly with regard to the length of time of revocation and what benefits may be derived from requesting a hearing. Studies are needed on the relative effectiveness of these variations in ALR laws.

### **Adjudication**

Adjudicative trends in the 1980s have moved toward the uniform imposition of more severe penalties. As mentioned earlier, jurisdictions may vary considerably in their interpretation of drunken driving laws and in their imposition of sanctions. Clearly, important differences do occur with regard to prosecution policies and imposition of sanctions. These differences may contribute significantly to the public's perception of risk and its attendant deterrence value.

#### *Prosecution Policies*

In most overcrowded traffic courts in the United States, plea bargaining has become a prosecutorial means of clearing the court docket. Recently, the increased pressure of citizen activist groups on the courts has resulted in fewer cases of plea bargaining and a greater likelihood of imposition of penalties. As of 1991, 20 states had enacted some type of anti-plea bargaining laws for those convicted of DWI (NHTSA, 1991).

Some jurisdictions have adopted judicial directives prohibiting charge reductions and plea bargaining as well as setting BAC levels above which a case will be tried and establishing sentencing procedures for those cases. Surla and Koons (1989) examined the effect of these policies in Arkansas and Kentucky and found that conviction on the DWI charge increased dramatically. Popkin et al. (1985) evaluated the deterrence effects of a major change in DWI legislation in North Carolina which included elimination of plea bargaining. This study indicated that those found guilty of the original charge of DWI increased from 59 to 72 percent. For those at the per se level, the guilty rate rose from 72 to 92 percent. Decreases in A/R crashes were reported in both studies, but these changes could not be attributed to the elimination of plea bargaining because other countermeasures were implemented at the same time. Council (1981) evaluated the effect of well-publicized high DWI conviction rates on A/R crashes in North Carolina, and found a small but significant relationship.

Changes in plea bargaining practices result in fewer reduced charges. This, in turn, may contribute to an increase in reported DWI recidivism. As Shinar (1992) states, "In the absence of no plea-bargaining laws, true

recidivism is actually higher than reported because repeat offenders are often not classified as such, having plea bargained their previous offense." The effect of this reduction on the 'recurrent' first time offender should be considered in any evaluations of deterrence.

#### *Sentencing Policies*

The public's perception of the risk of sanctions being imposed may be enhanced through the development of sentencing guidelines for offenders. Just as there is a demand for matching the offender with the treatment, there is an increasing demand that the sanctions applied to DWI offenders reflect the gravity of their offenses, the risk of a relapse, and the potential for remediation. Homel (1981, 1988) conducted a complicated analysis of the impact of penalties on the convicted drunk driver and found that the effects of punishments differ with respect to offender characteristics and outcome measures. He found no beneficial effects of imprisonment.

The certainty of application is important. Several studies indicate that mandatory license actions are more effective in reducing DWI recidivism than discretionary ones (Hagen 1977; Paulsrude and Klingberg 1975). Shinar (1992) mentions that court monitoring is associated with increases in conviction rates and that it may lead to increases in application of sanctions. While certainty of sanctions has highway safety benefits, it is not apparent that the severity of sanctions is important: e.g., Vingilis et al. (1990) found that increasing fines were associated with increasing likelihood of DWI recidivism.

When one aspect of the system is modified repercussions can be expected elsewhere; e.g., when DWI arrestees perceive that the consequences of their offense may be greater, they are probably more likely to contest their guilt. On the other hand, this may also result in increased satisfaction on the part of police officers and a greater likelihood that they will make a DWI arrest. While not well-evaluated, it appears that the public's perception of the increased likelihood of a guilty verdict and increased certainty that sanctions will be applied should enhance the deterrence effect of sanctions.

#### **Sanctions (Other than Licensing)**

Sanctions are important to deterrence theory since they reflect the consequences of negative behavior. According to Lacey and Voas (1991), DWI sanctions have eight purposes: punishment, education, rehabilitation, incapacitation, general deterrence, program financing, community service, and retribution/education. Limited

evaluations have been undertaken of the variety of sanctions applied to DWI offenders. Their respective effectiveness has been difficult to evaluate given the lack of uniformity of application to those convicted of DWI. While to some extent this failure to uniformly apply sanctions has been the result of resource limitations, to a greater extent, it is the result of prosecutorial and judicial discretion. For example, many sanctions including jail and license suspension are set aside as an inducement to accept treatment. Fines are also reduced to assist the offender in paying for the cost of treatment. A brief discussion of the deterrent effectiveness of these sanctions is discussed below:

#### *Incarceration and Incapacitation Alternatives*

The past decade has witnessed a substantial increase in legislation mandating incarceration for those convicted of DWI. Twenty-five states now proscribe mandatory jail terms for drunken driving, with first offenders typically ordered to serve 24 to 48 hours and repeat offenders to serve 10 days to 2 weeks. While the imposition of jail as a sanction has great appeal to those advocating the punitive aspects of sanctions, incarceration is costly. In some jurisdictions resources are not available for handling DWI offenders, particularly women. Popkin et al. (1985) found numerous complaints of jail crowding on weekends due to DWI offenders serving their jail time in a manner that would not affect their employment. Furthermore, because of overcrowding, many of those sentenced fail to serve their time or are released within a few hours. Situations such as these serve to erode perceived risk of jail as a sanction.

The effectiveness of jail as a sanction is much less evident than that of license suspension. Several reviews of the research literature have been conducted and have shown little deterrent benefit for jail (Ross and Voas 1989; Nichols and Ross 1989; Salzberg and Paulsruide 1984; Ross et al. 1990; and Jones and Lacey 1991). However, a few studies have reported beneficial effects. Falkowski (1984) and Cleary and Rodgers (1986) examined the effect of Minneapolis, Minnesota's judicial policy to sentence all first time DWI offenders to 48 hours in jail and found a 20 percent reduction in nighttime fatal crashes after the policy had been in place for two months. Jones et al. (1987) evaluated a mandatory 2 day jail sentence in Tennessee and concluded that the legislation might have produced up to a 15 percent reduction in A/R crashes. However, as in Minneapolis, there was a time lag before the effect was observed.

The public is increasingly demanding imposition of longer jail or prison sentences for multiple DWI offenders, in spite of the fact that long-term incapacitation appears to have very limited effectiveness in terms of the number of lives saved (Simon 1992). Furthermore, the annual cost of incarceration is estimated to be \$17,000 a year/per person. These factors make incapacitation alternatives seem highly appealing. Programs such as the Anoka County, Minnesota Repeat Offender Program provide a high degree of supervision, loss of freedom and treatment and education at a lower cost. In addition these programs require the offender to pay part of the cost of the program.

**House Arrest and Electronic Monitoring.** House arrest and electronic monitoring present an incapacitation alternative that might be used, for example, with multiple offenders as a condition of bail or probation. The basic technology calls for the wearing of a signal-emitting bracelet on the offender's wrist or ankle. The signal is relayed to the monitoring agency's computer by means of the offender's phone. If the offender leaves the house, the signal ceases, and the computer notifies the police. Costs of the program are paid for by the offender. However, real problems exist with the use of this as a sanction because when the offender violates the house arrest, adequate personnel must be available to handle the case. Furthermore, the courts must be willing to incarcerate these violators. Petersilia (1987) studied the effect of electronic monitoring and house arrest on drunk driving in Linn County, Oregon and found that none of the drivers participating in the home detention study were rearrested for drunk driving as compared with 15 percent of those on regular probation. This seems a positive enough finding to warrant further investigation.

In summary, the limited number of studies conducted in this country indicate that jail terms for first offenders can have a small general deterrent effect. However, the cost of jail as a sanction may outweigh its potential benefits. If all convicted DWI offenders had to serve jail time, more offenders would contest their guilt. Thus, the small deterrent effect derived from jail may be offset by crowding and reduced likelihood of a guilty verdict. Rather than completely eliminating jail, states may choose to make it a discretionary sanction or a mandatory sanction reserved for more serious offenders (multiple, manslaughter, etc.). Additional research is needed on the effectiveness of alternatives to incarceration.

### *Sanctions that Target the Vehicle*

**Vehicle Impoundment, Tag Identification, and Tag Confiscation.** The probability of being caught with a suspended or revoked license is small, and most states do not have serious sanctions levied against those who drive while license revoked (DWLR). Unfortunately, a large number of DWI offenders with suspended or revoked licenses do drive and, more importantly, drive drunk. This has led 30 states to enact laws to permit the impoundment of their vehicles or license tags (NHTSA 1991).

There is a great deal of variation from state to state regarding who may be subject to impoundment and the circumstances under which it may be imposed. Two Canadian provinces, Manitoba and Alberta, permit vehicle seizure and impoundment for 30 days for persons found driving with a revoked license. These provinces have reported both a large number of impoundments and law enforcement officer satisfaction (Neil Warner 1992). However, in the U.S., there is apparently some reluctance on the part of enforcement officers to use this sanction particularly in conjunction with a first time DWI.

**Tag Confiscation.** An alternative to vehicle impoundment is tag confiscation. Minnesota permits police to confiscate plates of those persons stopped who have had three or more DWI's within the 5 year period. They may also confiscate the plates of any other vehicles owned by the person.

**Tag Identification.** In some states, imposition of special markings such as zebra stripes on the license of those caught driving with a revoked license provides the officer with probable cause to stop the vehicle. Both Ohio and Minnesota replace conventional tags with a special tag to alert enforcement that this vehicle is owned by a suspended driver. The effectiveness of these laws must still be evaluated, but they appear to have a high specific deterrent effect since they facilitate detection and also may stigmatize the convicted DWI offender.

**The Ignition Interlock.** The ignition interlock is a technological device attached to the car's ignition system which prevents the operator from starting the vehicle if the BAC level exceeds a predetermined threshold. A BAC lower than the limit allows the driver to start the vehicle. The interlock bypasses any decision making requirement on the part of the driver. Thus, the driver is prevented from driving regardless of any personality or situational factors that might influence that decision. The possibility of incapacitating the car so that the driver

who is drunk cannot drive has intuitive appeal given the difficulties with educating or coercing drinking drivers to change their behavior or changing their social environment. Ignition interlocks target the car as a point of intervention, provide the driver with a reminder not to drink and drive each time s/he enters the car, and give immediate feedback on level of intoxication.

Being relatively new devices, ignition interlocks have received few evaluations. Existing studies have been limited by a lack of random assignment and short periods of follow-up. Four preliminary studies indicate that the interlock may have a positive effective on DWI recidivism (Morse and Elliot 1990; EMT Group 1990, Jones and Wood 1989; Popkin 1992). Popkin reports that those second time DWI offenders in North Carolina receiving conditional licenses and the interlock at the end of 2 years of a hard license revocation fared better than those second time offenders with the traditional 4 year hard license revocation. Unfortunately, recidivism levels for both the study and control groups returned to higher levels after full licensing privileges were returned and interlocks were removed.

**The Autotimer.** A new technological device, the Autotimer, has been developed by Voas (1992). This device, installed on the car of an offender who has been granted a limited driving permit, records the time of day during which the car is driven. The Autotimer is monitored by the probation officer. If the individual is found to have driven outside the acceptable time frame, the probation officer may revoke the permit. While no evaluation of this device has been undertaken, initial reports suggest that those with a limited driving permit curb their illegal driving behavior after a few counseling sessions with the probation officer.

In summary, interlocks depend on the car and not behavioral changes to separate the drinking driver from the road. Further evaluation of the utility of the interlock seems warranted, particularly obtaining information about the types of DWI offenders who would benefit from them, the optimal administrative setting under which to monitor those with interlocks, the long-term deterrent value of the interlock and the potential to use interlocks in conjunction with treatment programs.

### **Other Sanctions**

#### *Victim Restitution/Community Service*

**Victim Restitution.** Citizen activist groups and others have argued that DWI offenders must pay retribution to their victims. Victim restitution programs direct the offender to pay financial and service benefits to the

victim or his family. However, the DWI convictee frequently has no victim other than the community, and many who are responsible for A/R crashes in which there are personal injuries are frequently not prosecuted when they are injured themselves (Maull et al. 1984). This means that the group with the greatest likelihood of a victim is seldom penalized. For these reasons, this sanction has not enjoyed much popularity. No evaluations of the general or specific effect of this sanction have been conducted.

**Community Service.** Community service is a widely applied sanction which directs the offender to pay restitution to the community by providing general service through activities such as picking up litter on public roadways. Some community service programs attempt to tailor the particular skills of the offender to meet the needs of the community, thus optimizing the potential benefit. Some frequently mentioned impediments to community service programs are difficulties finding jobs, liability risk, the cost of supervision, and failure to provide service. Stenzel et al. (1985) failed to find any significant effects of a well-publicized community service program on self-reports of drinking and driving and crashes in Baton Rouge, La. Although Zador (1988) found that states with laws providing for mandatory jail or community service in lieu of jail had lower A/R crash rates, there is little evidence that use of community service alone when applied to a large number of offenders has a deterrent impact. None the less it may provide low cost payback to the community when well orchestrated.

#### *Public Condemnation*

Public disapproval/humiliation has seldom been used as a sanction for DWI offenders. Public sanctioning may take the form of published lists of DWI offenders or marking the vehicles of those convicted of DWI. While this seems an undesirable sanction, it does put the punishment in the hands of the community; and public disapproval has been shown to be a powerful deterrent in reducing undesirable behaviors, e.g., cigarette smoking in the United States. Clearly, there is an increasing amount of public sentiment that indicates public disapproval of drinking and driving. The extent to which social stigma contributes to general and specific deterrence requires further examination.

#### *Fines and Other Financial Costs*

**Fines.** In the United States, the value of fines as a deterrent has received little study. While in some jurisdictions fines provide a means of maintaining DWI countermeasure and treatment programs, in most they

are only a modest portion of the cost of a DWI conviction. Because fines have not been indexed to the rate of inflation, they have declined in terms of financial impact, and have certainly declined relative to the overall costs of insurance and legal fees. In addition, collection mechanisms have been extremely inadequate.

Imposition of fines has been evaluated in Europe and Australia. In Sweden, the offender's fine is linked to his annual income and with the severity of the offense. Votey and Shapiro (1983, 1985) found that the fines imposed in Scandinavian countries were associated with reductions in fatal crashes. In Australia, Homel (1989) found that increased fines were associated with decreases in DWI recidivism for those who were also charged with driving while disqualified, but not for other groups.

**Insurance Rates.** Insurance penalties/surcharges and costs of assessment and treatment present the DWI offender with additional financial penalties. Only one study (Lacey et al 1992) has evaluated the general deterrent effect of insurance sanctions accompanied by an intensive PI & E campaign. The authors concluded that it did not hold much promise as a general deterrent.

In summary, the deterrent value of fines and other financial sanctions has not been demonstrated in this country largely because they are generally not high and are often not collected. Given the effectiveness of this sanction elsewhere, the use of fines should be examined more closely in this country. Fines should be indexed to the offender's income and the gravity of the offense. Better collection mechanisms could certainly be developed. More information is required about financial costs associated with a DWI conviction to gain a better understanding of how they affect DWI offenders. Their deterrent value requires further evaluation especially since excessive fines may exacerbate the offender's problems and/or drive them out of the licensing and remediation systems.

## DISCUSSION

In the United States over the past decade, the effects of prevention, education, and other deterrence methods have resulted in reductions in A/R fatalities and in BAC levels of drivers participating in roadside surveys (Lund and Wolfe 1989). However, it appears that an increasing proportion of those arrested for DWI have had a previous DWI arrest, and that an increasing number of those involved in A/R crashes have had a previous DWI. These findings suggest that countermeasures are having a modest effect on DWI behavior, e.g., the proportion of

people arrested for first time DWI is declining. They also suggest that many of our strategies are less effective in deterring problem drinkers. In order to achieve a greater degree of deterrence, more must be done and innovative approaches must be explored.

Our review examined a substantial body of deterrence literature. Clearly, most sanctions, especially when accompanied by intensive public information and education, contribute to deterrence. Of those reviewed, licensing sanctions appeared to be most effective as both a specific and a general deterrent.

Important factors act as impediments to understanding which sanctions or combinations of sanctions might be most likely to deter. First, it is difficult to isolate individual sanctions in order to determine their contribution to general and specific deterrence. This is complicated by the fact that jurisdictions vary considerably in their application of sanctions. Moreover, when evaluating the effect of a particular sanction, in many cases researchers have only fragmentary information on other factors at work in the setting such as changes in enforcement levels and directives, adjudication policies, public information, education about DWI laws and sanctions, and specific factors affecting public attitudes toward the offense such as the frequency of negative publicity about drinking and driving. Moreover, the jurisdictional and/or state philosophy towards DWI has seldom been considered in deterrence evaluations.

Second, little is known about what actually deters people from drinking and driving. Apparently, the perception of swift and certain punishment is an important deterrent, but what other factors are at work? Are there informal sanctions that may be contributing as much or more to the reductions observed in DWI? For example, in states where there has been public demand for stricter drinking driving laws, is the public disapproval of this activity as significant a deterrent as the legislation that is being enacted? In other words, are we measuring the correct deterrent?

Donovan and Marlatt (1982) have demonstrated that there are several drinking driver types, yet little is known about which types of drinkers are affected by which sanctions. Perhaps fear of detection and the swift and certain imposition of sanctions have the greatest impact on those who are not problem drinkers. Unfortunately, approximately 30 percent of DWI offenders repeat the offense, and a substantial portion of them are problem drinking drivers. Of this group, the high BAC drivers appear to have been less deterred from drinking and driving (Laurell 1991). Some literature (Simpson and Mayhew 1992) suggests that high BAC drivers are not like other people who are deterred by the sanctions

discussed above. They are frequently aware of the laws and attendant sanctions associated with drinking and driving, and their behavior is unaffected by them. So more information is needed both on the ways in which people are deterred and on effective strategies to be used with various drinking driver types.

Thus, if we expect to make substantial changes in drinking and driving, we need to better understand who is being deterred by which sanctions; and we need to broaden our understanding of why people drink and drive. To accomplish this, the drinking driver must be viewed in a broader social context so that we may better understand where he does his drinking, under what circumstances and what his attitudes are toward drinking and driving. Furthermore, we need to understand to what extent his life revolves around his drinking behavior and what deters him from drinking and driving. This information should be helpful in designing more effective programs.

#### **Specific Recommendations for Increasing Deterrence:**

1. **Develop and evaluate more comprehensive provisional licensing programs.** These programs must be well publicized, and should use innovative approaches such as decals or special license plates. Extend some of the post-licensing control components of the program through the age of 20, a period when many younger drivers continue their over-involvement in traffic crashes.
2. **Increase the detectability of high risk drivers and evaluate.**
  - a. A special plate for provisional licensees will help increase the perception of risk of detection particularly during curfew hours.
  - b. Use a tag marker to identify a vehicle owned by a driver with a license revocation, and make it large enough so that it can enhance the likelihood of detection at night.
3. **Develop guidelines for sanctioning that link the seriousness of offense with the severity of the sanction and conduct a process evaluation.**
  - a. Use previous DWI activity, BAC level, and/or injury causation as measures of severity.
  - b. Do not make the penalties so severe as to lessen the likelihood that they will be levied or increase the likelihood that the offender will remain outside the system. Omit jail as a sanction except for the offender who has injured someone or who habitually refuses to comply with sanctions applied.
4. **Develop and evaluate a sliding scale for the imposition of fines that includes both the severity of the offense and the income level of the offender, and develop an effective collection mechanism.**

5. **Impound vehicles of those who habitually drive out of the system.**

6. **Use a period of hard license revocation, and then provide an opportunity for the granting of a limited driving privilege given that the offender will use special plate identification and will participate in remediation.**

7. **Develop and evaluate combinations of treatment, licensing sanctions and active probation with different offender types.** Consider the use of case control studies. More effective programs may be developed when specific deterrence sanctions and remediation approaches are combined.

8. **Increase cooperation between funding agencies in identifying and funding research programs.**

Because of severe limitations in research dollars, and because there are numerous agencies investigating DWI activity from a number of different perspectives, it is important that agencies better coordinate their research efforts and share research findings.

Future research should focus on identifying some of the informal sanctions which may be at work in states, communities, peer groups, and families to deter drinking drivers and how these may be enhanced. Similarly, more data is needed on which factors deter which types of drinking drivers. With regard to currently used deterrence methods, research is needed on

- The effect of fines and insurance sanctions on general deterrence;
- The extent to which fines may contribute to the offender's broader problems and to the likelihood that he will drive outside the system;
- The extent to which the recidivist is currently contributing to the A/R crash problem;
- The use of interlocks for both first time, high risk drivers and multiple offenders, and whether positive benefits endure after license reinstatement and interlock removal;
- The use of the interlock or similar devices as treatment monitoring tools;
- Methods to mark vehicles to increase detection;
- The value of social stigmatization;
- The relative effectiveness of variations in ALR laws;
- The residual effectiveness of licensing sanctions with or without attendant remediation; and
- Identifying younger DWI offenders who become DWI recidivists.

At the present time there are a limited number of deterrence options. As in many other areas in our society, barriers to change exist within the system. By expanding our understanding of differences in various

jurisdictions, differences in laws, differences in offender types, and differences in the ways in which sanctions are applied, we will be able to design and implement more effective and comprehensive programs to deter drinking drivers and also to plan more effective DWI treatment programs. Sound research is needed in order to make informed policy decisions. A pivotal question which should always be addressed: Is there really a sufficient amount of reliable research data available to permit the federal government to advocate changes in policy?

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### A Model Program

Because unrealistically severe penalties often force drinking drivers to operate outside the system, increasing consideration should be given to methods to keep them in the system while reducing their potential risk. Because driving is integral to social and economic survival in this country, all but the most serious offenders should be permitted to drive after a reasonable period of hard license suspension (period determined by severity of the offense). A model program should realistically deal with the fact that the automobile is frequently the only source of transportation available to most people and the fact that most people drive even when their license is revoked. For first time offenders begin with a hard license sanction of 90 days, while their license is revoked their car should receive a special plate to facilitate detection. Tie the granting of limited driving privileges to participation in some type of remediation and the use of vehicle markings to increase fear of detection. If the individual is picked up driving while impaired, punish with another license suspension and tie issuance of a limited license to the installation of an interlock device. When the individual with an interlock tampers with it or drives another car, forfeit the vehicle. Make the issuance of the driver's conditional license also contingent upon the payment of a set of fees which is tied into to the individual's income (using the past years income tax return).

If all else fails, imprison.

## APPENDIX D5B

### DETERRENCE AND REHABILITATION:

#### SECTION 2 — REHABILITATION AND SCREENING

Elizabeth Wells-Parker

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### INTRODUCTION

Convicted DUI offenders constitute a highly visible group of drinking drivers and exhibit a range of problems that potentially contribute to traffic safety risk. The identification of effective methods for dealing with convicted offenders continues to be a high priority among key actors (judges, etc.) within the system. Furthermore, some groups of drinking drivers, such as high BAC (>.15) drivers, are at elevated risk of having had a DUI offense prior to becoming involved in a fatal accident (Simpson and Mayhew 1991; Lewis, personal communication) and are unlikely to be affected by DUI prevention strategies targeting the general driving public. The population of detected offenders is an appropriate target for prevention of fatal accidents among such groups. Interventions that effectively target detected DUIs could become models for more broadly based prevention programs for undetected high risk drinking drivers who are relatively unlikely to be affected by traditional educational and media-based prevention strategies.

The major purpose of this paper is to provoke ideas about how to improve intervention methods with convicted DUI offenders. It is suggested that research on remedial intervention with DUI offenders must move beyond existing strategies and creatively consider new and untried approaches for improvements to occur. Also, the broader term "remedial intervention" is favored over rehabilitation and treatment to encourage the expansion of options that might be investigated.

For succinctness, reviews of such issues as efficacy of traditional rehabilitation, treatment, and probation approaches, treatment matching, and many technical screening issues have been omitted; however, these subjects have been qualitatively reviewed elsewhere (Mann, Leigh, Vingilis, and DeGenova 1983; Stewart and Ellingstad 1988; Wells-Parker, Landrum and Topping 1990; Wells-Parker and Bangert-Drowns 1991).

### State of Knowledge; Current Issues and Problems

The efficacy of traditional rehabilitation and treatment of convicted DUI offenders to reduce subsequent drinking/driving and crash involvement at best remains controversial after nearly two decades of research. (See Wells-Parker and Bangert-Drowns, 1991 for a discussion of existing reviews.) A comprehensive meta-analysis of this body of research, which contains between 200 and 300 primary studies of varying methodological rigor, is being conducted. Although still in progress, observations from preliminary stages of this analysis suggest that (a) in spite of the large number of studies conducted, the range of intervention options that have been evaluated is very narrow relative to options reported in the general alcohol literature, and some of the options that have been shown to be effective in the alcohol treatment literature, such as community reinforcement programs, have never been evaluated for DUI offenders; (b) the range of identifiable options is even more restricted among methodologically rigorous studies; (c) most rehabilitation/treatment programs for DUI offenders neither assess nor target polydrug use; and (d) virtually no systematic data on the effect of variation in the general social/cultural climate or the judicial systems interface with rehabilitation/treatment are retrievable from existing studies.

Recent reviews of studies that compared the specific deterrent effects of license actions to rehabilitation/treatment suggested that rehabilitation should not be substituted for licensing actions but that combining the two may prove the most effective option for reducing all relevant target behaviors (Nichols and Ross 1990; Peck 1991; Simpson and Mayhew 1991). Policies that combine, rather than substitute, rehabilitation with other deterrence strategies have been suggested (Nichols and Ross 1990). Initial results of alternative sentencing programs that combine long-term probation, treatment, and other sanctions, such as use of special custodial facilities, appear promising (Simon 1992; Voas and Tippetts 1989), but additional evaluation is needed. With the exception of license suspension, probation, and some information on jail based and custodial facility programs, virtually nothing is known about the efficacy of combining treatment/rehabilitation programs with other deterrence options. Less traditional options, such as ignition interlocks, home monitoring, tag identification, and vehicle impoundment, potentially provide more control and monitoring of the target behaviors of drinking/driving and could offer opportunities to specifically tailor remedial programs as companion countermeasures. Given the need to develop comprehensive programs targeting the "hard core"

offender (e.g., Simpson and Mayhew 1991), such intensive combined strategies merit investigation. Also, multi-tiered systems, which are more common in Europe and which involve continued monitoring, including medical monitoring, of chronic offenders as a basis for license reinstatement, should be investigated for possible adaptation to North American systems. (See Simpson and Mayhew 1991, for an extended discussion of such systems.)

### Screening, Assessment, and Treatment Matching

Screening and assessment of convicted DUI offenders has become a standard practice within many DUI control systems. Previous research, as well as ongoing research, has focused on the development of improved screening and assessment methods. For purposes of discussion at least two distinct, although interrelated, reasons for assessing convicted offenders can be identified as typical within the U.S.<sup>1</sup>

1. In the traffic safety arena there is interest in risk screening—identifying instruments that yield improved prediction of subsequent traffic safety or alcohol problem outcomes and that provide superior validity with regard to defining risk categories (e.g., high versus low risk) for DUI offenders (Wieczorek, Miller, and Nochajski 1991). Such an instrument should be easy to administer and not too costly, and often is justified as a first stage screening device to identify offenders who are at higher risk of the target behavior and, therefore, justify a more intensive, expensive, and/or invasive alternative. In this regard, it is assumed that the "low risk" group requires minimal treatment—but that it will be cost effective to give expensive treatment to the high risk offenders. The utility of such screening devices hinges on their ability to predict a criterion (e.g., recidivism, accidents, severe alcohol problems, etc.) and the identification of appropriate cut points to define risk groups for decision making.

2. A second reason for assessment is closely linked to the client/treatment matching hypothesis, which is an interaction hypothesis, and which continues to gain much attention in the general alcohol treatment field (Institute of Medicine 1990). Recent interest in matching offenders to treatment has led to the development of multidimensional schemes and multivariate typologies in which the areas of problem assessment are expanded to include dimensions such as attitudes, expectancies, and personality traits, other drug use, situational indices, family history, and neurophysiological deficits. (See Wells-Parker, Anderson, Pang and Timken, in press, for review.) These schemes have been based on the

hypothesis that heterogeneity on such traits among convicted offenders is clinically relevant (i.e., that offenders falling into different categories require different types of intervention). Such typologies are not necessarily predicated on a single risk dimension, either for behavior repetition or for "alcohol problems." Indeed it would be possible for different "types" to have similar risk potential (e.g., for recidivism) but to require different treatment strategies.

Within the matching agenda, the value of a screening device would be predicated more on the relative magnitude of the interaction effects (type x treatment interaction) rather than the ability of the device to predict subsequent risk independent of the intervention's effect (i.e., a main effect).

Some would suggest a multi-stage process (e.g., risk screening for triage followed by diagnosis/assessment for matching). Others would develop a single device that achieves both purposes. Although the two reasons for screening are interrelated, they are clearly distinct: demonstration of validity with respect to one of these reasons (e.g., risk prediction) does not substitute for demonstration of validity with respect to the other (e.g., treatment matching).<sup>2</sup>

Also significant problems remain with each approach. Improved risk screening is predicated on (a) prediction of a substantially larger amount of criterion variance than predicted by existing schemes, (b) development of superior cut points for classification, or (c) simplification or cost reduction over existing schemes without loss of prediction. Problems exist with some of these goals. For example, considerable debate has occurred with respect to the nature of the arrested DUI population, and the proportion of true social or non-problem drinkers (Arstein-Kerslake and Peck 1986; Perrine 1990; Wilson, 1991) within the population. Although population parameters could vary with both locations and time period because of social/cultural or enforcement differences, etc. (Wells-Parker, Anderson, Pang, and Timken 1989), one view is that the entire convicted population is at elevated risk for subsequent rearrest/crash incidents (Wilson 1991); therefore, prediction within the population suffers from restricted range. As a technical point, the criterion measurement problem has been noted frequently within the DUI literature, (Mann, Leigh, Vingilis, and DeGenova 1983; Wells-Parker et al. 1990; Howard, Taylor, Ross, and Ganikos 1988) and the unavailability of inexpensive, valid, and reliable outcome criteria obviously limits the estimate of a validity coefficient for risk screening devices. In general, previous efforts at prediction have at best accounted for approximately 16-17 percent of the

variance in a subsequent criterion, (e.g., recidivism, accidents etc.) even when multiple sources of records variables, personality/attitude measures, life circumstances indices, and demographics were included in multivariate prediction equations. Such equations seldom have been cross-validated.

Also, the ability to predict risk levels may be substantially lower for some sub-groups of DUI offenders than for others. Screening devices developed for adults may be inappropriate for teen and young adult offenders (Popkin, Lannenberg, Lacey, and Waller 1988). For example the level of prediction of DUI recidivism has been found to differ significantly for both racial and age groups. In a large-scale study in Mississippi, prediction was significantly better in the over 30 age group than in the under 30 age group. [Dunbar (1990) has noted a similar reduction in predictive validity of blood screens (e.g., GGT) for younger as compared to older groups.] Also, in the Mississippi study, variables that predicted rearrest for all other groups failed to predict rearrest for young (under age 30) black offenders. Such differential predictive validity has both practical and ethical policy implications when predicted risk is the basis for decision making; however, the differential validity of assessment devices is rarely evaluated.

The second problem for assessment—treatment matching—depends on confirmation of what are essentially interaction hypotheses, which are, with few exceptions, untested in the DUI literature. Difficulties with testing such interaction hypotheses are discussed elsewhere (Wells-Parker et al. 1990) as are difficulties in developing the complex, multidimensional schemes upon which to base such interactive hypothesis (Wells-Parker et al. in press). In spite of such difficulties, it is clear that the validity and utility of an assessment mechanism cannot be separated from the actual confirmation of the matching hypothesis itself if matching is the primary reason for assessment. That is, until variables that specify the effects of an intervention have been verified by testing the matching hypotheses, appropriate assessment tools for matching cannot be developed.

From a policy perspective, the substitution of new but unvalidated instruments for existing instruments, even if existing instruments have well documented deficiencies, should be viewed with caution especially if the newer instruments are more costly or time consuming to administer, score, or interpret. From a pragmatic perspective, even if it were possible to assess convicted offenders and to identify the best treatment options for those who would benefit from rehabilitation, this ability will be useless in many communities where options don't exist or are too expensive to be within the

range of many offenders. Russillo (1992) has noted the futility of improving screening and treatment through research if these improvements are never made available to offenders. In many U.S. communities, practical options are non-existent. Options are limited by payment policies of health insurers and by legislative restrictions. Policy research focusing on expanding the range of feasible intervention options that are available to offenders in most communities is a needed companion to treatment matching research agendas. Exploration of methods to expand the types of intervention options that are covered by health insurers also could be appropriate, especially if options that are more cost effective than currently covered methods are identified. Also, barriers to expansion of options beyond the traditional treatment and intervention modes need to be identified, and methods of overcoming such barriers need exploration. Barriers might include resistance by the local alcohol treatment community to new and different options, and to adequate evaluation of existing options.

#### **Emerging and Future Research Agendas**

The underlying premises of this section reflect two themes: (1) Strategies for "rehabilitating" DUI offenders have been limited to education, traditional treatment, and traditional criminal sanctions such as probation. It is time to expand and rethink the range of options for remedial intervention that are available for convicted offenders. (2) Sociocultural diversity within the U.S. population is reflected in the convicted DUI population, and this diversity is highly relevant to expansion of remedial intervention strategies.

In reviewing virtually all of the hundreds of studies that attempt to evaluate the effectiveness of rehabilitation with DUI offenders, the limited range of options that have been adequately investigated for DUI offenders is obvious. These options have been primarily short term education or group discussion programs, group therapy, some short-term behaviorally based therapies, probation, (both intensive and non-intensive) and traditional alcohol treatment. As mentioned earlier, the range of options that have been evaluated specifically for DUI offenders appears much narrower than the range of options tested within the general alcohol treatment literature.

Also, there has been considerable discussion of problems associated with trying to change an individual offender's behavior without changing the social, economic and physical environment that tends to maintain that behavior (Stewart and Ellingstad, 1988). Vingilis, (1990) has cited the need to consider the general social control context in developing viable

deterrence options. However few specific deterrence strategies (with the possible exception of technological systems such as the interlock), attempt to alter negative environmental influences or to develop new support systems for alternative behaviors.

Would it be possible to develop intervention strategies for convicted DUI offenders that focus on changing the environment or the life circumstances of the offender in ways that would reduce the environmental causes and maintainers of drinking driving? In the alcohol treatment field, the community reinforcement approach is unique in that components of the treatment (such as alcohol free recreational clubs) potentially become part of the community support system for alternative behaviors to heavy social drinking. Could a similar strategy be adapted for DUI offenders? [An example of such a strategy for one subgroup—young minorities—will be discussed shortly.] This would represent an attempt to place intervention with convicted offenders in the context of the community and could be a cost effective method to intervene for traffic safety purposes with offenders who are unlikely to afford more expensive treatment options. Community intervention programs for drinking driving among the general public seldom assess the extent to which they reach and are relevant to detected offenders. While it is true that many drinking drivers are undetected, it would seem that at least some components of community programs should be relevant to the detected offender as well. It cannot be assumed that community programs relevant to the general population of drinking drivers, many of whom drive only at low BAC's and/or infrequently after drinking, will be relevant to frequent, or high BAC drivers or drinking drivers at high risk of detection. This is not to say that community support structures and programs could not be relevant to these groups. Indeed, if community interventions were developed to serve convicted offenders, such programs might be appropriate for a broader sub-population of undetected drinking drivers who also are at high risk of accident involvement and frequent drinking/driving.

An interrelated point is that remedial intervention programs for DUI offenders should take into account demographic and social changes as well as sociocultural diversity. In the United States the population is aging, women are found in increasing numbers in public drinking settings and in the DUI population, and ethnic groups in some areas are at particularly high risk of recidivism and accident involvement (Wells-Parker et al. 1990; Popkin and Council, in press). These trends should have relevance for planning intervention strategies. In the existing literature several studies have reported that intervention outcomes (e.g., recidivism reduction) could

differ according to demographic characteristics. Race (Wells-Parker, Anderson, McMillen and Landrum 1989; Reis 1982 a and b); age (Wells-Parker et al. 1989); education (Neff and Landrum 1983; Wells-Parker et al. 1989; Reis 1982 a and b); and gender (Wells-Parker et al. 1989), have been found to specify treatment outcome. Yet relatively little energy has been devoted to studying drinking driving issues for women, minority, and other demographic groups. Such strategies are likely to entail approaches beyond traditional education or alcohol treatment.

For example, young (under age 30) black DUI offenders are at especially high recidivism risk; yet virtually no studies have focused on understanding the act of drinking and driving within this group. (See Wells-Parker et al. 1991 and Howard et al. 1988 for additional commentary on research relevant to this group.) For this group nontraditional programs that avoid labeling these offenders as "criminal"; that provide role models; and that provide assistance in finding/maintaining jobs, etc., might be more appropriate recidivism prevention strategies than more traditional educational or treatment programs. If such programs developed as part of the DUI remediation structure, they might evolve toward more broadly based community programs targeting underserved young adult minorities (e.g., unemployed black males) and potentially reach undetected high risk drinking/drivers within these underserved groups. This is merely an example of potential recidivism reduction options that have not been considered for investigation of efficacy.

## Recommendations

**A. Expand remedial options available for DUI offenders; develop countermeasures targeted toward specific sub-groups of DUI offenders; continue intervention matching research.**

1. Test the relative efficacy of programs combining rehabilitation strategies with technological/driving restraint options such as vehicle interlocks; home monitoring; vehicle impoundment/plate confiscation, especially for habitual offenders.

2. Examine possible adaptations of European medical monitoring/relicensing programs for habitual offenders. This could include assessment of the utility of biochemical markers within the U.S. offender population.

3. Adapt and test promising approaches from the general alcohol treatment field for DUI offenders. Include options, such as community reinforcement and family intervention, which have

been previously untested for DUIs.

4. Continue intervention matching research for DUI offenders. Identification of appropriate assessment materials should be an integral part of this research. Consider matching, not only on alcohol problem indices, but on other variables such as driving behavior, social/family/life/circumstances, sociodemographics (e.g. age, gender, etc.), and polydrug use.

5. Develop and test non-traditional options for underserved sub-groups. Consider options that could become community based and that create new support systems for alternative behaviors to drinking and driving for underserved high risk groups. Investigate the dissemination of such programs to similar but broader populations that potentially include undetected drinking drivers at high risk of accident involvement. Development of such options will require additional investigation into drinking-driving behaviors among minority, ethnic, and cultural groups. Also well-designed longitudinal studies that include adequate samples of females, minorities, and various age groups would inform development of intervention options.

6. Identify mechanisms for expanding affordable and appropriately diverse options for remediation within various types of communities, and for the dissemination of promising new options to diverse communities. Take into account demographics, and social trends in the development of ranges of intervention options.

**B. Exploit on-going treatment research by explicitly examining DUI offenders as a sub-group of existing samples; improve the methodological and reporting standards for ongoing and future research.**

1. DUI offenders frequently constitute a substantial portion of alcohol treatment participants (Institute of Medicine, 1990)<sup>3</sup>. When ongoing clinical trials of alcohol intervention involve substantial numbers or proportions of DUI offenders, outcome data sufficient for calculation of treatment effect sizes (e.g., means and standard deviations for treatment groups; significance tests; and numbers of subjects in treatment groups, etc.) should be reported separately for the DUI sub-sample. In some circumstances it may be appropriate to report such information for several sub-groups within the DUI sub-sample (e.g., men and women; different age groups, levels of alcohol problems, etc.). Thus, the knowledge base about the effect on alcohol specific interventions on various outcomes for DUI

offenders can be expanded at relatively low cost.

2. Research reports, whether published or unpublished, should provide sufficient information for calculation of effect sizes for all comparisons tested, regardless of statistical significance. A simple table of standard deviations with means (both corrected and uncorrected for statistical adjustments, if applicable) generally will suffice. This reporting practice would facilitate their inclusion in quantitative summaries of similar studies.

3. Funding agencies should require minimal methodological standards for intervention effect studies, including quasi-experimental studies and studies using existing groups for comparison. Also, standards should incorporate issues such as criterion measurement, the integrity of implementation, and process evaluation, as well as basic research design. Funding agencies should encourage the use of adequate follow-up intervals to permit the assessment of both short term and long term efficacy.

#### C. Set standards for assessment/screening research

1. In the search for risk screening devices, the marginal utility of proposed schemes should be compared to simpler or existing schemes. Take into account the criterion problem. [This could involve new approaches to the problem of criterion measurement as well as the improvement of existing records systems.] Examine differential validity, the need for group-specific norms, and/or the need for special screening instruments for sub-groups such as minorities, women, or different age groups (e.g., teen offenders).

2. When the purpose of assessment is matching, assessment research should be integrated with research to confirm the underlying matching hypotheses.

**D. Explore the possibility of systematically examining data on the interface between intervention and the legal/judicial system (e.g., the impact of length of time between arrest and intervention referral by the courts) in terms of its effect on intervention efficacy. Evaluate programs designed to improve the interface (e.g., reduce arrest/referral delays).**

**E. Increase interagency cooperation and coordination of research on intervention and screening for DUI offenders. Examine the possibility that DUI offenders, or some portion of DUI offenders, constitute a high risk group that is frequently involved with a variety of systems, such as the criminal justice system, and the health care system, as well as more focused traffic and alcohol systems. Facilitate inter-agency research to design and evaluate innovative and comprehensive approaches to intervention with this**

**group.**

#### Notes

1. In other systems, such as some European DUI control systems, assessment of alcohol problems using biochemical markers as well as other data, is used to monitor offenders under license action and to make decisions about relicensing. The experience of other countries with other types and uses of assessment could be useful to U.S. researchers in revising assessment strategies.

2. Also, the common practice of assignment to intervention based on risk assessment assumes the validity of a matching strategy based on risk, and renders it impossible to directly test the matching hypothesis. [See Mann et al. 1983; Wells-Parker et al. 1990 for additional discussion on this point.]

3. Although DUI offenders, as a group, may overlap other populations seen in treatment they appear sufficiently distinct on a variety of indices (e.g., gender, age, problem severity, etc.) to require specific identification for understanding treatment response.

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#### APPENDIX D6 PREVENTION OF ALCOHOL-INVOLVED TRAFFIC CRASHES

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#### INTRODUCTION

The purpose of this paper is to review research concerning alcohol access, price and mass communication, and discuss the potential to prevent alcohol-involved traffic crashes. Alcohol access is defined here in a broad manner including forms of alcohol availability, site of purchase and use, type of alcohol, and limitations on availability.

Alcohol policy research has a 20-year history in public health concerned with the effects of alcohol consumption and chronic alcohol problems such as liver

cirrhosis or alcoholism. See reviews by Bruun, et al. (1975), Holder (1987), and Room (1990). However, well-controlled studies which examine the effect of alcohol restrictions on an acute alcohol problem such as alcohol-involved traffic crashes have a much shorter history.

One set of studies (see summaries by U.S. Dept. of Health and Human Services (1981) and Popham, et al. 1976) has concluded that state ABC laws and regulations have little or no effect in holding down per capita consumption and alcohol-related problems. Smart (1977) found positive association between a nine-factor availability score (composed of ABC restrictions) and consumption but concluded the association was spurious after statistically adjusting the data for urbanization and income.

Watts and Rabow (1981) argued that interstate tourism, particularly for Nevada, Vermont, and New Hampshire, as well as the District of Columbia, accounts for much of the association between availability and consumption. But their conclusion was based on results from a 1977 national survey with 1972 state consumption data for a period when the minimum age was changed in 29 states. In a study published later, the same research team found positive links between availability and alcohol-related problems in California (Rabow and Watts 1982). In addition, Colon et al. (1981) found significant association between consumption and two types of composite measures of availability, while controlling for tourism and urban conditions.

A combined cross-sectional and longitudinal analysis of the consumption of distilled spirits by Hoadley, Fuchs, and Holder (1984) found that certain laws and restrictions do reduce distilled spirits consumption.

As indicated earlier, the final model predicted a decrease of about two drinks per person per month if a state were to shift its regulatory laws (including the price of liquor, which is not always subject to regulation) from being relatively loose (ranking twelfth among the 48 [contiguous] states) to being relatively strict (ranking thirty-sixth). This decrease in drinking would cut back the level of consumption in the typical (median) state by nearly one-fourth.

Rush, Gliksmann, and Brook (1986) conducted statistical analyses using linear structural relations applied to a set of county-level data from Ontario, Canada. They found a high positive association between retail availability of alcohol, alcohol consumption, and alcohol-related morbidity and mortality. They concluded from their analyses that government policies that restrict the availability of alcohol will reduce per capita consumption and, indirectly, lower alcohol related

damage.

As a group, these studies, along with cross-cultural analyses from other countries (see Makela et al. 1981; Single, et al. 1981; Single et al. 1984; and DeLint 1980), have provided evidence to support a conclusion that environmental restrictions can affect both consumption levels (which are shown to be related to alcohol-related problems) and alcohol abuse. Room (1984:310) in reviewing studies from the United States and other countries concluded, "The evidence is thus by now compelling that alcohol controls can affect the rates of alcohol-related problems, and that they often particularly affect the consumption patterns of high-risk drinkers."

#### TRAFFIC SAFETY AND ALCOHOL AVAILABILITY

The field of traffic safety research which has concentrated on reducing the number of drinking and driving crashes, injuries, and fatalities has primarily emphasized driving decisions, e.g., threat of enforcement, conviction, and sanction if one drinks and drives. There has not been an equal emphasis on drinking prior to (or even concurrent with) driving.

This could be the result of several assumptions. First is the alcoholism assumption, i.e., most crash-involved drivers are heavy, chronic users of alcohol. Therefore, detection through enforcement and routing into treatment is the preferred countermeasure. Changes in retail access to alcohol is therefore assumed to have no affect on these dependent individuals. However, we know that while heavy, dependent drinkers are more at risk of crash per person, they do not constitute the largest population of drivers at risk. This has been called the prevention paradox (see Kreitman 1986). In addition, chronic drinkers have also been shown to be affected by changes in availability. See, for example, Cook and Tauchen (1982).

A second assumption is that changes in alcohol access can only affect alcohol problems related to long-term chronic drinking. (Note that assumption two actually contradicts assumption one.) Research, as reviewed here, has shown results which are contrary to this assumption.

The third assumption is that the tradition of alcohol-involved traffic crash prevention is best served through deterrence, i.e., DUI enforcement and associated sanctions. This appears to be more related to the tradition of highway safety from law enforcement than from a public health and safety perspective.

This section will review some of the published research which addresses the relationship of alcohol

consumption and alcohol availability to traffic safety.

#### *Form of Spirits Availability*

The availability of distilled spirits for on-premise consumption by the individual drink is taken for granted in most states in the U.S. and in most foreign countries. However, the relationship of spirits availability for consumption at on-premise establishments or liquor-by-the-drink (LBD) as a specific form of alcohol availability to alcohol-related problems has gone largely unexplored. Since 1968, nine states in the U.S. legalized the sale of LBD. Studies that specifically evaluated LBD in the U.S. were rare and provided limited information regarding this phenomenon. Bryant (1954) studied the implementation of LBD in the state of Washington, but his findings are confounded by limited time-series data (a long series of observations after the intervention but only one prior), reliance entirely on measures that are particularly sensitive to enforcement and other biases (e.g., public drunkenness arrests), among other problems. Womer (1978) found a minor impact of LBD on consumption in Virginia, but used no control group and felt his analysis was inconclusive. Hoadley, Fuchs and Holder (1984) utilized multiple regression analysis to analyze the impact of state-level regulatory measures on per capita distilled spirits consumption during the period 1955-1980. Their results suggested that the absence of LBD was associated with lower distilled spirits consumption.

The implementation of LBD in North Carolina in 1978 represented an important opportunity to undertake a natural experiment to evaluate the effect of a change in distilled spirits availability on alcohol-involved traffic crashes. With the passage of legislation in that year, counties and cities in North Carolina were authorized to hold referendums on whether to allow LBD. Before this, only "brown-bagging" was permitted (i.e., patrons could bring distilled spirits to licensed restaurants and clubs and purchase ice and "set-ups"); the establishments themselves could sell only beer and wine or non-alcoholic mixes. In those counties and municipalities, implementing LBD, full-service bars now existed for the first time since Prohibition in North Carolina. LBD thus represented a change in distilled spirits availability that is quite specific to on-premise consumption.

The implementation of LBD resulted in major changes in on-premise distilled spirits availability. It resulted in the creation of a new type of drinking environment, increased the number of locations at which distilled spirits could be purchased, altered the mix of the types of establishments where drinking could occur and made distilled spirits more accessible in terms of

hours of sale and convenience. On the other hand, there was a temporary drop in the number of places at which distilled spirits consumption could occur and an effective increase in the price of on-premise consumption. There are two other ways in which LBD may have affected the system of distilled spirits availability which have implications for traffic safety. First, server monitoring and intervention is more feasible under LBD than was the case under brown-bagging. Second, when the LBD legislation was under consideration, some argued that LBD might actually inhibit consumption by replacing generous self-poured drinks with ones measured by a bartender (Popkin, Stewart, and Lacey 1982).

Holder and Blose (1987) conducted an interrupted time-series analyses of counties within the state of North Carolina, U.S., which first permitted such sales in 1978 compared with a comparison set of counties within the state which continued the ban. A quasi-experimental study was conducted to estimate the impact of liquor-by-the-drink (LBD) on alcohol-related traffic accidents in North Carolina counties. Time-series analysis for the period from January 1973 through December 1982 found LBD was associated with statistically significant increases of 16 to 24 percent in both the number of police-reported alcohol-related accidents and in single vehicle nighttime accidents among male drivers 21 years of age and older in counties implementing LBD. No change in alcohol-related accidents was found for non-LBD counties. Single vehicle nighttime accidents involving male drivers under 21 did not change for either the experimental or comparison groups suggesting that only drivers eligible for spirits purchases were affected. Holder and Blose (1987) found that spirits sales rose from between 6 and 7.4 percent. These analyses used a multiple-level design intended to control for a number of threats to the validity of these conclusions.

#### *Increased Minimum Age of Purchase*

At the end of Prohibition, each of the states established a minimum age of purchase or drinking. The states varied in terms of the established legal age, some 18, some 19, some 21. In addition, some states established differential legal ages by beverage, e.g., 18 for beer and wine and 21 for spirits.

During the early 1980s, the U.S. voting age was uniformly dropped to 18 and concurrently a number of states with legal drinking (or purchase) ages above 18 lowered their minimum age to 18 in order to be consistent with the voting age. However, research into the impact of this lowered age suggested that there was a subsequent increase in alcohol-involved traffic crashes

for the newly enfranchised age groups (see research summaries in Wagenaar 1983 and Holder 1987).

This research made public the negative consequences of the lowered age and stimulated a considerable public debate during the late 1980s concerning the appropriateness of a lower legal age. A number of states subsequently increased this minimum age which provided the opportunity for research studies of both lowered and increased minimum age.

The research results took on practical implication with U.S. federal legislation to incentive all states to increase their legal age to 21 for all beverages. This legislation, reluctantly, signed by President Ronald Reagan, called for withholding a portion of federal highway construction funds from states which did not increase their age to 21 by October, 1986. The "grass roots" public support for such legislation came from the national organization of Mothers Against Drunk Driving (MADD) which used both the concern of their members about drunk driving and these research findings to bring considerable pressure to bear for this legislation on the U.S. Congress and the Presidency.

Historically the minimum age of purchase has been used to reduce drinking by the young and to prevent alcohol-related problems, particularly accidents and injuries, involving young people. The effect of changes in the minimum purchase age on youthful drinking and traffic accidents has been extensively researched. Overall, there is evidence that a higher minimum purchase age results in lower per capita consumption (following the conclusions of Maisto and Rachal 1980, which were based on their analysis of a recent national adolescent drinking study). Longitudinal analyses of aggregate sales, of which young purchasers represent a small part, have shown that beer (and sometimes wine) sales are sensitive to changes in the purchase age (Smart 1977; Wagenaar 1983; Douglass and Freedman 1977).

An exception to such findings was Massachusetts, where the level of self-reported alcohol consumption by young people did not change following an increase in the minimum drinking age from 18 to 19 (Hingson et al. 1983; Smith et al. 1984). This exception might be explained by under- or over-reporting, of drinking by the young respondents, a lack of compliance, or a lack of enforcement.

Research findings support the conclusion that higher minimum age of purchase can reduce alcohol-related traffic accidents. The longest time-series analysis of an increased minimum age has been conducted by Wagenaar (1981) and (1987) in Michigan. Michigan is a good state for such analyses, since the greatest population concentrations are sufficiently far from state borders to reduce the "border effect," whereby

under-aged youths cross to lower minimum-age states to purchase alcohol. Wagenaar (1981) found an 18 percent reduction in alcohol-related crashes among young drivers in the first year following a change in the minimum age from 18 to 21. His follow-up analysis to the time-series, carried out four years after the age change, showed a statistically significant 9 percent reduction over the total 5 years (Wagenaar 1987). These findings in Michigan are consistent with those of Filkins and Flora (1981) in an independent analysis conducted in the same state.

Maxwell (1981) found a statistically significant reduction in alcohol-related accidents in Illinois for 18- to 21-year-old drivers following an increase in the minimum age to 21. These findings are confirmed by a nine-state analysis conducted by Williams et al. (1983), in which they found decreases in fatal crashes among young drivers following an increase in the minimum age.

The state with the least reduction in fatal crashes following a one-year increase in minimum age (18 to 19) was Massachusetts. No statistically significant changes in fatal crashes in Massachusetts were found by Hingson and co-workers (1983) for the entire 16- to 20-year-old age group and by the same research team (Smith et al. 1984) for the 16- to 17-year-old group. However, a statistically significant reduction in single-vehicle, nighttime fatalities was found in Massachusetts for 18- to 19-year-olds over the three years following the increase in the minimum age. These outcomes are consistent with findings by Williams et al. (1983) that Massachusetts had the lowest reduction in fatalities of nine states that raised their minimum purchase age. Other states that appear to have a greater level of enforcement of the minimum age and compliance have recorded statistically significant reductions in alcohol-related crash involvement among the age groups most affected by the raised minimum ages. A recent study by Du Mouchel, Williams, and Zador (1987) of 26 states found similar results.

In an adjoining state, New York, which was used as a comparison state for the Massachusetts study by Hingson et al. (1983), an age change from 18 to 19 yielded statistically significant changes in the auto accident rate. Lillis, Williams, and Williford (1987) report nearly a 21 percent decrease in fatal and injury crashes and a 46 percent decrease in self-reported drinking and driving for New York young people following the age change. A recent study of Texas showed that a one-year change in the minimum drinking age affects youthful crashes (Wagenaar and Maybee, 1986).

Taken as a group, such studies of individual states or state groups support a conclusion that a higher minimum

age of purchase has the potential to reduce both youthful consumption (particularly of beer, the beverage of choice of the young) and alcohol-related traffic accidents. The potential reduction appears, like the effects of most restrictions on alcohol availability, to be a function of compliance and enforcement. If compliance is poor, as a result of the lack of diligence by retail establishments in checking identification of lack of enforcement by ABC authorities, the reduction of alcohol-related traffic accidents is less.

Three national studies are worthy of note. An analysis by Cook and Tauchen (1982) found a 7 percent increase in the number of youths killed in automobile accidents associated with a lowering of the drinking age from 21 to 18. A national comparison by the National Highway Traffic Safety Administration (1982) found that higher drinking-age states had lower serious-injury rates.

Grossman, Coate, and Arluck (1987) conducted a national evaluation of the sensitivity of youthful consumption of specific alcoholic beverages to minimum-age changes. Based on their findings, they projected that an increase in the minimum age for the purchase of beer from 20 to 21 would yield a 10 percent drop in the number of youths who drink beer, a 17 percent reduction in those drinking beer two to three times a week, and a 17 percent reduction in the number drinking as many as three to five glasses of beer on a typical drinking day. (For a similar analysis, see Saffer and Grossman 1987b.)

Asch and Levy (1990) in one counter-finding hypothesize that some proportion of traffic deaths among the youngest legal drinkers in a given state (say, 18 year olds before the minimum age was raised) would be due to inexperience with drinking per se, independent of their absolute age. When the drinking age is raised, therefore, it is possible that we would see an increase in deaths among the (now older) inexperienced drinkers (21 year olds). Using data from the Fatal Accident Reporting System (FARS) for the period from 1975 through 1984, the authors employed a covariance model and found that age (a surrogate for drinking experience) was a key variable in predicting fatality.

A report by the National Highway Traffic Safety Administration (Arnold 1985) analyzed traffic-crash data for 13 states that raised their minimum age between 1975 and 1982. The study considered annual figures for driver involvement in fatal crashes among drivers who were affected by minimum-age changes, with those among drivers up to age 23, who were not affected by the law change. Pooled data from all states revealed an average reduction of about 13 percent in fatal-accident involvement; the range was about 6 percent to 19 percent. The U.S. General Accounting Office (1987) completed a review of published research concerning the

impact of drinking-age laws on highway safety. The report concluded:

Raising the drinking age has a direct effect on reducing alcohol-related traffic accidents among youths affected by the laws, on average, across the states. The evidence also supports the finding that states can generally expect reductions in their traffic accidents, both the magnitude of effects depends on the outcome measured and the characteristics of the state.

Decker, Graitcer and Schaffner (1988) found that after Tennessee increased penalties for DUI in 1982 and raised the drinking age to 21 years in 1984, alcohol-related motor vehicle deaths declined by 33 percent among persons aged 15 through 18 years, probably because of publicity. Their results suggest that it may be particularly important to maintain continuous, high-profile anti-DUI programs within high schools. Alcohol-related motor vehicle deaths declined 38 percent among persons aged 19 through 20 years; this effect appears to be attributable to the increase in drinking age and to be durable despite decreased publicity.

A most recent study by O'Malley and Wagenaar (1991), found that a higher minimum-purchase age produced lower numbers of traffic crashes but also lower self-reported drinking. In addition, this preventative effect continues on as young people mature such that lower drinking levels and lower traffic problems involving alcohol can be observed even after young adults reach the legal age of purchase.

#### *Server Intervention*

An alternative intervention is at the primary location of drinking for impaired drivers. Studies of the location of drinking drivers have shown that substantial numbers of such drivers (in some cases the majority) are coming from licensed alcoholic beverage drinking establishments, i.e., pubs, bars, and restaurants (O'Donnell 1985). These findings suggest that prevention interventions at such public drinking establishments could reduce the number of impaired drivers on the road. Mosher (1987), Saltz (1985, 1987), and others have discussed how changes in alcohol beverage serving practices and establishment sale policies could be effective means to reduce the level of intoxication of customers, particularly those who subsequently drive. One means to accomplish such changes is to train servers in techniques to reduce the intoxication level of customers and to intervene in situations of high-risk drinking.

Servers can undertake a number of positive practices including encouraging lower consumption by all

consumers but especially reducing heavy drinking. Servers can assist consumers in spacing their drinking out over time and increasing food consumption in order to slow down the absorption of alcohol. The effect of slowed alcohol absorption or increasing the length of time for alcohol absorption by the body can reduce the blood alcohol level (BAL) of the drinker and their level of impairment.

If the customer is intoxicated, the server can positively intervene by obtaining alternative transportation such as a taxi or non-drinking friends or relatives and/or by asking the customer to remain in the establishment until their BAL has reached a lower and potentially less impaired level (Holder and Wagenaar 1991).

Training can also equip the server to assist the drinker in slowing consumption such as by suggesting food to slow absorption to reduce his/her blood alcohol level and thus their level of impairment. Server training assists pubs, bars, and restaurants in changing serving and pricing policies to reduce the likelihood that customers will leave the establishment impaired. Reviews of the impact of server intervention on customers can be found in Saltz (1989), and Gliksman and Single (1988). Two U.S. states, Oregon and Utah, require that all persons who serve alcohol must have completed such training. One state, Texas, allows licensed establishments to obtain protection against liability suits if their serving employees have completed a state-approved training program.

More recent research studies of server training, Saltz and Hennessy (1990a and b) and Saltz (1988) have demonstrated that server training is most effective when coupled with a change in the serving and sales practices of the licensed establishment. Like the increased minimum drinking age, research into server training has been used to support policies to encourage such training.

Evidence that changes in server practices can affect customer behavior comes from controlled evaluations of beverage server training. Changes in customer drinking behavior (lower number of high volume or intoxicated patrons) have been documented either through use of structured observations of customer consumption (Saltz 1985, 1987; Hennessy and Saltz 1990) or documentation of intervention with intoxicated customers using pseudo patrons (research assistants posing as customers) (Russ and Geller 1987; Geller, Russ and Delphos 1987; McKnight 1987; Gliksman and Single 1988; and Saltz and Hennessy 1990a and 1990b) as well as breathalyzer measures for pseudo patrons (Russ and Geller 1987).

Such research supports a conclusion that changes in server behavior can produce differences in the Blood Alcohol Level (BAL) of patrons leaving licensed establishments and thus the subsequent risk of becoming

involved in a traffic crash or other alcohol-involved problem. The results of this research were summarized by Saltz (1989).

However, such server training studies do not, by themselves, demonstrate that server training reduces alcohol-involved traffic crashes or given to a large number of servers can actually reduce aggregate levels of such crashes. The only state which mandates server training is Oregon. Texas and Utah encourage voluntary training but such training is not required (Holder, et al. in press).

The state of Oregon provides a unique opportunity to examine the research question whether server training provided to a significant percentage of all alcohol servers in a state can reduce alcohol-involved traffic crashes. Prior to the mid-1980s, Oregon established a state-wide requirement that all servers in retail establishments selling alcohol must obtain permits. This permit was good for five years. No special training was required to obtain this permit. In June, 1987, the Oregon legislature passed state bill 726 which required that effective December 1, 1987, all new applicants for a beverage service permit must successfully complete a state approved server training course. In addition, the bill required that all persons holding existing alcohol retail licenses or applying for new licenses must also complete a training program in 1987.

This legislation was modified in July 1987, to require that existing server permit holders were required to complete training only on the five-year anniversary. New server permit applicants must still complete the training as a condition for their initial permit. As a result, approximately 20 per cent of existing permit holders are trained each year beginning in 1988. Thus all servers will be trained within a five-year period, December, 1993.

Responsibility for supervision of the server training and thus the certification of training programs is with the Oregon Liquor Control Commission (OLCC). The one-day training program covers state laws governing the sale and consumption of alcohol, the effects of alcohol on the body and behavior. Trainees are given skills in how to intervene, politely but firmly with a customer who is drinking too much or shows signs of intoxication. The course is provided in about 24 locations throughout the state either at community colleges or through private organizations who are certified by OLCC. Each student must pay a \$20 tuition and a \$13 fee for program administration. The course averages from five to eight hours in length. Each student must pass a written test at the end of the training in order to obtain a new or renewed server license.

Approximately 36,000 servers and 6,000 owners/managers of establishments licensed to sell alcohol completed the course by the end of December

1988 and approximately 13,000 new servers and existing licensed servers seeking their renewal are completing this required training each year.

This time series analysis has demonstrated that when at least 50 percent of the servers of alcoholic beverages in a state and 100 percent of the licensees are trained, there is a statistically significant reduction in alcohol-involved traffic crashes. A similar finding was obtained examining the effect of training for alcohol servers alone. This analysis has controlled for a number of alternative threats to this finding including national trends in fatal crashes which are strongly influenced by driving patterns and economic conditions. Other significant traffic safety programs and legislation were also controlled for.

This finding coupled with demonstrated ability of controlled evaluated server training to alter serving practices sufficiently to reduce the impairment level of customers leaving these establishments strengthen the support for server training as a potentially effective means to reduce alcohol-involved traffic problems. These results provide clear support for the potential of server training when completed by a significant percent (in this study at least 40 percent) of all servers to reduce alcohol-involved traffic crashes. This suggested that server training can be used effectively as a part of a comprehensive set of alcohol counter-measures.

#### *Sanctions Against Service to Intoxicated Patrons*

All U.S. states have either criminal or civil sanctions against serving patrons who are obviously intoxicated. However, the effectiveness of these laws is a direct function of compliance and enforcement. Such compliance has rarely been studied. A recent study by McKnight (1992) found that compliance, expressed as frequency of service intervention or termination, increased by 37 percent after visits and warnings by law enforcement. This was confirmed by a drop (from 31.2 percent to 24.6 percent) in the percentage of persons arrested for DUI who came from a bar or restaurant.

#### *Server or Dramshop Liability*

Legal liability of servers of alcoholic beverages has existed in some states in the U.S. since the 19th century, but only in recent years has its potential for reducing alcohol-involved problems been systematically discussed (Mosher 1979; Mosher 1987; Rinden 1987). Server liability (or dramshop liability) is civil liability faced by both commercial servers and social hosts for injuries or damage caused by their intoxicated or underage drinking patrons and guests. A typical liability suit involves bar A, which serves obviously intoxicated or underage patron B. Patron B leaves the establishment and, while intoxicated, crashes into citizen C on a public highway. Dram shop

liability law permits, within limits, citizen C to sue both bar A and patron B for losses associated with the crash based on the negligent actions of both A and B.

Until the early 1970s, policy makers and opinion leaders of most states did not view commercial servers or social hosts as having responsibility for the harm caused by their patrons or guests. Early dramshop statutes only imposed fines and other penalties on retailers for serving intoxicated or underage persons, or "habitual drunkards." The provisions were not widely used as a basis for lawsuits by the injured victims and state courts did not recognize an independent cause of action under common law. Instead, courts adhered to the "old common law" rule that servers of alcohol could not be held accountable (in a tort suit) for the actions of patrons because the able-bodied customer was responsible for his own actions.

The citizens' movement to prevent drunk-driving in the 1970s dramatically changed the legal landscape. Increasingly, state courts refused to accept the traditional common-law approach, finding instead that retailers could be held liable for serving alcohol to obviously intoxicated or underage persons who subsequently injured others. This "new common-law rule" of third-party liability is based on general concepts of negligence law (see Mosher 1979; Mosher 1987; Rinden 1987) which hold that an alcohol server is responsible for foreseeable harm caused by his negligence.

Under the new common law rule, both the drinker and the retailer are viewed as potential defendants in a dram shop case (in legal terminology, potential "tortfeasors"). Since such liability is predicated on common-law principles of negligence, state courts have the power to adopt the new common law rule as part of their inherent powers without the need for legislative directives. However, state legislatures can set the parameters of common law if they choose. Several states have done so in the server liability area, creating a patchwork of statutory and case law over the 50 states and the District of Columbia.

In a study by Holder et al. (in press), an expert legal panel was used to identify and rate the major legal factors contributing to server liability. As a result, each state was ranked according to its relative level of liability exposure. States which ranked highest in server liability were found to have more publicity about such liability, greater awareness and higher concern among licensed establishment owner/managers, and different serving practices compared to states with lowest liability exposure. As a result, the authors concluded that server liability has a real potential for reducing alcohol-involved problems but additional research is needed.

The level of actual liability in a state appears to be linked to the level of publicity about such liability and to

the awareness of such liability by owners and managers of licensed establishments and thus to differences in self-reported serving practices.

Holder et al. (in press) found that alcohol beverage establishments in high liability states are more aware of their liability than their counterparts in low liability states. Thus, server and manager perceptions match the independent rating of states by legal experts. Respondents from high liability states obtain liability insurance more often, and fewer believe they do not need such insurance. However, liability does not appear to stimulate formal training or underage checking. Establishments in both high and low liability states conduct training and check IDs equally often. Liability does apparently reduce low-price promotions and increase refusals of service to intoxicated patrons. The authors concluded, based upon both the legal analyses and survey data, that server liability laws have the potential to change server behavior and thus reduce risks associated with alcohol use if such laws effectively stimulate responsible alcohol serving practices among licensees.

Wagenaar and Holder (1991) examined effects on the frequency of injuries due to motor vehicle crashes of a sudden change in exposure to legal liability of servers of alcoholic beverages in the state of Texas. A multiple time-series quasi-experimental research design was used, including ARIMA and intervention-analysis statistical models on injury data from 1978 through 1988. The authors controlled for the effects of several other policy changes expected to influence injury rates in Texas, and for broader nationwide changes in injury rates in the 1980s. Results revealed 6.5 percent and 5.3 percent declines in injurious traffic crashes following the filing of two major liability suits in 1983 and 1984.

Server liability is connected to several other policies and practices that may reduce alcohol-impaired driving, such as training of alcoholic beverage servers. Training of servers is intended to increase skills in cutting off obviously intoxicated patrons and, if they are driving, assist them in using alternative transportation. Servers can be trained to notice heavy drinkers, space drinks out over time, and encourage food consumption to reduce average blood alcohol concentrations.

One motivation for establishments to train servers is legal liability resulting from inappropriate serving practices. Many questions regarding the content and effectiveness of server training need to be answered (Saltz, 1989). As effective program components are

identified in continuing research, implementation might be encouraged by permitting alcohol establishments to use good faith efforts to prevent impaired driving as a defense in liability suits.

Future research should examine other states which have undergone dramatic changes in the exposure of licensed establishments to legal liability over the past 20 years. In addition, studies should be undertaken of the actual behavior of specific licensed establishment managers and owners in response to their perceptions of the liability risks in their state. We need more information about the relationship between liability as defined by statutory and case-law, the perceptions of owners and managers about the level of liability, and actual changes in specific serving practices which have the potential to reduce heavy alcohol use and alcohol-impaired driving. The current research clearly indicates that legal liability of alcohol servers should not be reduced without careful attention to compensating actions that should be required of alcohol servers to reduce the risks of morbidity and mortality associated with alcohol misuse.

#### *Low- or Nonalcohol Beverages*

Lower-alcohol beverages have been used in recent years in many countries as a potential means to reduce levels of absolute alcohol consumed, and thus, associated levels of intoxication. These lower-alcohol beverages have been often taxed at lower levels which produces lower prices in countries such as Sweden, Norway, and Finland where such low-alcohol beer is sold in grocery stores rather than in state-monopoly retail stores. This lower taxation has been used in many Scandinavian countries which have encouraged three classes of beer according to their alcohol content and at least two classes of wine. See Österberg (1990) for a summary of these policies.

Low- or nonalcoholic beverages have not met with great success in the U.S. This is likely true because of two factors. First, unlike other countries, there have been no special price incentives (other than no federal and/or state excise taxes according to a classification as an "alcoholic beverage" based on ethanol per volume) which have made such beverages more economically attractive. Low- or no-alcohol beverages in on-premise establishments usually has the same price as regular alcohol beverages. Second, one of the social values of alcohol is its ethanol content which produces a "high" and thus more relaxed social feelings, which is considered desirable by many drinkers. Low or no alcohol beverages do not provide this perceived benefit. No research has evaluated the effects of such beverages in the U.S. drinking environment.

### *Warning Labels*

A recent public policy developed in the United States has been mandating warning labels on alcohol-beverage containers. The required warning level in the U.S. is

"GOVERNMENT WARNING: (1) According to the Surgeon General, women should not drink alcoholic beverages during pregnancy because of the risk of birth defects. (2) Consumption of alcoholic beverages impairs your ability to drive a car or operate machinery, and may cause health problems."

No complete evaluation of the effectiveness of this policy has been published. Early documentation of public awareness and public values has been provided by Hilton and Kaskutas (1990). These policies have two objectives. First, these warnings are intended to deter risk of drinking in conjunction with pregnancy or the operation of machinery. Second, warnings could be considered a part of proscriptive and prescriptive norms, described earlier. These warnings do provide a continuous message of warning about the risk of alcohol use in situations of risk. Warnings about the hazards of smoking have been on cigarette packs in the United States for some time and there is considerable evidence of their contribution to reduce levels of smoking. See Office of the Assistant Secretary of Health (1987).

### *Hours and Days of Sale*

Except for their inclusion in several omnibus analyses of variables purportedly related to alcohol consumption rates (Hoadley et al. 1984; Ornstein and Hanssens 1985; Nelson 1988), and the inclusion of these variables in general measures of availability determined by formal laws (Smart 1977; Janes and Gruenewald 1991), studies of the effects of changes in hours and days of sale are notable in the literature for their general absence. The exceptions to this rule are a series of studies conducted by Smith (1987, 1988) on a variety of changes in hours and days of sale made in various cities and states of Australia (see also Lind and Herbert 1982) and one descriptive study of the impact of extended operating hours at Scottish public houses and hotels (Bruce 1980). Although containing a number of rather serious methodological flaws, these studies present some, at least anecdotal, evidence for impacts of changes in hours and days of sale upon a number of alcohol problems.

Smith (1988), for example, presents a study in which the introduction of Sunday alcohol sales in the city of Brisbane, Australia, is related to casualty and reported property damage traffic crashes. Pre-post chi-square tests of problem rates aggregated over two years before and three years after the change in Sunday sales were used

to test whether this change in availability had the expected impact. Estimates of the relative daily rates of problems were constructed by comparing Sunday rates to rates on other days of the week. Similar tests in surrounding comparison communities were used as controls for other possible contemporaneous changes affecting traffic crashes in the geographic area at large. Smith found that the measured relative daily rates did in fact increase in Brisbane, but not in the comparison communities, and that the time of day of these increases reflected the new opening hours of alcohol outlets. As he notes, the striking temporal relationships among these variables strongly suggests that hours and days of sale can have a substantial impact on alcohol-involved traffic crashes. Gruenewald (1991) has observed that these studies suffer from failures to account for contemporaneous alterations in components of the alcohol control system (for example, beverage prices or other aspects of availability) and the degree to which the effect represents an increase in crash rates versus a redistribution of crash rates over time (days of the week).

### *Location and Density of Alcohol Outlets*

The number and concentration of alcohol retail outlets have been suggested to increase consumer convenience, and thereby increase consumer purchasing and thus consumption. Support for this observation has been provided by Colon (1982), as well as for the counter observation that outlet densities are only in response to demand for alcoholic beverages (Ornstein and Hanssens 1985). Restrictions on alcohol availability through formal laws has been a central part of policy efforts in Canada and the United States as well in many other parts of the world (Room 1987; Kortteinen 1989).

Examining cross-sectional state level data, there is some evidence that measures of the density of alcohol outlets may be important in predicting alcohol consumption and problem rates (Parker et al. 1978; Harford et al. 1979; Colon 1982; Colon et al. 1982). However, these studies suffer from serious problems in mis-specification (neglecting sociodemographic and economic variables and possible sources of simultaneity bias) and statistical testing (reliance on multiple testing procedures). More recent studies have been executed at the county (Rush, Steinberg and Brook 1986; Gliksman and Rush 1986) and city (Watts and Rabow 1983) levels. These studies are of importance for their efforts to avoid previous problems in statistically testing for the effects of availability. Using two different cross-sections (49 counties of Ontario, Canada and 213 cities in California) these studies demonstrate stable and statistically significant effects of outlet densities and sociodemographic background variables upon

consumption and problem rates (alcoholism, cirrhosis morbidity and mortality, arrests for public drunkenness, and traffic related fatalities). Of these three studies, all neglect alcohol price effects in local markets and the last neglects income effects upon alcohol consumption.

A critical subset of economic studies have included market variables in their analyses of time series (McGuinness 1983; Walsh 1982), cross-sectional (Schweitzer et al. 1983), and time series cross-sectional (Wilkinson 1987) data on physical availability and consumption. The first two studies, using data from the United Kingdom, suggest that availability measured in terms of outlet densities may be related to consumption rates but are limited by the shortness of the series studied (at most 25 years). The third, a cross-sectional examination of data from states of the U.S., uses a very limited subset of units (34 states) measured on a very large number of variables (up to 20) resulting in loss in statistical power.

The fourth study, based on a relatively large sample of data from 50 states over 5 years, tests the relationship between numbers of outlets and alcohol sales in the context of an analysis of policies to reduce drunken driving. The analysis suggests a small but significant relationship between these variables.

Recent research conducted by Gruenewald et al. (in press) using two-stage least squares (2SLS) analyses and data from all 50 U.S. states found that outlet densities are not only in response to demand but also act to stimulate demand. These findings were limited in their generalizability in that only cross-sectional data were used. Gruenewald et al. (in press, p. 18) concluded: "Great sales of alcohol stimulate more alcohol outlets per capita... In a complimentary manner, increased licensed densities produced upward pressure upon alcohol beverage sales."

There has been increased interest in the United States concerning possible interventions aimed at the local regulation of the densities of alcohol outlets. See work by Curry (1988), Wittman and Hilton (1987), and Wittman and Shane (1988). For example, the state of California, U.S., has limited the number of distilled spirits outlets per 100,000 population for both on-premise and for off-premise sales in each county.

Godfrey (1988) has examined the issue of the endogeneity of availability and consumption in the context of time series data similar to that used in McGuinness (1983) and Walsh (1982). She finds that there is some evidence that outlet densities are related to use (for spirits, wine, and beer) and that use is related to outlet densities (beer). Gruenewald et al. (under

review), directly addressing this potential endogeneity using time series cross-sections of state data from the U.S., show that outlet densities are related to consumption, significantly, and that consumption places upward pressure on alcohol outlet densities. Both of these studies include beverage prices and incomes as covariates. The latter also includes a subset of sociodemographic variables believed to be related to consumption rates and is based upon a relatively substantial data base (114 to 290 time series cross-sectional units).

Although it is clear that some progress has been made toward the adequate determination of the effects of changes in outlet densities upon alcohol consumption and problems, no study has yet been conducted to determine the relative costs and benefits of this approach to alcohol problem prevention. It is of particular importance to determine the extent to which changes in physical availability simultaneously alter changes in consumption and problems. Because of the very high incidence of alcohol related traffic crashes (Evans 1990) and the heavy dependence of U.S. citizens upon the automobile as their primary source of transportation, reductions in outlet densities may have a number of hidden costs, not the least of which is a potential increase in alcohol related traffic fatalities due to increased driving exposure. Given striking differences in routine activities related to the purchase and consumption of alcohol at different outlets (for example, the probability of driving after consuming alcohol when purchasing these beverages at restaurants versus liquor stores), the relative costs and benefits of reductions in outlet densities may vary strongly by outlet type.

## ALCOHOL PRICE

Price has been a historically important part of alcohol problem prevention in many parts of the world. Alcoholic beverages appear to behave in the market like other goods, i.e., as prices decline and/or income increases, then alcohol consumption will tend to increase. A number of studies have estimated this relationship (the elasticity or sensitivity of alcohol consumption to changes in price and income). See, for example, work by Ornstein and Levy (1983), Österberg (1975), Saffer and Grossman (1987a), Levy and Sheflin (1983), and Cook and Tauchen (1982).

The elasticity of alcohol is influenced by many other factors. It has been pointed out that the more restrictive the availability of alcohol, the smaller the influence of

changes in prices and income of consumers will be. See work by Malmqvist (1948), and Huitfeldt and Jorner (1972), for analyses of Swedish data and Gruenewald et al. (in press) for recent analyses of U.S. data. A recent summary of U.S. research on alcohol prices is in work by Leung and Phelps (1991).

Grossman, Coate, and Arluck (1987) determined the differential price sensitivity of consumption by young people (16-21 years old), paying special attention to beer, the alcoholic beverage of preference for the young. They concluded that youthful consumption is sensitive to price changes of both beer and distilled spirits and that increases in beer prices are not accompanied by increases in liquor and wine consumption. They found that a 10 cent increase in beer price will result in a 14.8 percent decrease in the number of youthful heavy beer drinkers (3 to 5 drinks of beer per day) and a 30 cent increase in distilled spirits would result in a 27.3 percent decline in the number of youthful heavy liquor drinkers (3 to 5 drinks of liquor per day).

Since the overall consumption of distilled spirits as well as consumption of spirits by heavy drinkers can be demonstrated to be sensitive to price, it is reasonable to hypothesize that other alcohol-related problems will also be price sensitive. Cook (1981) investigated the short-term effects of changes in liquor tax on the auto-accident death rates utilizing the same quasi-experimental design used to investigate the sensitivity of the correlation between liquor consumption and cirrhosis mortality. The same 39 state liquor tax changes used in the consumption study were employed. About 66 percent of the net-change observations for auto fatalities were negative. The probability that 66 percent or more would be negative is less than 4 percent. Therefore, one can conclude that a liquor tax increase tends to reduce the auto fatality rate.

In recent years there has been increasing attention to the public health benefits of increasing tax rates as well. The 1987 *Economic Report of the President* (Council of Economic Advisors, 1987) noted that an increase in the federal excise taxes on alcoholic beverages would reduce mortality rates from alcohol-related causes. The U.S. Department of Education's National Commission on Drug-Free Schools (1990) advocated an increase in alcohol excises as a deterrent to use by youths, and the 1990 report on National Health Promotion and Disease Prevention Objectives advocated such an increase in order to reduce highway fatalities and cirrhosis deaths (U.S. Public Health Service 1990). The Center for Science in the Public Interest has publicized the case for

excise taxes as a health promotion mechanism, and its National Alcohol Tax Coalition, representing 40 groups, has lobbied for a substantial increase on the same basis (Godfrey 1990).

## MASS COMMUNICATIONS AND ALCOHOL-INVOLVED DRIVING

A consideration of mass communications and alcohol-involved traffic problems involves both intentional and unintentional communications. Intentional communication is that which is designed to purposefully affect drinking and driving such as mass media campaigns, [e.g., using Public Service Announcements (PSA's)]. Unintentional communication has an effect on drinking and driving behavior but such effect is unplanned. Two types of unintentional communication are examined here: News Coverage and Alcohol Advertising.

**Public Service Information Campaigns.** These campaigns have become the most frequent types of PSA on television. They are produced by the federal government, the National Association of Broadcasters, and a variety of beverage producers such as Coors and Anheuser-Busch. A discussion of these campaigns is provided by Atkin (1988).

The evaluation of the effects of such purposeful communications is quite sparse. Worden, Waller, and Riley (1975) found that a media campaign conducted in conjunction with enforcement produced significant changes in knowledge, attitudes and related behavior. However, the authors found that the effect decayed rapidly over time. Haskins (1985) in a review of 15 years of mass communication campaigns designed to change drinking and driving behavior concluded that very little had been learned.

Atkin (1986) found in a program evaluation of a parent program to prevent teenage participation in social events where alcohol was available that parents were strongly influenced by a communications program using newspaper stories, radio PSA's and pamphlets. However, Atkin found that the changes in parental awareness resulted in only slight changes in teenage drinking and drinking-driving rates.

Worden et al. (1989) conducted a public information campaign using "BAC Estimation" cards which provided data to drivers about steps to determine one's BAC. These "Know Your Limit" cards were widely distributed in an experimental community. Using roadside survey

and community survey data, the authors found following the campaign only .06 percent of drivers in the experimental community were over the legal limit while 3 percent of drivers were over the limit in the control community.

Atkin (1988, p. 23) concluded following his review of public service information programs for the Surgeon General's Workshop on Drunk Driving that:

In general, mediated drunk-driving campaigns appear to have had relatively little effect on drinking and driving. This lack of significant influence is consistent with studies of related campaigns in the domains of safety belt promotion, substance abuse prevention, and other health practices.

Vingilis and Coultres (1990, p. 69) reviewed two public information campaigns which used mass media only. They found mixed to no effects on traffic crashes across these studies and concluded that the research on campaign effects is very limited in terms of the number of controlled studies and methodological problems. They observed:

We do not have enough information on other factors such as media coverage, penetration, message, etc. and on the potential for behavior change through mass communications campaigns in the drinking-driving field.

However, Atkin (1988) points out that there is increasing evidence of the potential for well-designed information campaigns to have behavioral effect using the principles of social marketing. This is especially true, according to Atkin, when formative research is used to develop campaigns which investigate the most effective sources, message appeals, and channels.

Vingilis and Coultres (1990) reviewed the research evidence on mass media campaigns with other countermeasures, which they observe, is the majority of such purposeful communications programs. For example, mass information campaigns typically accompany the passage of new laws or specialized enforcement programs. Vingilis and Coultres (1990) concluded from their review of such campaigns that the results were mixed, sometimes effects were achieved and sometimes not.

The major intervening factor between mass communications and drinking-driving has been defined as the perceived risk of detection and/or apprehension for drunk driving, not the actual probability of arrest, which is quite low. See work by Ross 1982, Voas 1982,

and Williams and Lund 1984.

This relationship has been confirmed by the research of Jonah and Wilson (1983), Vingilis and Salutin (1980), and Williams and Lund (1984). Because it is the perception rather than the reality of the detection risk which is significant to deterrence, some studies have found that drinking and driving can be manipulated through publicity alone (Mercer 1985; Liban et al. 1985; Vingilis and Salutin 1980; and Lacey et al. 1990).

However, publicity alone has rarely produced lasting changes in safety behavior (Wilde et al. 1971). The best understanding of deterrence effects can be seen as an interaction between mass media information and the personal experience of drivers. Thus Ross (1982) in his report on the British Road Safety Act of 1967, noted that the public was initially lead to believe that the probability of being tested for alcohol and arrested was much higher than it proved to be. He states, "It seems reasonable to me to ascribe (the subsequent reduction in effectiveness of the law) to the gradual learning by U.K. drivers that they had overestimated the certainty of punishment under the law."

Therefore, the difficulty of sustaining behavioral changes resulting primarily from purposeful communication about laws or enforcement establishes a natural decay in this process. Vingilis and Coultres (1990, pp. 74, 75) conclude their review on a rather pessimistic note:

This review suggest first and foremost that there is much rhetoric and little substance on the impact of mass communications campaigns on drinking and driving...Even of those systematically analyzed, the methodological problems preclude definitive statements on overall campaign effectiveness, let alone on what types, media, messages, etc. of campaigns are effective in the drinking-driving field.

#### *Alcohol Advertising*

A number of studies have sought to examine the relationship between alcohol advertising and alcohol consumption. Few, if any, studies have explored a direct relationship between advertising and alcohol-involved traffic crashes. The relationships between alcohol advertising and consumption, in general, and between alcohol consumption and traffic crashes is, at best, an incomplete means to examine the advertising-consumption-traffic crash linkage.

Wagenaar and Streff (1989), using non-linear time series modeling over 10 years (1976-1985), found a strong association between alcohol consumption and single vehicle nighttime fatal crashes. They were found

to lag one month behind a change in alcohol consumption. Colon (1982) found significantly lower single vehicle fatalities in states with more restrictive availability of alcohol, usually spirits and sometimes wine, through the use of state retail monopolies.

Several countries, particularly those with governmental-monopoly retail sales of alcohol have restrictions or outright bans on alcohol advertising. For example, Sweden prohibits advertising of medium- and high-alcohol-content beer and there is a voluntary ban in the United States on distilled-spirits advertising on television. There has been conflicting research results on whether alcohol advertising promotes alcohol use and/or misuse. Summaries of alcohol advertising research can be found in work by Partanen and Montonen (1988), Smart (1988), and Moskowitz (1989). Saffer (1989) reports a pooled-time series over 14 years in 17 countries which suggests that countries which have advertising restrictions or bans have lower levels of alcohol abuse.

Adlaf and Kohn (1989) reanalyzed Strickland's data on drinking students from grades 7, 9, and 11 and found that for these youth: 1) a common factor of abuse was present; 2) frequent intoxication contributed to abuse; 3) peer association had greater effect than advertising. These data were interpreted by the authors as indicating little support for further advertising restrictions.

A full review of the potential effects of advertising on consumption is beyond the intent of this paper. However, an assessment of the effects of advertising bans should have as a background the general effects of advertising. In other words, most certainly if there is no advertising effect, then studies of bans are unnecessary. Perhaps the most complete review of the rationale for postulating advertising effects and of the available literature to that data was by Smart (1988).

Smart observed that the findings of a variety of studies using various research strategies including econometric analyses, experimental exposure studies, and self-reported consumption studies produced mixed and inconsistent findings. A most recent review of econometric studies by Saffer (1991) finds that the relationship of advertising expenditures is weak but that studies are often limited by data (small number of observations) and design (failure to control for confounding variables).

The strongest design for an advertising ban study would be longitudinal, for example, an interrupted time series design. Advertising bans provide for greater variation to exposure than advertising expenditures. In addition, bans most often reflect a public policy choice concerning alcohol advertising and a society's collective disapproval of such advertising.

The earliest published study of advertising bans was

conducted by Smart and Cutler (1976) examining a ban in British Columbia. The ban of all alcohol advertising lasted only 14 months in 1971-1972. Little effect on alcohol consumption was found. A second study by Ogborne and Smart (1980) of a Manitoba ban on beer advertising also found no effects on alcohol consumption. However, as Smart (1988) observed, these were not total bans as only local marketing was banned and all out-of-province advertising continued to be available.

Norway prohibited all alcohol advertising in 1975 and Finland did so in 1977. These bans are of considerable interest as neither country received much foreign television or other media influences. An examination of per capita consumption figures for 1974-84 shows no obvious postban effect. A different comparative approach was taken by Simpson et al. (1985), who examined consumption in two groups of countries for 1972-81: in Hungary, Finland and Norway where advertising was totally prohibited and in Denmark where radio and television advertising was banned and print advertising allowed; and in the Netherlands, Australia and Japan where advertising was unrestricted. Gross inspection of the data shows that per capita consumption varies greatly in both groups and there are no obvious differences. Countries with no advertising did not have lower rates of consumption.

Another study of advertising bans was done by Ornstein and Hanssens (1985). They examine the effect of bans on billboard advertising, bans on consumer novelties and bans on price advertising on beer and spirits consumption in the United States. State data for the period 1974 to 1978 are used. The results show that states that allow price advertising and consumer novelties have higher spirits consumption. They also find that billboard advertising and novelties have no effect on beer consumption while there is some evidence that price advertising increases beer consumption. Wilcox (1985) examined beer sales in Michigan before, during, and after a price advertising ban and found that allowing price advertising and then banning it had no significant effects on total sales of beer.

Saffer (1991) examines the effect of banning broadcast advertising of alcoholic beverages on alcohol abuse. This study contains the first set of estimates, using international data, of the effect of television advertising bans on alcohol abuse. The effect of a ban cannot be estimated using data from one country because the adoption of new advertising bans is an infrequent event and requires many years for adjustment. However, an international data set can be used since there is considerable variation in the use of advertising bans across countries. The data used in this study were a pooled time series from 17 countries for

the period 1970 to 1983. The empirical measures of alcohol abuse were alcohol consumption, liver cirrhosis fatality rates, and highway fatality rates. Cultural factors which influence alcohol use were measured by alcohol production variables and a set of country dummy variables. The empirical results showed that both alcohol advertising bans and alcohol price can have a significant effect in reducing alcohol abuse.

Smart (1988) concluded that advertising bans appear to have little impact on overall sales of alcohol although a total ban has been very difficult to achieve. He observed

Given the global nature of mass media, total advertising bans are almost impossible to achieve. An additional problem is that advertising effects may persist for a long time after a ban has been imposed and hence effects on sales may be long delayed. Perhaps an entire generation never exposed to alcohol advertising would drink less than those exposed to advertising for years and then a ban.

This raises the research question of whether young people are prepared for drinking in the reinforcement of alcohol advertising. This question was addressed in a recent study by Grube et al. (1991) which investigated the relationships among awareness of television beer advertising, drinking intentions, alcohol beliefs, and knowledge about beer brands and slogans. Nonrecursive modeling with latent variables was used to estimate the effects of awareness of alcohol advertising on beliefs, intentions and knowledge and the simultaneous effects of these variables on awareness.

The sample comprised 468 fifth and sixth grade school children from a Northern California community. Data were collected using a combination of self-administered questionnaires and structured interviews conducted in the home. The children were regularly exposed to and moderately aware of beer advertising. They also were moderately skeptical of it. Even so, beer advertising had a significant effect on them. Children who were more aware of beer advertising held more favorable beliefs about drinking and were more knowledgeable about beer brands and slogans. Awareness had an indirect influence on intentions to drink as an adult that was mediated through beliefs. Evidence of reciprocal effects was found also. Specifically, knowledge of beer brands increased awareness of beer advertising. As Grube and Wallack concluded

Considering the effects of beer advertising on children, this study provides direct evidence that

awareness of beer commercials predisposes elementary school children to drinking.... That is, awareness of advertising causes children to be more favorably predisposed to alcohol and drinking.

#### *News Media*

The unplanned news coverage of drinking and driving as well as planned countermeasures are relevant to the research discussion. The potential preventative effects of such news coverage is similar to that of planned public information campaigns, named the public's perceived (as opposed to the actual) risk of being stopped and arrested for DUI.

An excellent example of this relationship is provided by Voas and Hause (1987). A special enforcement program, sponsored by NHTSA, in Stockton, CA, provided for ten extra police patrols dedicated to DUI enforcement which was a ten-fold increase in enforcement capacity. The special enforcement program, which began on January 1, 1976, had no planned public information program but naturally produced considerable coverage in local papers and electronic media beginning in late 1975. During the high coverage phases, alcohol-involved traffic crashes declined by 25 percent. During the next year of the enforcement program, the novelty of the program to the news media declined leading to a subsequent decline in news attention. Even with lower news coverage, crash levels remained 10 percent below baseline during the period of special enforcement. After the enforcement program ended, the crash rate remained at the same level for approximately 6 months (until the motoring public became aware that enforcement patrols were ended) and then trended back to the baseline level. The authors concluded that permanent change must be based upon an increase in the efficiency and effectiveness of enforcement together with public education programs which provide continuing support for the program by enhancing the perceived risk of detection by the police.

Atkin (1988) concludes that the most powerful role (and possible longest lasting effect) of the new media is in setting the agenda for policymakers and the general public.

Thus, news is a means to raise the salience of drunk driving, stimulate public discussion, legitimize the seriousness of the problem, and increase acceptance and support of efforts to prevent the problem.

#### CONCLUSION

The research reviewed here provides a scientific basis for considering prevention interventions which limit the

retail availability and access to alcohol as a strategy to reduce alcohol-involved traffic crashes. While many of these alcohol policy alternatives have been shown to reduce alcohol-involved traffic crashes, these policies are "broad brush," i.e., they impact both drivers and nondrivers. They are not always specifically targeted to the reduction of alcohol-impaired drivers.

Perhaps the best example of a policy which most directly affects drinking before driving is server training and server liability. If the BAC of patrons in bars and restaurants is lowered as a result of server intervention, then drinking and driving is the alcohol-related problem most likely to be impacted. Yet other alcohol problems can also be affected, i.e., violence, falls, burns, etc., which result from alcohol-impairment.

This suggests that efforts to prevent alcohol-involved traffic problems may best be seen as part of a public health perspective on community safety in which drinking and driving plays a major part but other causes of death and injury related to alcohol impairment are also a part as well. This has two advantages. First, strategies such as alcohol regulation are seen as part of total injury prevention, and second, a larger base of public support can be developed.

Environmental alcohol policies have a number of advantages. First, as structural or environmental approaches, they are not dependent upon persuasion and individual driver judgement. Second, they do not necessarily decay over time. For example, perceived risk of detection for DUI has been shown to be a powerful strategy for reducing events of alcohol-impaired driving, but the affect invariably decays over time.

Third, many of the alcohol policy strategies have clear scientific evidence of effect on reducing alcohol-involved traffic crashes. This provides a solid empirical basis for considering such strategies.

Fourth, alcohol policy strategies can work synergistically with more conventional enforcement and judicial strategies. For example, retail establishments can be stimulated to participate in server training by DUI enforcement. In like manner, server intervention with customers can reinforce the preventative aspects of enforcement by reminding customers of their risk and the need to use restraint in their drinking.

## IMPLICATIONS FOR RESEARCH

In many cases, the alcohol prevention policies reviewed in this paper were not designed to specifically reduce alcohol-involved traffic crashes. For example, while traffic crash reduction was a useful measure of success for changes in the minimum drinking age, the reduction

of drinking by young people was a primary target. Alcohol-involved traffic crashes are a desired and a convenient indicator (with the availability of archival crash records with which to construct long time series).

There is clear evidence (as reviewed in this paper) that strategies for alcohol problem prevention affect alcohol-involved traffic crashes. This has been shown in such alcohol policy areas as the minimum drinking age, changes in alcohol availability, alcohol prices, etc. Therefore, there are at least two major research opportunities in the next decade.

First, the challenge is to seek integration. Alcohol-involved traffic safety research needs to become more integrated with alcohol problem prevention research in general. For example, responsible beverage service (RBS) programs can reduce the level of intoxication of patrons leaving licensed beverage establishments. This means that not only are drinking and driving events reduced but likely so are public drunkenness, alcohol-related violence, drinking and drownings, etc. The random breath testing for DUI in Australia has shown an effect on fighting in pubs. Thus alcohol problem prevention research has much to gain and to offer alcohol-involved traffic safety research.

Second, another important future research area is synergism of alcohol-involved traffic safety prevention strategies. Future prevention research should examine the interaction and mutual reinforcement of say DUI enforcement and alcohol sales to minors or RBS, parents training and mobilization, and underage drinking. See discussion by Holder 1991. To date, much of our research has been focused on determining the effectiveness of a single, isolated prevention strategy or counter-measure. This is necessary to determine the efficacy of that single strategy or countermeasure. However, there is reason to hypothesize that the combined effect of two or more strategies can exceed the sum of the two as separate strategies due to their mutual reinforcement.

The effects of increased DUI enforcement have been shown to decay after the driving public develops a more realistic assessment of their actual low likelihood of being detected for drinking and driving. Therefore, it is certainly possible that other strategies such as educational or structural changes in alcohol availability can serve to reinforce enforcement strategies. In short, a major challenge for the future in alcohol prevention research including traffic safety will be to develop strategies and research techniques which can examine the ability of multiple strategies to reduce alcohol-involved traffic safety problems.

Specific research areas which need attention in my

judgment include: (a) effect of alcohol prices on traffic crashes at a local level, (b) effect of increased DUI enforcement (particularly high visibility enforcement) on other alcohol problems, especially violence, and (c) effect of changes at the local level of density and location of alcohol outlets on alcohol-involved traffic problems.

This suggests to me that future traffic research can benefit by comprehensive approaches to countermeasures. This would make alcohol control policies a part of this broad spectrum of strategies available for which research can be of assistance.

The attractive aspect of this proposal is that we do not have to advocate for the inclusion of alcohol availability policies in isolation from enforcement but as part of broad community injury prevention efforts.

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**APPENDIX E**

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**APPENDIX E1  
COMMENTS ON DETECTION AND  
ENFORCEMENT**Adrian K. Lund

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I would like to begin my comments by thanking David for providing a very complete overview of the evolution of DUI detection and enforcement issues over the last few decades. More importantly, I would like to congratulate him for avoiding a trapdoor that was opened here yesterday—reaching too far into the future for the answers to today's problems. Rather than asking what the alcohol-impaired driving issue will be 10 years from now, he has focussed on the issues that exist today. And this is where our attention should be. Not only is the problem persistent and unlikely to change, as Bud Perrine stated eloquently yesterday, but the issues we face in impaired driving today are likely to require a decade or more to resolve and the research that we perform during that time is likely to provide the means for their resolution. The future is now, and there is nothing on the horizon that suggests we should redefine the problem.

Thus, David is correct to focus our attention on issues such as 0.08 BAC limit, enforcement aimed at youthful alcohol-impaired drivers, the use of sobriety checkpoints, and the benefits of new technologies such as passive alcohol sensors and video cameras. The directions that society takes on these issues are likely to be determined during the next decade, and it should be our goal to maximize the likelihood that those directions are based on empirical evidence rather than political whim.

Although these are the general issues, I would state differently the critical aspects of some that need research. For example, David has discussed the need for research to identify the factors that "cause some departments to conduct checkpoints and others to rely solely on saturations and/or DWI patrols." But what factors should we look for? There's no virus or genetic predisposition that determines the acceptability of checkpoints. The fact is that some Senior officials don't see them as appropriate, and they have the power to block them. The departments that do conduct checkpoints may have come to that position in a variety of ways—by having a mayor committed to doing something visible about drunk driving, a young police officer anxious to make a mark in his or her community, or, in rare circumstances, an emergency services head

who actually understands the concept of deterrence (as was the case in Montgomery County, Maryland). The point is, the decision to conduct checkpoints is a political one that may be reached in a variety of unique, and probably nonreproducible, ways. It may be of sociological interest to understand these decisions, but I don't think this research would be of much practical use to those of us concerned about the more immediate public health problem of impaired driving.

There are important research questions to be asked about sobriety checkpoints—questions that have already been indicated by the opponents of checkpoints. For example, there's the question of arrest productivity. Many have written this question off by noting that the goal of sobriety checkpoints is not arrests but deterrence. But, this answer misses two interrelated points: many officers are only interested in sobriety checkpoints if they do have arrests to show for them, and early research by Bob Voas in Charlottesville, Virginia, documented that checkpoints can be just as productive as DWI patrols, if not more so. To counter the arguments of checkpoint detractors, we need more research that can identify the factors that make sobriety checkpoints more productive and efficient. At the same time, we need research on ways to conduct checkpoints that maximize their public visibility and deterrence, which is their primary objective.

Another area of slight disagreement with David is his characterization of the issue of 0.08 BAC limits. He suggests that research is needed to develop new procedures that can increase the ability of officers to enforce the lower limit effectively. However, that should not be the goal, at least not at this time. The fact is that officers are still doing a poor job of arresting drivers with much higher BACs. The primary benefit of lower BAC limits is not that officers can focus their attention on those drivers but that when they do arrest someone whom they identify as being impaired that arrest is not nullified by a breath test that is not above 0.10. In other words, the problem is not to identify additional alcohol-impaired drivers but to ensure the conviction of drivers who already are being identified as alcohol-impaired.

The real research questions about 0.08 concern the effects on the court system, the public's perception of the chances of getting caught, and subsequent crashes. And we need to study whether there is any evidence that attention is distracted from more serious alcohol impairment when BAC limits are lowered; if that is true, it would be a mistake to adopt 0.08.

I'd like to discuss some of the other issues raised by David in more detail, but there is not time here. Instead, I want to raise several additional issues that need research. The first issue was mentioned by Bob Voas yesterday. How do we change the focus of police traffic efforts from one of catching bad guys to one of deterring dangerous behavior such as alcohol-impaired driving? This is an issue of training. Police officers are not accustomed to using passive alcohol sensors to screen for possible bad guys; they use sophisticated equipment to prove that their suspicion, based on other grounds such as police judgment, is justified. They will not be happy conducting a sobriety checkpoint at which no one is arrested, even though it means their efforts have been highly successful in deterring drunk drivers. We need more research on development of effective training programs for police, so that when their superiors are favorable to new strategies, those new strategies are accepted.

An example or two may illustrate how differently the police and researchers or policy makers often perceive the issue. In San Antonio, one of the Institute's insurance company Sponsors donated passive alcohol sensors to the police department. After discovering that the officers were using them infrequently, I went to investigate. There were some technical problems with the sensors, but ultimately there was a more important factor. San Antonio, one officer pointed out to me, has 5,000 alcoholic beverage outlets; as a result, he said, he did not need passive sensors to locate alcohol-impaired drivers because they were already too easy to find. This, clearly, is a different perspective on the problem.

Another example further illustrates the issue. In Charlottesville, Virginia, a year of successful sobriety checkpoints was conducted with federal money. These checkpoints were models of productivity and deterrence, and they provided the first evidence that passive alcohol Sensors could make an extraordinary contribution to arrest productivity. Nevertheless, Charlottesville no longer conducts checkpoints and has, to my knowledge, not purchased a single sensor. Despite a model experience with new techniques and technology for enforcing alcohol-impaired driving laws, this city has not adopted those techniques and technology as its own. Undoubtedly, some of the reluctance to adopt or continue sobriety checkpoints is a perceived lack of funds. However, there is also an unwillingness to reallocate patrol hours to checkpoint hours, a lack of recognition that activities that deter alcohol-impaired driving may be more effective than punitive efforts, and a failure to perceive such activities to be as rewarding as catching lawbreakers. It's to this motivational issue that some research attention should be addressed. The state

of Victoria, Australia, appears to have partially resolved this issue by demonstrating the overwhelming public support for checkpoint activities and by using junior officers, just out of the training academy and in their first months on the job, to conduct checkpoints.

The last issue I'd like to address may be less a research question than an observation on current political realities. I think we all recognize that a good deal of the progress made in recent years has been due to the political activism of citizen groups such as MADD, SADD, and RID. Progress was rapid in the early 1980s, but it has slowed down. Since 1987, some measures of the problem have declined only slightly, if at all. If deterrence is the source of the gains, then it's important to recognize that much of the gains we have seen could be lost if there is a reduction in enforcement or public attention. We need to understand how public commitment is maintained and what kinds of legislative or other actions are least sensitive to alterations in public awareness and support for actions against alcohol-impaired driving.

## APPENDIX E2 REACTION TO PAPER BY WELLS-PARKER AND POPKIN ON REHABILITATION AND SCREENING

R. Jean Wilson

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I am going to start with my reaction to the question that was raised at the very end of the first paper because it applies to all forms of intervention, to both primary and secondary deterrence measures and is particularly apropos to rehabilitation. **To repeat the question: Is there really a sufficient amount of research data to permit the Federal government to advocate changes in policy?** I would also broaden that question to include all levels of government and decision making. I believe there is even greater reason for hesitancy in responding in the positive to this question in the case of rehabilitation than perhaps for other forms of sanctions and interventions, where we might be a little more confident. I do believe however that we know considerably more than we knew 12 years ago; in the very least we are in a better position to define what it is we need to know.

Before responding to some of the specific points and recommendations made in the paper by authors Wells-Parker and Popkin, I want to mention what I believe is one of the most basic issues that requires resolution. Looking at macro-level effectiveness what is the overall potential of individual reform measures (to

coin the expression used by Nichols and Ross) to influence traffic safety. Just amongst present company in this room I suspect you would probably find considerable disagreement. On the one hand, you read statements in the literature to the effect that even with 100 percent effectiveness of individual reform measures of all types, you could only prevent less than 5 percent of alcohol-related fatal crashes over a one-year period because 95 percent of all alcohol related fatal crashes involve a driver with no drunk-driving convictions. Therefore why waste money on specific deterrence and remedial intervention, which we know is far from 100 percent effective in any case? To counter this argument, we are now seeing fatality data from the state of Minnesota showing that almost 35 percent of alcohol-related fatal crashes involve a driver with a prior DWI, and furthermore that proportion appears to be growing. There is no reason to believe that Minnesota is atypical, except for the thoroughness of their record-keeping on DWI offenses. In other words, the potential for individual reform may be greater than what previous estimates indicate.

To move now to the micro or individual level of effectiveness, one of the things that really struck me in reading the paper was that our progress in the area of rehabilitation and screening seems to have lagged behind that of some of more punitive sanctions, discussed in the second paper. By progress, I mean not only the measured success of an approach or program; I also mean advance in learning and accumulating knowledge. As the paper points out, our learning has been hampered by the unavailability of assessment instruments with high criterion validity. We can't even agree on what criterion is most appropriate.

Another obstacle to progress highlighted by the paper is the lack of imagination given to treatment options for DUI offenders and the lack of consideration for individual differences. Rarely has the differential validity of assessment devices been evaluated. Even more rarely has differential assessment been used to specify differential treatment. Recognizing, that we are dealing with somewhat of a chicken-and-egg problem in the case of intervention matching research, I believe that there is sufficient information out there from isolated sources on the differential effectiveness of treatments and subgroups of DWIs that one can start to formulate and test specific matching hypotheses. However, there may be a lot of hit-and-miss and the learning process is likely to be lengthy. On the other hand, we can't do too much worse than what we're doing now.

What I found to be one of the most exciting suggestions in the paper (actually it was in the form of a question) was:

**"Would it be possible to develop intervention strategies for convicted DUI offenders that focus on changing the environment or the life circumstances of the offender in ways that would reduce the environmental causes and maintainers of drinking driving?"**

It is clear that we have to get rid of the narrow notion that DUI offenders are a special group. DUI offenders are neither homogenous nor unique. At various times they may wander through the alcohol treatment population or the general criminal offender population, especially if they are recidivists or high BAC drivers. Research also shows that DUI occurs in conjunction with a variety of other problem or high-risk behaviors, many of which are illegal. Therefore focusing on the DUI behavior may fail to deal with the root causes of the problem. Particularly in the case of youthful offenders, providing community support systems, that offer desirable alternatives to criminal behavior, may reduce the levels of a variety of social problems including drug abuse, street violence, vandalism and DUI. An example might be the sort of programs and facilities to provide recreation and entertainment to low income inner-city areas. The paper suggests that this type of community support system be evaluated for its potential not only to reduce recidivism and but also to prevent first-time offenses. The message that I'm getting from the paper is: let's get the blinkers off and see the DWI problem in a much broader context.

Therefore I totally concur with the final recommendation for increasing inter-agency cooperation and coordination, not only with the view to maximizing utilization of community resources for treatment options, but also for research purposes in facilitating the evaluation of treatment options and the initial identification and long-term follow-up of individuals.

One thing we can count on, at least for the near future, is shrinking social program and research dollars and greater accountability for how they are spent. In such a climate the idea of piggy-backing remedial intervention and research to meet multiple objectives is all-the-more appealing. Obviously some exploratory research is necessary to estimate the degree of overlap of the DUI population with the client population of other agencies.

In reading through this paper, I was found myself trying to separate those recommendations that aimed at policy makers and those that were aimed at researchers and I realized that I couldn't. Although the majority of the recommendations were policy or program oriented, it was apparent that research needs for the next decade were very much dependent on what options were put in place. It made me realize the extent to which research

in the area of rehabilitation is at the mercy of the whims and the constraints, both real and artificial of the policy makers and the program implementers. I have the impression that maybe that situation is changing and that research needs are having a greater influence on program orientation and design and that as a group we're being listened to more, but I'm not certain of that. Traditionally, program constraints, lack of understanding of the principles of evaluation research and a general conservatism on the part of programmers and decision-makers have been among the biggest barriers to conducting methodologically sound evaluations. Perhaps there is an opportunity here for researchers to try to expand their sphere of influence in policy areas. Also to recommend that certain programs not be evaluated where adequate evaluation is not possible, i.e., why spend the money if little knowledge can be gained? Not only do researchers have a role to play in promulgating certain standards for evaluation research but, more than that, we have to get our foot in the door at the early planning stages if we are to have any influence on such parameters as assessment techniques, choice of treatment options, assignment to treatment, mechanisms for follow-up, etc.

In all fairness the paper points out that we can't place all the blame for faulty evaluations on the program implementers. One of the recommendations refers to standards for research reports. In order to allow comparisons between various studies, the authors make a plea for the inclusion of means and standard deviations of all groups in order to permit calculation of effect sizes. At the very least it would ease the lives of those attempting to synthesize large bodies of research.

Overall, the track record of rehabilitation programs in reducing recidivism or alcohol-related accidents is not terribly impressive. Certainly there are a number of methodologically sound evaluations showing significant treatment effects but effect size is usually modest. I don't hold out a lot of hope for the future of DUI rehabilitation unless, as Wells-Parker and Popkin argue, radical modifications are made. Even then, there's a large risk that the new improved models won't work any better. I think that we at least have the limited knowledge to make and test some predictions.

### APPENDIX E3 A FRAMEWORK FOR FUTURE RESEARCH ON CHECKPOINT PROGRAMS

Dr. Robert B. Voas

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#### INTRODUCTION

The recent favorable Supreme Court decision finding that sobriety checkpoints are constitutional and the interest shown in this procedure by citizen's groups such as MADD which sponsors an annual checkpoint day suggests that the use of this enforcement technique will increase. This should lead to increased research on the cost effectiveness of this procedure. While some studies have been conducted in the past, the limitation in many of these studies is failure to analyze carefully how checkpoints impact the driving public. Previous studies have principally interested themselves in the overall impact of checkpoints on alcohol-related crashes in jurisdictions conducting checkpoints. If checkpoints are to be properly evaluated and understood, it is necessary to develop a model which describes the mechanism of their impact and to carefully measure the elements of this model. This paper attempts to present an outline of such a model and to discuss some of the elements which need to be measured if we are to evaluate this potentially-effective enforcement technique.

In order to design an evaluation study, it is necessary to come to a general understanding of the method by which sobriety checkpoints influence the behavior of drinking drivers and produce a reduction in alcohol-related crashes. Figure 1 presents one model of the chain of action between the implementation of a checkpoint program and the desired bottom-line result of reduced alcohol-related crashes. This model is presented as an aid to the analysis of the issues arising in carrying out the research on checkpoint programs. Further, the model is intended to generate hypothesis for future research. The six major elements of the model are shown across the top of *Figure 1*. Below are the measures which can be used to evaluate each element.

### Checkpoint Input

The *input* factors which determine the nature of checkpoint operation are the: (1) number of officers, (2) number of vehicles (including vans), (3) availability of field breath test equipment, (4) availability of other safety equipment (such as cones, flashers and lighting equipment), (5) policies to be implemented at the checkpoint, and (6) location, time, and frequency of these programs.

### Checkpoint Output

A number of *output* measures are available for evaluating the activity generated at a checkpoint. The visibility of a checkpoint can be evaluated by the total number of vehicle occupants who come in contact with the operation and its productivity determined by the number of drivers apprehended for DWI.

These output factors determine the number of public impressions which result from the checkpoint operations. These impressions, in turn, vary in intensity. Obviously, the most significant impression upon a motorist is being arrested for DWI. However, a feature of checkpoints is that they affect many motorists who are not arrested. Figure 1 lists a hierarchy of impressions running from: (1) being arrested for DWI, (2) to being detained at the checkpoint for field sobriety tests but not being arrested, and (3) being stopped and checked for impairment but not being detained.

In addition to these personalized experiences for the drivers actually stopped at checkpoints, there are impressions created among those who are not stopped. There are those drivers who are passed through the checkpoint in order to avoid lengthy queues and traffic jams. There are those who sight the checkpoint before entering it and turn away and finally, there are those motorists who pass a checkpoint while driving in the opposite direction. As noted, these impressions form a hierarchy from the most intense, fear-provoking situation—being arrested for DWI—down to the least intense impression which is passing a checkpoint while travelling in the opposite direction where there is no immediate threat of being stopped and checked.

### Public Information

These outputs of the checkpoint program lead to the dissemination of information through the community regarding the risk of being stopped and arrested for DWI. Three major channels for this dissemination can be identified. The first of these is the electronic and print media which can publicize the presence of a checkpoint program. This is a very powerful source of immediate information on the checkpoint activity which is relatively

divorced from the characteristics of the checkpoints themselves. The specific input features of the checkpoint, such as the number of officers and vehicles may be relatively unimportant with respect to the impact of publicity. A good public information program can magnify a limited checkpoint effort.

The other two channels of information dissemination depend much more directly on the nature of the checkpoint program itself. Reports by families and friends of contacts with the checkpoints serve as an important word-of-mouth publicity system. Here, the type of contact may be significant. The impact of knowing someone who was arrested is probably more significant than the impact of knowing someone who passed by the checkpoint while it was in operation. Homel (1990), in his study of random breath testing in New South Wales found that the best predictor of a driver's perceived probability of arrest was the number of friends or associates who had been breath tested.

Despite this finding, it is probable that personal experience has the most significant impact on the perceived probability of arrest. The type of personal experience is presumably very significant. Arrest for DWI presumably has the most powerful impact. However, being detained for a sobriety test or simply examined at the checkpoint by a police officer may also have a strong effect on the perception of risk of arrest. It is important, in this connection, to recognize that the impact of the personal experience can be both positive and negative with respect to the perceived probability of arrest. The individual allowed to drive on, may come to the conclusion that the checkpoints are "paper tigers". For such drivers, checkpoints will lack credibility. Such experiences may decrease a driver's perceived probability of arrest.

### Perceived Probability of Arrest

Information received through mass media, by word-of-mouth or through personal experience, can produce a critical change in the psychology of the drivers; an increase in perceived probability of arrest. This perceived probability can be analyzed into at least two elements: the perceived probability of being stopped at the checkpoint and the perceived probability of being arrested if stopped. These two together produce an overall probability of being arrested at a checkpoint in the mind of the driver.

### Change in Drinking Driving Behavior

If there is a sufficient increase in the perceived probability of arrest among those drivers at risk for drinking and driving, then a change in drinking and driving behavior may occur. This might involve less

consumption of alcohol or avoiding the necessity of driving by drinking at home making alternative transportation arrangements such as using public transportation or designated drivers. Less constructive would be changes in behavior which affect neither drinking nor driving but consist of avoidance maneuvers; attempts to determine where checkpoints are located and taking alternative routes in order to avoid them. If, rather than using such avoidance measures, the driver actually changes either drinking or driving behavior, then these at-risk drivers should report reduced driving at high BACs.

### Alcohol-Related Crashes

If drivers at risk for alcohol-related crashes reduce their driving while at high BACs, the number of alcohol-related crashes should be reduced. A number of proxy measures for alcohol-related crashes are available. Among those most frequently used are nighttime v. daytime crashes, "had-been-drinking" (HBD) crashes (where the police officer indicates that a driver had consumed alcohol) or single-vehicle crashes, particularly nighttime crashes. Such measures provide evidence of a bottom-line impact for a checkpoint program. The confidence that any changes in these measures has been produced by the checkpoint program is increased if there are indications that the expected changes have occurred at each of the steps in the chain of action shown in Figure 1.

### FACTORS IN CHECKPOINT EFFECTIVENESS

Sobriety checkpoints are a relatively new enforcement technique which has not been extensively evaluated. The limited practical experience with this technique, however, suggests that five factors are important in determining the effectiveness of the checkpoints. These factors are summarized in Table 1 together with a measure which can provide an operational definition of the factor.

TABLE 1 FIVE FACTORS IN CHECKPOINT EFFECTIVENESS

FACTOR	MEASURE
1. PRODUCTIVITY	Number of DWI, DWID and other serious offense arrests
2. VISIBILITY	Traffic Counts: (1) Through Checkpoints, (2) Passing by Checkpoint
3. CREDIBILITY	Proportion of over-the-limit drivers identified
4. PREDICTABILITY	(1) Number of checkpoint sites, (2) Frequency of movement between sites
5. PROBABILITY	Number of drivers interviewed at checkpoints divided by the number of drivers in the jurisdiction

### Productivity

The quality of a DWI enforcement program is generally judged (at least initially) in terms of the number of offenders apprehended and arrested. Arrests, of course, provide only an initial measure of the effectiveness of an enforcement program. It is generally recognized that the principal objective of enforcement programs is to deter the impaired driver and that the increase in the number of arrests does not necessarily indicate the extent to which deterrence has been achieved. The bottom line measure for deterrence is a reduction in the number of high-BAC drivers on the road as measured in roadside surveys and the reduction in alcohol-related crashes as reflected in local accident record systems. These bottom line measures, however, are generally not immediately available to police department management and therefore the immediate productivity in terms of arrests is frequently the only basis available to management for determining a program's effectiveness.

Relative to the number of drivers stopped and checked, the number of arrests at the checkpoint is generally small, (1 percent or less). Given the relatively large Commitment of officer hours required by checkpoint operations, DWI arrest productivity often appears low; causing this enforcement technique to appear not to be cost effective. According to the National Roadside Survey (Lund and Wolfe 1989) approximately 3 percent of drivers are over the .10 percent BAC limit. Checkpoints, such as those in Charlottesville, Washington, D.C. and New Jersey typically arrest about 1 percent of the drivers checked. The difference between the 3 percent incidence and the 1 percent arrest rate is apparently accounted for by the fact that some drivers become aware of the checkpoint and turn away. A second factor which reduces the arrest rate is the data which suggests that without passive sensors or other special techniques, the officers miss approximately half of the .10 percent BAC drivers who they interview at checkpoints. Thus, a 1 percent productivity is about what should be expected. While this seems low on the basis of total drivers through the checkpoint, it can still result in a reasonable productivity based on arrests per officer hour. In Charlottesville, the arrest rate per officer hour at the checkpoint was approximately one for every 6.5 officer hours. This compared with 7.9 hours per arrest for an officer to make an arrest on traditional DUI patrol. Thus, it is possible for checkpoints to provide essentially the same arrest efficiency as traditional patrols. It should be noted that in Charlottesville, in addition to DWI arrests, there were an equal number of other citations—principally for Driving While Suspended. Thus, as the productivity of a checkpoint need not be limited to DWI offenses.

### Visibility

It is generally argued that checkpoints are not intended to be highly productive in arrests, but that their principal purpose is to create deterrence through high-visibility enforcement. This issue was a central feature of the Michigan state Police position in the Sitz case which went to the Supreme Court (*Sitz v the state of Michigan, 1990*). While high visibility is rarely defined operationally, it clearly refers to the impression created by the operation on motorists who are not arrested but who pass through or pass by, the checkpoint. As noted in Figure 1, a checkpoint can create a hierarchy of impressions upon motorists; running from the most significant, a DWI arrest, down to the least significant which is probably running a checkpoint in the opposite direction where the motorist should have little fear of being stopped, examined and arrested. The use of traffic counts (counting the number of vehicles through the checkpoint) and the number of vehicles passing in the opposite direction provides a rough measure of the checkpoint visibility. A more sensitive measure would probably be created by providing different weights for the different levels of impression shown in Figure 1. However, a basis for these weights is not yet available.

### Credibility

Rarely mentioned in the checkpoint literature is the issue of enforcement credibility. Since the emphasis has been placed on the visibility of checkpoints, and their potential for creating deterrence through contacts with large numbers of drivers, the issue of the proportion of over-the-limit drivers detected is rarely considered. Several studies, however, have caged attention to the fact that large numbers of high BAC drivers pass through checkpoints without being apprehended. Jones and Lund (1985) found that 52 percent of the over .10 percent BAC drivers passing through the Charlottesville checkpoints were not apprehended by the police. Vingillis et al (1982) estimated that 90 percent of the drivers above the Canadian limit of .08 percent BAC were not apprehended in checkpoints in Ontario. Compton (1985) in his experiment involving a simulated checkpoint found that police officers using the typical interview identification procedure identified only 63 percent of the driver's with BACs between .10 percent and .15 percent. Worden et al. (1989) found that between 3 percent and 5 percent of the individuals who successfully passed through a checkpoint were over .10 percent BAC, the same percentage that would be expected in a survey of nighttime drivers.

These studies demonstrate that a significant portion of DWI offenders are escaping detection at checkpoints. Clearly, this reduces the credibility of the checkpoint system for those high-BAC drivers. It is important that the checkpoint be credible, particularly with the heaviest drinkers. Thus, the proportion of over-the-limit drivers who pass through undetected is an important factor in the effectiveness of checkpoints over the longer term.

### Predictability

Another factor in creating deterrence through the use of checkpoints is the extent to which their location and timing is predictable to the driving public. Clearly, if the public knows when and where checkpoints will occur, those who do not wish to pass through the checkpoint will be able to avoid them by taking a different route. If the heavy drinkers who are most motivated to avoid them by taking a different route. If the heavy drinkers who are most motivated to avoid checkpoints can easily avoid them they will choose to do so. Predictability can be reduced by implementing checkpoints at a larger number of sites and by moving more frequently from site to site. This use of larger numbers of sites and moving more frequently from site to site is sometimes confused with visibility since, on its face, it appears that the use of a greater number of sites would increase the number of motorists who come in contact with the checkpoint. This, of course, is not necessarily the case. It depends upon the traffic volume at the sites employed. A site which stays permanently in a very high traffic area is likely to be seen by more motorists than is a site which moves from location to location where some traffic counts are relatively small. Thus, visibility can be measured independently of the large number of sites and the number of moves. Movement and use of multiple sites is particularly significant in respect to the avoidance of the checkpoint by high-BAC drivers. Checkpoints are typically initiated early in the evening, around 9:00 PM or 10:00 PM. Early in the evening when a motorist is on the way to a bar or restaurant, seeing a checkpoint may be an important factor in reducing drinking. However it may be of little effect if drinkers know that once they leave the bar, the checkpoint will be in the same place so that they can avoid it on the way home. In the Charlottesville study, interviews were conducted with the employees of drinking establishments. Sixty percent of the servers interviewed reported instances in which the patrons stated they would attempt to avoid the checkpoints by changing their route home after their evening out. In Charlottesville, however, the checkpoints were moved during the evening so that individuals who did change their route home still might be caught at the checkpoint.

## Probability

The probability that the at-risk motorist will be stopped at a checkpoint obviously depends upon the number of checkpoints mounted and the number of officers deployed in each checkpoint. That is, the overall size of the effort. The impact of a given level of manpower is obviously related to the size of the jurisdiction. In Charlottesville, Virginia, a 5-person team (4 officers, and 1 supervisor) implemented checkpoints twice a week during the 1984 calendar year putting in 1,880 officer hours overall. With this time commitment just under 24,000 interviews with motorists were conducted in a jurisdiction of 60,000. Thus, there was one stop for every 2.5 county residents produced by an officer-hour commitment of approximately 1 hour for every 30 residents. To make a similar time commitment in a city of 200,000 would require approximately 7,000 officer-hours.

While the exact relationship between the probability of being stopped and interviewed and the perceived risk

of arrest has not been established. It is clear from the experience in Australia that the total number of tests has a significant impact on the reduction of alcohol-related crashes. In the Australian states of New South Wales and Tasmania where the probability of being tested is high, the impact of the Random Breath Test (RBT) program has been large, whereas in states like Victoria, where the PBT procedure is used less frequently, the impact has been marginal. In future research, it will be important in comparing checkpoint programs across communities to relate the checkpoint effort to the size of the community. Within limits, this should occur naturally since larger communities should have larger police departments, which in turn will have larger traffic divisions and larger DWI squads which can mount larger and more frequent checkpoint operations. However, this proportionality may be limited since some of the larger urban areas may have to devote proportionally more officer hours to crime and drug control and therefore have a smaller proportion of their force devoted to traffic and DWI enforcement.

**APPENDIX F**

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