Report of the Second Technical Consultation on Drug Use and Road Safety

16-17 December 2015

Meliá Palas Atenea Hotel Mallorca Spain

World Health Organization

Department for Noncommunicable Disease Management, Disability, Violence and Injury Prevention

Department of Mental Health and Substance Abuse

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Dr Margie Peden and Dr Vladimir Poznyak from the Departments for Noncommunicable Disease Management, Disability, Violence and Injury Prevention (NVI) and Mental Health and Substance Abuse (MSD) coordinated the project on drug use and road safety. Dr Meleckidzedeck Khayesi and Ms Maria Renström were the technical leads of this project. Dr Prasanthi Puvanachandra prepared draft notes of the second technical consultation on drug use and road safety. Experts who attended the drug use and road safety meetings hosted by the World Health Organization contributed to the discussions and presented background working papers. Production assistance and administrative support was provided by Angelita Ruth Dee and Divina Maramba. Charlotte Brown assisted with proofreading and formatting the document.

Bloomberg Philanthropies and the Government of Sweden provided financial support for the meeting, during which presentations and discussions on drug use and road safety were conducted.

Introduction

In order to meet the increasing demand from countries for technical assistance and policy guidance on drug use and road safety, WHO, through its Departments for NVI and MSD, held a first technical consultation on 17-18 December 2014. The first consultation was attended by over 20 experts. The meeting suggested that WHO should consider preparing a policy brief on drug use and road safety. Over the course of 2015, WHO took up this suggestion and held a second technical consultation on drug use and road safety on 16-17 December 2015 in Mallorca, Spain. DGT, Ministry of Interior, Spain, kindly agreed to host the consultation. The objectives of the meeting were to:

- a) review thoroughly the content of a draft policy brief on drug use and road safety, and provide feedback on improvements needed on specific issues or sections.
- b) discuss practical ways to take work on drug use and road safety forward with regard to research, measurement, legislation and interventions.

A detailed agenda for the meeting is provided in Appendix I. The meeting was attended by 30 experts from academia, policy development and enforcement. In addition, three members of staff from WHO attended (see Appendix II for a list of participants). This meeting report provides a summary of the deliberations of the second technical consultation.

Overview of the meeting deliberations

Opening Session

Dr Maria Segui Gomez, Director of the General Directorate of Traffic (GDT) in Spain commenced the meeting by welcoming the participants to Mallorca, Spain. Dr Gomez highlighted that whilst Spain has a road traffic fatality rate of 3.6 deaths per 100 000 population, it is one of the top ranking countries in terms of drug use and therefore the burden of drug-driving and road safety remains large. She explained how there had been a push for implementation of drug-driving policies in parallel with drink-driving policies and that with either a decrease or zero percent change in road traffic fatalities over the past 4 years, these drug-driving policies, which were implemented in 2012, are showing some success in Spain.

Dr Margie Peden, Coordinator of Unintentional Injuries Prevention in NVI, WHO, commented on two important milestones for the field of road safety which had occurred in 2015. The first was the incorporation of a goal on road safety and a reduction of road deaths and injuries into the Sustainable Development Goals (SDGs). Whilst this inclusion is a great achievement for the field, the target of reducing road traffic deaths by 50% in *five* years is an incredibly ambitious one to meet, requiring much work. The other milestone was the Second Ministerial Level Meeting on Road Safety in Brasilia, November 2015. Fifty-two ministers from 122 countries (more than 2000 delegates) met and adopted the Brasilia Declaration which included the following recommendation around drug-driving: "Identify other risks which lead to distracted or impaired driving such as medical conditions and medicines which affect safe driving, fatigue, the use of narcotic, psychotropic drugs and other psychoactive substances".

Dr Vladmir Poznyak, Coordinator of Management of Substance Abuse in MSD, WHO, reiterated the importance of such a meeting not only for road safety issues but also for the public health dimensions of drug policies at national and international levels. Dr Poznyak highlighted the main concerns in 2015 from the perspective of mental health and substance abuse:

- Preparations were underway for the special section in the United Nations General Assembly on the World Drug Problem (April 2016, New York). This session was called to review the policies and international actions required to counter the worldwide drug problem and potentially shape the public health responses to drug-related problems.
- There had been a call from member states to develop public health responses to the drug problem.
- In January 2017, the Executive Board of WHO was to discuss drug policy issues as a separate agenda item "Public Health Dimensions of the World Drug Problem". The report of the secretariat was published online: (http://www.who.int/substance_abuse/news_eb_140/en/).
- The inclusion of drugs and road safety in the SDGs would shape priorities of development agencies for the next 15 years. Target 3.5 is focused on the prevention and treatment of substance abuse.

General D. Benito Salcedo, Head of the Department of Traffic, Madrid, welcomed the group to Spain and provided a short description of the traffic unit in Spain. The unit has over 10 000 members and is dedicated to the surveillance of traffic. General Salcedo explained that drink-driving policies and breathalyzers were introduced in Spain in the 1970s and that drug-testing followed 30 years later. In 2015, they carried out over 500 000 alcohol breathalyzer tests with over 50 000 positive results. About 14 000 drug tests were carried out in 2014 with over 6 000 positive results. This data serves to highlight that there is a large problem of alcohol and drug use in Spain which needs to be focused on and, in particular, the behavior of drivers needs to be addressed in order to decrease the risk of injuries and fatalities. The General commented that the public is becoming increasingly aware of the risks of alcohol and drug use and that the risks involved whilst driving under the influence are immense.

Country Updates

Updates given on recent developments in four countries are summarized below.

1) United Kingdom – Mr Martin Ellis

Mr Ellis gave an update on the activities of the Drug Driving Team in the UK. The new drugdriving laws were introduced in England and Wales on the 2nd March 2015. Illegal drugs were given a zero tolerance approach, and medical drugs thresholds were set by an expert panel. Nationally the UK has seen a four-fold increase in the number of drivers charged. Whilst it is more expensive than alcohol testing, the wider benefits (time, disruption of other crime) are being seen with a 95% successful conviction rate in 2015 (compared with 52% in 2012). The next step will be to consider alternative non-invasive evidence e.g. Oral Fluid Samples (OFS) as well as rehabilitation courses.

- 2) Spain Dr Juan Carlos González Luque
 - Dr González-Luque began by presenting the magnitude of the problem in Spain. While the control of drink-driving is working effectively, with alcohol consumption in drivers being much less than in the general population, there is room for improvement in terms of drug-driving figures. Dr. González-Luque explained the "Double-Way" approach in Spain of having administrative laws which result in a fine of EUR 1000 and 6 points from the license as well as criminal laws which could lead to imprisonment, community service and the removal of the licence. The results have been positive and the Driving Under the Influence of Drugs, Alcohol and Medicines (DRUID) study 2008/2013 has shown an important reduction in drug-driving.
- 3) Canada Dr Douglas Beirness

Dr Beirness gave an update from Canada, presenting results from roadside surveys in Ontario with 10.2% being positive for the substances being tested. The introduction of *per se* limits is being considered and remains a challenge but will most likely be implemented for cannabis in light of the forthcoming legalization of cannabis which will have profound influence on road safety.

4) Netherlands – Professor Han de Gier

Professor Han de Gier presented updates from the Netherlands which has recently brought in new drug use and road safety legislation. Currently there are legal limits for alcohol but not for any other substance. Professor Han de Gier described the research of the expert working group brought on to look at limits for illicit drugs concerning impairment.

A summary of the presentations, discussions and feedback from the subsequent sessions shown in Appendix I is given below.

Estimate of road traffic fatalities associated with drug use

Professor Jürgen Rehm, Social and Epidemiological Research, Centre for Addiction and Mental Health, Ontario, Canada.

Professor Rehm commenced by giving a general background on comparative risk assessments and the generation of population attributable fractions (PAF) before presenting the assessment of causality for different drugs as a risk factor. He highlighted the estimates of deaths globally that are due to illicit drug use. Professor Rehm concluded that causality seems well established. He mentioned that even though the risk relations are based on fewer studies than alcohol, they remain relatively stable. Subsequent discussions and questions revolved around the use of benzodiazepines (BDZ), particularly amongst the elderly populations. It was suggested that roadside surveys should include all those drugs which are pertinent to their populations and that the risks of BDZ would be best assessed in Europe and other high-income countries. Professor Rehm reiterated that the issue of medications versus illicit drugs remains a difficult one which will need to be addressed. A discussion of the policy implications of these findings focused on the need to look closely at obtaining estimates on harm to others and on obtaining effectiveness and cost-effectiveness data in order to persuade policy makers. There was further discussion on cannabis policies in light of the data presented. A critical point raised was the need to obtain more data – particularly for non-fatal injuries - perhaps by carrying out multi-country studies on drug use and road safety.

Effects of drug use on the performance of drivers and other road users

Professor Marilyn Huestis, National Institute on Drug Abuse, Baltimore, Maryland

Professor Huestis provided a valuable insight into the effects of drug use on driver performance, explaining the four main circuits in the brain including the reward system involved in drug abuse and addiction. She explained how drug use leads to impairment of executive function and gave insight into how different drug classes affect the brain in differing ways through neurotransmitters. Professor Huestis also focused on cannabis and its clear effect on the brain (functionality and development) which is of great importance particularly in light of policies regarding its legalization and the effect of drugs in combination with alcohol. Research focusing on determining the concentration of THC in the blood that produced equivalent level of impairment as alcohol at the time of driving was presented. Professor Huestis also commented on the effects of sedatives, opioids, hallucinogens, stimulants and other medications on neurotransmitters and their subsequent effect on driving, cycling and walking. Discussions following the presentation focused on how to summarize the information presented for policy-makers.

Prevalence of drug use among drivers and other road users

Professor Guilherme Borges, Instituto Nacional de Psiquiatria, Mexico City, Mexico

Professor Borges' presentation focused on the prevalence of drug use among drivers, those involved in a crash and those killed in a crash. He commenced by explaining the methodological approaches: how the data was gathered, including the use of the population and roadside surveys. From roadside surveys it was found that the prevalence of any drug use ranged from 3.95% to 20% and the self-reported use from population surveys varied between 3.8% to 19% (mostly cannabis). Among persons involved in a crash that led to a medical intervention: any drug use (illicit and medical) ranged from 9.0% to 50.9%. Prevalence of drug use among persons killed in a crash: the lowest prevalence was 11.9% while the highest prevalence was 33.5%. He emphasized that a minimum set of standards for international research in roadside surveys should be adhered to and that this should include reporting practices on summary measures such as "any drug use". The issue of a lack of data on vulnerable road users was reiterated.

Risk of road traffic injury associated with the use of drugs

Professor Mark Asbridge, Department of Community Health & Epidemiology & Emergency Medicine, Dalhousie University, Canada

Professor Asbridge presented on the research focusing on the risk of road traffic injuries associated with the use of illicit and prescription drugs as well as new psychoactive substances and on how the combined use of different drugs and alcohol influences that risk. The risks for amphetamines, opioids, cocaine and cannabis were presented for those involved in fatal, non-fatal injuries and property-damage only. Data for prescription medications which showed significant risk after taking opioids, BDZ and sedatives was also presented. The use of multiple prescription drugs and the combination of alcohol with drug use was also shown to significantly

affect risk. Professor Asbridge commented on the numerous challenges in studies, particularly for prescription medicines and the limited data available for NPS. His closing recommendation was to use level 1 or level 2 designs in different populations of drivers, employing exposure assessment that adjust for confounders. There was a discussion surrounding the use of the term "minor risk" from a policy-maker's viewpoint and a suggestion to avoid this terminology. The importance of not minimizing the effect of cannabis on driving was reiterated particularly from a legislation point of view.

Testing of drugs in road traffic injury

Mr Martin Boorman, Road Policing Operations & Investigation Division, Victoria Police, Australia

This presentation focused on approaches and issues relating to the testing of drugs in road traffic injury settings - both at the roadside and in the emergency rooms of hospitals. Mr Boorman discussed several factors that need to be taken into consideration when approaching testing: legal context, duration of action, sensitivity/specificity, implementation, cost, and new psychoactive substances. He highlighted the four main measures of drug presence and their respective strengths and weaknesses (behavioural tests, urine, saliva and blood). Mr Boorman explained the nature of roadside testing and the differences between per se laws and impairment based laws and gave case study examples from Victoria, Australia, where both types of law are used in combination with good success. The final section of the presentation focused on emergency room testing and the various methodological challenges faced in this setting particularly with regards to types of drugs used, thresholds and time-lapse between use and examination. He commented on the ethical and legal considerations of screening in the emergency rooms. Mr Boorman concluded this section by talking about the need to consider brief interventions for illicit drugs in the emergency room setting. Subsequent discussions focused on the cost of testing which will be of paramount importance to policy makers and the need to provide estimates or case studies at the very least. Low-cost alternatives for low-and-middle income countries, such as drug-recognition programmes, were also brought up as an important point to consider and it was concluded that policy makers from these countries would need more guidance.

Interventions to address drug use and road traffic injury

Professor Jürgen Rehm, Social and Epidemiological Research, Centre for Addiction and Mental Health, Ontario, Canada

Professor Rehm provided a summary of the potential interventions to address drug use and road traffic injuries. He commenced by discussing legislation and policies with a main consideration being the intersection between legality and road safety considerations in terms of reaction times, psychomotor disturbances etc. Professor Rehm talked about the difficult distinction between prescription medications and illicit drugs particularly as *per se* laws do not distinguish between origin of drug. Whilst they seem to be the best approach for legislation, Professor Rehm raised the issues surrounding *per se* laws in terms of defining which drugs should be included, what the thresholds of single drugs should be and the thresholds and legal consequences of multiple drug use and combining with alcohol. The recommendation he suggested was:

"Countries should consider enforcing substance-related traffic safety legislation through roadside oral fluid testing by officers trained in recognizing drug impairment. This can then be confirmed through blood or accredited oral fluid laboratory analysis to satisfy the administrative and criminal justice system."

Professor Rehm continued with a discussion of restrictions on drivers licences particularly for recurrent offenders and those with certain medical conditions. He reiterated previous discussions on the need to involve the medical and health community in educating both physicians and pharmacists as well as the patients on how certain drugs would affect driving ability.

Discussion on emergent content, structure and length of potential policy brief

Professor Marilyn Huestis and Mr Martin Ellis

This session was led by Professor Marilyn Huestis and Mr. Martin Ellis. It became apparent over the course of the previous presentations that there was much overlap between the chapters and a significant amount of repetition. Professor Huestis and Mr. Ellis summarized the main points which had been brought up in the discussions and suggested a new format for the policy brief. The proposed revision would divide the brief into two main parts. Part 1 would focus on the main drug classes (stimulants, sedatives, cannabis, antihistamine drugs etc.). For each drug class information would be given on its effect on the brain, magnitude/burden/prevalence, and the injury risk for drivers, cyclists and pedestrians. Part 2 would focus on interventions beginning with setting the main goals (reducing deaths/injuries, integration into drug strategies, legislative goals i.e. zero tolerance/impairment/per se). This section would introduce the various types of legislation, methods of testing including tables with thresholds. A section on alternative intervention packages for different settings e.g. high-income and low- and middle-income countries was also suggested as an addition to the brief.

Feedback from Working Groups

Participants were divided into three working groups. Each group was assigned a question to discuss and report back on to the main group. The following is a summary of the findings of the three working groups:

a) What are the current thresholds for drugs in traffic and what actions are needed to standardize these thresholds?

Members from this group approached this question on thresholds regardless of legal considerations of substances, medications etc. Different threshold definitions were discussed including detection (based on equipment). The group looked at introducing new definitions of "identification" and "impairment" threshold. It was felt that we were not ready to put in place thresholds for impairment testing. Therefore, for practical purposes, there would need to be a simple presence/absence of drug that would be under the "identification" definition. *Per se* laws would need fixed thresholds to be able to deal with medications and illicit drugs separately.

b) How can testing of drug use in road traffic be improved?

This group took a broad approach to discussing testing. Primarily they looked at opportunities to improve testing based on location of testing:

- Emergency rooms perhaps not the most feasible but by teaching hospitals and academic centers there would be an opportunity to collect data. It was felt that health care professionals should be taught about drug use, its impact on driving and tested on this knowledge.
- Testing professional drivers big companies have facilities to test drivers before they start their shifts. This could be brought in to all companies and made mandatory.
- Costs of testing can be expensive screening devices/training/lab analysis/upkeep cost-benefit analysis could be taken into account. It was thought that it may be possible to pay for some of the testing through the taxes on certain substances such as alcohol and tobacco (e.g. Thailand).
- Apps on smartphones being used to bypass enforcement. Brings to discussion the difference between prevention (deterring people from taking drugs as they know that police checkpoints are nearby) and detection (thereby not allowing police checkpoints to be identified in the apps).
- Low- and middle-income countries police employed but next steps are important legislation needs to be active and not have gaps. The next question would be whether technology available to LMICs? Can we train police forces to do impairment detection in absence of saliva testing.

c) What minimum elements on drugs and driving should be included in the text in a road safety law?

This group began their discussions by asking the question: "Where do we see drug driving legislation in five years?" The question was answered with a convergence towards zero tolerance with devices in high-income and low- and middle-income countries particularly as technology becomes more affordable. It was agreed that there would still be a need for two parts of the law:

- Impairment law "driving with any psychoactive substance that adversely affects the ability to drive" this would require the officer to give evidence of impairment or medical opinion if they are medicines and confirmatory sample of some kind.
- A limits approach "driving with specified drug in the body above a specified limit". Some countries have specified drugs in their primary legislation but it was felt that ideally it would be best to do this in secondary legislation which would be easier to amend.

It was felt that the legislation should specify illicit drugs only within the limits of law and the rest would fall under the impairment law, for example, in Ireland.

Additional laws could be considered.

Main Action Points from the technical consultation – Dr Margie Peden, WHO

Dr Peden summarized deliberations of the two-day meeting, highlighting the main action points that had come out over the course of the presentations and discussions. Dr Peden commented on

several overarching issues which would need to be addressed during the preparation of the policy brief:

- Overall structure of the brief it was apparent from the immense amount of work done for each background working paper that there were large areas of overlap between the papers and that the brief would need to be restructured in order to minimize this.
- Consistency of data between the background working papers was also brought up as an issue that would need to be addressed as there were some areas where data conflicted between papers.
- The use of prescription drugs and the policy implications thereof was felt to be an area that would need more attention in the revised brief.
- The development and incorporation of case study boxes from different countries into the final document.
- Contextualizing the evidence and information for low- and middle-income and high-income countries by providing more data where possible and giving alternative recommendations.
- The effect of drug use on vulnerable road users was another major area where it was felt that more work was required.
- Multiple drug use and the combination of various drugs with alcohol was a topic which had been highlighted as needing more focus during the presentations.
- Education of patients by physicians and pharmacists was frequently highlighted as an important aspect of intervention programs and should be addressed as an option in the brief.

It was felt, given the nature of the document and the amount of information available that numerous outputs would be possible from this working group:

- A technical document¹
- A policy brief (3-5 pages) to be delivered by March 2016
- A fact sheets (1-2 pages) to be delivered by March 2016
- Academic papers stemming from the individual background working papers of the original draft brief².

Dr Peden stressed the importance of getting additional research done in this area particularly in low- and middle-income countries. Additional discussion revolved around the creation of a webpage on WHO website for the drug-driving data and perhaps a tool that would permit calculation of attributable risk fraction by geographical areas.

Closing Remarks

Dr Vladimir Poznyak, WHO, closed the meeting by thanking all those present for the immense amount of work that had gone into producing the draft policy brief. He reiterated the importance of this work in terms of the increasing burden and challenges presented by this issue including the changes in drug policies, the introduction of new substances and advances in technology. Dr Poznyak emphasized the need to build on the political commitment to address this issue. He also

¹ Instead of a technical report, this meeting report has been prepared with background working papers that what would have formed the technical report added as an appendix.

² Individual authors had not developed any journal papers from the background working papers by the time this meeting report was prepared.

pointed out that developments in the field of road safety and drug use need to be in parallel and harmony with developments in overall drug policies.

Dr Segui-Gomez, DGT, thanked participants for their dedication to supporting the preparation of a policy brief on drug use and road safety.

Dr Peden, WHO, urged everyone to keep the momentum going in order that the various outputs mentioned became a reality particularly with the Brasilia declaration in mind.

Appendix I: Agenda, Second Technical Consultation on Drug use and Road Safety, Mallorca, Spain, 16-17 December 2015

Wednesday, 16 December 2015								
08:45 - 09:15	Registration							
09:15 - 10:10	Welcome Brief remarks 	Dr María Seguí Gómez Dr Margaret Peden Dr Vladimir Poznyak General Benito Salcedo						
	 Adoption of meeting programme and objectives 	Dr Margie Peden						
	 Introduction of participants 	Dr Margie Peden						
	 Updates UK Drug Driving Team Policy Award Spain: recent developments in drug use and road safety legislation Canada: recent developments in drugs and driving Add any updates participants suggest 	Mr Martin Ellis Dr Gonzalez-Luque Dr Douglas Beirness						
	 Approach to developing the policy brief 	Dr Melecki Khayesi						
10:10 - 10:30	TEA/COFFEE BREAK							
Objective 1: To de draft zero chapter Chair: Dr Margie	evelop a draft policy brief on drug use and road safety by rev s Peden	iewing and consolidating						
10:30 - 11:30	Estimate of road traffic fatalities associated with drug use	Professor Jürgen Rehm						
11:30 - 12:30	Effects of drug use on the performance of drivers and other road users	Professor Marilyn Huestis						
12:30 - 13:30	LUNCH							
<i>Objective 1 (contil Chair: Professor (</i>	nued) G. Gururaj							
13:30 - 14:30	Prevalence of drug use among drivers and other road users	Professor Gui Borges						
14:30 - 15:30	Risk of road traffic injury associated with the use of drugs	Professor Mark Asbridge						
15:30 - 16:30	Testing of drugs in road traffic injury	Mr Martin C. Boorman						
16:30 - 17:30	TEA/COFFEE BREAK/PREPARATION FOR EVENING EVENTS							
17:30 - 21:00	Visit a drug testing site and participate in a guided tour of							

	Mallorca, ending with "Tapas" dinner .							
Thursday, 17 December 2015								
Objective 1 (cont	inued)							
Chair: Dr Vladin	nir Poznyak							
08:30 - 9:30	Interventions to address drug use and road traffic injury	Professor Jürgen Rehm						
9:30 - 10:30	Discussion on emergent content, structure and length of report	Professor Marilyn Huestis and Mr Martin Ellis						
10:30 - 11:00	TEA/COFFEE BREAK							
Objective 2: To d	levelop a framework for future work on drug use and road	l safety						
Chair: Dr Anesh	Sukhai							
11:00 - 12:30	 Working groups What are the current thresholds for drugs in traffic and what actions are needed to standardize these thresholds? 	Dr María Seguí Gómez (moderator)						
	• How can testing of drug use in road traffic be improved?	Mr Martin C. Boorman (moderator)						
	• What minimum elements on drugs and driving should be included in the text in a road safety law?	Mr Martin Ellis (moderator)						
12:30 - 13:30	LUNCH							
13: 30 - 14:30	Report back from working groups	Working group moderators and/or rapporteurs						
14:30 - 15:30	Presentation of main action points from the meeting	Dr Margie Peden						
15:30 - 16:00	Conclusion	Dr Vladimir Poznyak Dr María Seguí Gómez Dr Margie Peden						

Appendix II: List of Participants, Second Technical Consultation on Drug use and Road Safety, Mallorca, Spain, 16-17 December 2015

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Appendix III: Background papers presented at the Second Technical Consultation on Drug use and Road Safety, Mallorca, Spain, 16-17 December 2015

This appendix contains five unedited background papers that were considered at the meeting.

How does drug use impair driving? (Marilyn Huestis) Prevalence of drug use among drivers (Gui Borges, Horst Schulze, Enying Gong) Risk of road traffic injury associated with the use of drugs (Mark Asbridge, Rune Elvik) Testing of drugs in road traffic injury (Robert E. Mann, Anesh Sukhai, Martin C. Boorman) Interventions to address drug use and road traffic injury (Jürgen Rehm, Robert E. Mann, Martin Ellis and María Seguí Gómez) Conclusions (Elizabeth Reed and Meleckidzedeck Khayesi)

Effect of drug use on the performance of drivers and other road users

Marilyn A. Huestis

Introduction

Psychoactive drug use affects the functioning of the brain and may lead to impaired driving, for example, by delaying reaction time and information processing, reducing perceptual-motor coordination and motor performance, as well as attention, road tracking and vehicle control. This chapter evaluates the effects of different classes of drugs including cannabis, sedatives, opioids, hallucinogens, stimulants, and anti-depressants on driving, cycling and walking. Most impairing effects involve changes in perception, cognition or psychomotor function and observable changes in behavior, which are driven by changes in neurotransmitter synthesis, release and reuptake and availability of receptors for stimulation or inhibition. Communication in the central nervous system is through transmission of action potentials along neurons that must be converted into chemical messages between neurons. Neurotransmitters are the chemical messengers that carry the information across synapses between nerve cells. These may be excitatory (increasing the ability to produce action potentials) or inhibitory (decreasing the ability to transmit electrical signals or impulses between neurons).

Approaches to determining the effects of drug use on the performance of drivers

There are multiple approaches for determining the effects of drug use on the performance of drivers and other road users, each with their own advantages and disadvantages as indicated in Table 2.1. Phase I controlled drug administration studies are conducted in laboratory settings in healthy normal controls (licit pharmaceuticals and over the counter medications) and in drug users (for illicit drugs). Other sources of data on the effects of drugs come from driving simulators. These studies offer many of the advantages of controlled laboratory studies and include behaviors closely related to authentic driving requirements. On-the-road driving studies more closely resemble authentic driving, but also are limited by doses that can be administered, have somewhat less control over the environment, and are also challenged by face validity issues. Epidemiological studies provide excellent data on the prevalence of drugged driving, but are expensive and difficult to perform, lack control over the driving environment, require large numbers of subjects and adequately selected controls to achieve statistical significance, and have more constraints on the types and numbers of biological specimens that can be collected. Culpability studies that require determination of percent of crash culpability without knowing drug test results provide excellent data on drug effects on driving performance, but they are expensive and difficult to conduct, and have a major challenge in obtaining enough cases with only a single drug present to adequately evaluate the drug's effects.

Table 2.1

Advantages and disadvantages of approaches for determining effects of drugs on driver performance

Pro in the		
Approach	Advantages	Disadvantages
Phase I controlled drug administration studies	 Can evaluate effects of drug dose and route of drug administration, participant population, timing of events, collection and analysis of parameters and biological specimens Tightly controlled environment thereby increasing sensitivity or statistical power to detect impairment 	 Ethical and safety concerns on maximum dose administered (usually less than drivers might self-administer) Face validity of evaluated tasks (i.e. degree to which the tasks reproduce authentic driving experiences)
Driving simulator studies	 Offer many of the advantages of controlled laboratory studies Include behavior closely related to authentic driving requirements 	 Limited by the doses administered Sophistication of simulator varies Drivers' risk perception is altered May not reflect authentic driving conditions
On-the-road driving studies	 Most closely resembles authentic driving conditions 	 Limited by the doses administered Less control over environment Participant knowledge of safety net (second driver and additional set of driving controls)
Epidemiological studies	• Excellent data on prevalence of drugged driving	 Expensive Difficult to perform Lack of control of driving environment Requires large numbers of subjects and adequately selected controls to achieve statistical significance More constraints on types of biological specimen that can be collected
Culpability studies	• Determination of crash responsibility percentage without knowing drug testing results	 Expensive Difficult to conduct Challenges in obtaining enough single drug cases to adequately evaluate a drug's effects

Classes of drugs and their impairment effects on drivers

There are many neurotransmitters in the brain that affect behaviour and physiological functions. Dopamine is a neurotransmitter that provides feelings of pleasure and satisfaction associated with desirable food or sex, or illicit drugs. However, dopamine also effects movement, and motivation.

Norepinephrine increases heart rate and contracts blood vessels to increase blood flow to the muscles and oxygen to the lungs, leading to heightened awareness and attention. Serotonin contributes to feeling good and regulating sleep. Acetylcholine is involved in thought, learning and memory, attention, and sensory perception. Gamma-aminobutyric acid (GABA) is the major inhibitory neurotransmitter of the brain. GABA release makes it more difficult for neurons to fire, increasing relaxation and sedation, and effecting motor control and vision. Glutamate is excitatory and the most common neurotransmitter in the brain. Glutamate is important for cognitive function and regulation of brain development. Excess glutamate is toxic to neurons. The mechanisms of most drug actions occur through modulations of neurotransmitter function.

Δ 9-tetrahydrocannabinol

The most common drug other than alcohol identified in drug-driving cases and deaths in most countries is $\Delta 9$ -tetrahydrocannabinol (THC), the primary psychoactive substance in cannabis or marijuana. The endogenous cannabinoid system in our brains is critically important for executive function i.e. receiving, integrating and processing sensory information from our environment and making sound decisions based on this information. Executive function involves multiple brain areas but is coordinated by the prefrontal cortex. Other critical functions of the endogenous cannabinoid system that affect driving performance include psychomotor function (basal ganglia and cerebellum), memory and learning (hippocampus), and the source of the euphoria, panic and dysphoria that follows cannabis intake, the emotional center of our brains, the amygdala. When an individual uses cannabis, THC stimulates cannabinoid receptors in the brain, primarily CB1cannabinoid receptors in the basal ganglia (critical for initiating and planning movement), the cerebellum (important for ongoing movement) and the corticolimbic areas (altering cognition). THC hijacks the normal function of the endogenous cannabinoid system that may result in cannabis-impaired driving, cycling or walking. Cannabis impairs cognition, lateral vehicle control or weaving within the traffic lane, time estimation (important for monitoring stopping and maintaining distance between vehicles), balance, decision making, divided attention, sustained attention and other critical driving tasks.

Ramaekers et al (2004) concluded that the degree of performance impairment in experimental studies after 21 mg THC were equivalent to the impairing effect of 0.05% alcohol, the legal limit for driving under the influence in most European countries. Significant performance impairment emerged at serum THC concentrations >2 μ g/L and crash risk at 4–10 μ g/L. Combined THC and alcohol use produced severe driving impairment and sharply increased the risk of drivers' accident culpability as compared to drug-free drivers, even at low doses. THC-positive drivers, particularly following high doses, were 3-7 times more likely to be responsible for their crash as compared to drivers that had not used drugs or alcohol. Further studies (Ramaekers et al 2006) defined performance impairment as a function of serum THC to provide a scientific framework for developing per se limits for driving under the influence of cannabis. Twenty cannabis users smoked 0, 250 and 500 μ g/kg THC and completed performance tests measuring skills related to driving up to 6 hours after smoking including measures of perceptual-motor control (critical tracking task), motor impulsivity (stop signal task) and cognitive function (Tower of London). Blood was collected prior to and up to 6 h post dose. There was a poor relationship between magnitude of performance impairment and serum THC. Defining threshold impairment by comparing the proportion of observations showing impairment or no impairment as a function of THC concentration produced better results that progressively increased with serum THC in every task. Binomial tests showed a significant shift toward impairment in the critical tracking task for serum THC concentrations between 2 and 5 µg/L, and at 5 and 10 µg/L 75-90% of observations indicated significant impairment in all performance tests.

Elvik (2013) conducted a systematic review and meta-analysis of 42 studies assessing the risk of

crashes following cannabis use. All estimates indicated that the use of drugs was associated with an increased odds ratio of becoming involved in a crash. Cannabis use during driving had a significant increase in odds ratio (1.48, 95% CI 1.28-1.72) on crashes involving property damage, but not for the risk of fatal and serious injury crashes. They noted that estimates of the effects of drug use on crash risk tended to be smaller in well-controlled studies. However, Li et al 2013 estimated the odds ratios of fatal crash involvement for cannabis as 3.03 (95% CI: 2.00, 4.48). Drivers who tested positive for both alcohol and drugs were at substantially heightened risk relative to those using neither alcohol nor drugs (odds ratios 23.24; 95% CI: 17.79, 30.28). These results indicated that drug use was associated with a significantly increased risk of fatal crash involvement, particularly when used in combination with alcohol.

Gjerde et al. (2015) evaluated the association between self-reported driving under the influence of cannabis with road traffic crashes of previously reported studies. The DRUID case-control studies published by Bernhoft et al. 2012 and Hels et al. 2013 found a significant association between THC and road traffic crash injuries (odds ratio 1.91, 95% CI 1.15–3.17), but no statistically significant association with fatal road traffic crashes (odds ratio 1.25, 95% CI 0.45–3.51). The Belgian DRUID component reported a high odds ratio of 13.40 (95% CI 3.95–45.42) for road traffic crash injuries. Li et al. 2013 and Romano et al. 2014 found significant crude odds ratios of 1.83 (95% CI 1.39–2.39) and 1.55 (95% CI 1.42–1.94), respectively.

Cannabis' effects on driving are the best studied effects of non-alcohol drugs, with a general consensus from laboratory, simulator, on the road driving, and many epidemiological studies indicating an approximate two-fold increase in injury or fatal road traffic crashes with quantifiable blood THC, increasing with increasing THC concentration. However, there are epidemiological case-control studies that do not support an increase in odds ratio with THC exposure after adjusting for age, gender, ethnicity, and presence of alcohol; therefore, the debate continues (Compton and Berning, 2015; Schulze et al).

Depressants

Depressants or sedatives are a class of drugs that produce significant driving impairment including drowsiness, cognition impairment, decreased motor function, and respiratory depression. Barbiturates, benzodiazepines, zolpidem and zopiclone, carisoprodol and meprobamate are examples of sedative agonists that act on GABA A G-protein chloride ion channels receptors in the brain and inhibit neural transmission. Alcohol and barbiturates demonstrate linear increases in GABA A effect with increasing concentrations. GABA B receptor agonists increase potassium efflux and calcium influx at the cell level. Baclofen is a medication that works through the GABA B receptor to reduce muscle spasticity.

Benzodiazepines

Benzodiazepines replaced the more toxic barbiturates for treatment of anxiety, insomnia, spasticity, epilepsy, and pre-anesthesia amnesia due to a lower maximum effect. Tolerance to benzodiazepines occurs over time, reducing the potential for drug-drug interactions. During the first two weeks of treatment, these highly effective medications may increase crash risk at therapeutic concentrations. Bramness et al (2003) studied the effectiveness of 25 components of the Norwegian clinical test for impairment for identifying benzodiazepine driving performance impairment (Bramness 2003). The Romberg test, orientation to time and place, motor and coordination tests (walk and turn, finger- to-nose and finger-to-finger tests), speech articulation and content, and general conduct and appearance were related to blood benzodiazepine concentrations. Benzodiazepine clinical effects include anxiolysis, sleep induction, muscle relaxation, anti-convulsant, and memory loss during anesthesia. However, these are accompanied by negative effects on cognition and driving

impairment with an increased risk of crash. Dasanayake et al. (2011) reported a significant increase in the risk of traffic crashes and responsibility of drivers for crashes in younger drivers on benzodiazepines, and much higher risk following co-ingestion of alcohol (OR 4.83 (95% CI: 3.18, 7.21) for depressants, increasing to 23.24; 95% CI: 17.79, 30.28) if alcohol also was present) (Li et al 2013). Comparison of prescription and road traffic crash databases reported increased crash risk during the first seven days after the start of benzodiazepine therapy for tranquilizers (standardized incidence ratio [SIR] of 2.9, 95% CI 2.5–3.5) and hypnotics (SIR 3.3, 95% CI 2.1–4.7) (Engeland et al 2007). A similar increased risk was observed for patients starting to use diazepam (SIR 2.8, 95% CI 2.2–3.6) (Bramness et al 2007).

Opioids

Opioids, another depressant class, are agonists at μ , κ and δ G_i-inhibitory receptors, producing euphoria, analgesia, sedation, respiratory depression, and miosis. Opioids can impair driving performance, based upon the type of opioid, the dose, and frequency of opioid intake, due to potential tolerance development (Walsh et al 2004). In the DRUID case-control studies, the odds ratio for being injured after medicinal opioids was 7.37 (95% CI 4.99–10.88) and for dying after opioid intake, 4.07 (95% CI 2.14–7 (Gjerde et al 2015). The odds ratio was not statistically significant for injured drivers following illicit opioid intake, but for killed drivers, it was 10.04 (95% CI 2.04–19.32). Gjerde et al 2015 found 17 of 25 epidemiological studies of opioids effects on driving showed statistically significant associations between opioid use and road traffic crashes (Gjerde 2015). Results were mixed in case-control and culpability studies, but three cohort studies found significant associations between prescribed opioids (with the exception of tramadol) and crash risk. Elvik (2013) reported significantly increased odds ratios (1.94-4.76) in 26 studies, and Li et al (2013) estimated odds ratios of fatal crashes after narcotics of 3.57 (95% CI: 2.63, 4.76).

When Norwegian prescription registries were matched to road traffic crashes increased risk for road traffic crashes were found for patients using natural opium alkaloids (SIR 2.0, 95% CI 1.7–2.4) (Engeland et al. 2007). Later, significant increased road traffic crash risk was noted for codeine (SIR 1.9, 95% CI 1.6–2.2) but not tramadol (SIR 1.5, 95% CI 0.9–2.3) (Bachs et al. 2006). Male but not female opioid maintenance treatment patients had increased road traffic crash risk (SIR 2.4, 95% CI 1.5–3.6) following methadone (Bramness et al. 2012). In the European DRUID case-control studies, there was a 7.37 (95% CI 4.99–10.88) odds ratio for being injured after using medicinal opioids and 4.07 (95% CI 2.14–7.72) for being killed (Hels et al 2011, Bernhoft et al 2012). For illicit opiates, the odds ratio was not statistically significant for injured drivers, whereas for killed drivers, the odds ratio was 10.04 (95% CI 2.04–19.32). However, impairment was observed for several hours after heroin use, beyond the time for measureable heroin and 6-acetylmorphine in blood (Bachs et al 2006).

Other drugs

Fewer data are available for other sedative compounds. Two of three reports on antihistamines found no association between use and road traffic crashes, while the third showed a modest increased risk (McDonald, Trick, Boyle 2008; Vuurman E, Vuurman L, Lutgens I, Kremer 2014; Theunissen, Vermeeren, Vuurman, Ramaekers 2006). Mydriasis can follow intake of antihistamines, atropine-like drugs, tricyclic antidepressants and antipsychotics. Hypnotics are prescribed to 3-7% of adults and results on their association with motor vehicle crashes was mixed. More drivers were judged impaired with higher zopiclone than zolpidem concentrations; however, there were few low concentrations for either drug, potentially obscuring a significant positive relationship (Gustavsen et al 2009). Drivers with blood zopiclone concentrations >130 µg/L had similar impairment to drivers with BACs > 0.1%; there was no significant adjusted odds ratio increase for zolpidem. However, others found a significant increased odds ratio for zopiclone of 4.0

for property damage only (Elvik 2013), and a SIR 3.3, 95% CI 2.1–4.7 for hypnotics (Gjerde et al 2015, Engeland et al 2007). No significant increase in odds ratios for analgesics was reported and a 1.31 significant increased odds ratio for anti-asthmatics was noted (Elvik 2013). Ketamine, nitrous oxide and xenon act predominantly as N-methyl-D-aspartate (NMDA) receptor antagonists, inhibiting excitatory neurotransmission of this glutamate gated cation channel (Meerts et al 2013).

Hallucinogens produce driving impairment including psychosis, agitation, mood changes, nightmares, catatonia and ataxia. These mental and cognitive disturbances are not compatible with safe driving practices. 5HT2A agonists (tryptamines, psilocin, phenethylamines [mescaline], ergolines [LSD], serotonin releasing agents, and CB1 receptor cannabinoid agonists) are psychedelic hallucinogens. NMDA antagonists, PCP, ketamine and dextromethorphan are dissociative hallucinogens.

Ketamine was shown to significantly distort self-body and environmental perceptions, alter eye movement, visual perception, time estimation, divided attention, reaction time, ability to adapt to changing conditions, and decreased ability to track the road and associated objects (Giorgetti et al. 2015). No driving simulator or real driving environment data are available for ketamine. Effects were dependent on dose and, at sub-anesthetic doses, lasted for about 2.5 h. Ketamine use was characterized by dilated pupils, blood shot eyes, lack of convergence, horizontal gaze nystagmus, unsuccessful walk-and-turn and one-leg stand tests. When ketamine and amphetamine were combined, amphetamine attenuated the ketamine-induced working memory impairment, but increased euphoria, arousal, and thought disorder.

A single experimental dose of less than 20 mg PCP resulted in severe cognitive and psychomotor function for about 14 h (EMCDDA). Arrested PCP users were incapable of performing or failed the standard field sobriety tests including the Romberg test, finger-nose test, one leg stand and reciting the alphabet. Blood shot eyes, slurred speech, and staggering also were observed. Symptoms did not correlate with blood PCP concentrations of 21 to 203 μ g/L. PCP also was identified in 1.5 and 3.1% of injured motor vehicle and motorcycle drivers, respectively (Poklis et al 1987).

An interesting recent case report described driving under the influence of the dissociative anesthetic methoxydiphenidine (MXP), an NMDA antagonist. Amnesia, out-of-body experiences, bizarre behavior, and decreased motor abilities were observed (Stachel et al 2016). A 33-year-old man crashed into a railway-crossing gate and damaged a wall while driving erratically. Serum concentrations of 57 μ g/L MXP, 111 μ g/L amphetamine, 28 μ g/L MDMA and 3 μ g/L MDA were found. Amnesia, out-of-body experiences, bizarre behavior, and decreased motor abilities were observed. To date, there are no human data on MXP toxicity, or on the duration and intensity of its impairing effects. Due to MXP similarity in structure and action to PCP and ketamine, it is likely that MXP exerts similar severe psychotropic action in man due to its antagonism at the NMDA receptor.

Stimulants increase dopamine, norepinephrine and/or serotonin concentrations in the synapse between neurons. Dopamine increases euphoria, but also motor incoordination. Serotonin increases can produce hallucinations, hyperthermia, and sweating. The novel psychoactive substances, synthetic cathinones, and amphetamine and methamphetamine increase dopamine and norepinephrine more than serotonin and their intake is characterized by agitation, anxiety and seizures, while MDMA produces similar symptoms but increases serotonin more than norepinephrine and dopamine. High amphetamines concentrations effect self-perception, critical judgment, and risk taking; however, fatigue, anxiety, and irritability also follow stimulant use. Crash risk may be increased during the stimulated and fatigue periods after high stimulant doses.

Following high abused methamphetamine doses, performance deficits on complex psychomotor tasks and increased risk-taking were observed. Significant increased odds ratios for amphetamine (Terhune et al 1992) and other stimulants (Drummer et al 2004) were described. In 878 amphetamine-only impaired driving cases, hypersomnolence might occur after the end of binge amphetamine use (Gustavsen et al 2006). A significant correlation was observed for amphetamine blood concentrations, up to a 0.27–0.53 mg/L ceiling. Young drivers were more frequently identified as impaired compared to older drivers at these concentrations. In some low dose laboratory experiments, amphetamines were performance enhancing; however, these investigators documented a positive concentration-effect relationship between blood amphetamines concentration and traffic related impairment. Chronic abuse of amphetamines also may produce cognitive damage due to alterations in brain function.

In the European DRUID case-control studies, amphetamines alone were associated with adjusted odds ratios of 14.15 95% CI 5.82–34.42) for being injured and 34.34 (95% CI 13.18–89.49) for being killed (Gjerde et al 2015). In 508 drivers' blood samples from those killed in Norwegian road traffic crashes from 2003–2010, adjusted odds ratios of 20.9 (95% CI 7.3–60.0) and 41.6 (95% CI 12.6–137.1) after only amphetamine or methamphetamine intake were found, while odds ratios increased to 76.9 (95% CI 38.7–152.9) for amphetamines with or without other substances (Gjerde et al 2015). In 11 amphetamines studies, there were significant increases in odds ratio of 5.61-8.67 for fatal, injury and property damage crashes, while cocaine only cases had an odds ratio of 2.96 only for fatal crashes (Elvik 2013). Several studies found amphetamine and methamphetamine posed the highest road traffic crash risk of all drugs, including when they were not combined with other psychoactive substances (Elvik 2013; Gjerde et al. 2015).

Effects of cocaine on road traffic crashes were investigated in 9 epidemiological studies (Elvik 2013). A significant association between cocaine use and crashes was found in 5 studies, while 4 did not find a significant effect, however 3 were of low statistical power. Odds ratios were generally lower than those reported for amphetamines. The estimated odds ratios for fatal crashes were 3.57 (95% CI: 2.63, 4.76) for stimulants (Li et al 2013).

Anti-depressants

First generation tricyclic anti-depressants were generally impairing based on controlled experimental studies, especially in older drivers. Newer generation anti-depressants do not appear to interfere with performance except at higher doses (National Transport Commission, Austroads, 2012). Increased crash risk associated with Tricyclic anti-depressants may become insignificant after about 2 weeks treatment due to tolerance development (Verster et al. 2015). In 8 of 13 epidemiological antidepressant studies, there was a statistically significant association for antidepressants and road traffic crashes; only one investigation showed a small risk increase for selective serotonin reuptake inhibitors (SSRIs), but not for tricyclic antidepressants (Gjerde 2015). Elvik also showed a significant increase in odds ratios for crash injuries by anti-depressants of about 1.39 (1.17, 1.70) (Elvik 2013).

Conclusion

Both licit pharmaceuticals and illicit drugs may cause changes in cognitive effects (knowing, thinking, judging, evaluating and planning), and psychomotor effects (coordination, reaction time, motor skills, and tracking). The odds ratio for having a motor vehicle fatality or injury may increase, making it unsafe to operate a vehicle or other complex equipment while under the influence of drugs. The effects of different classes of drugs including cannabis, sedatives, opioids, hallucinogens, stimulants, and anti-depressants on driving, cycling and walking were reviewed, as

well as the advantages and disadvantages of different methods to study drug effects on driving. Drugs produce their effects by increasing or decreasing the release or binding of neurotransmitters to their specific receptors in the brain or body, changing human behavior, physiology and/or other function. Drug dose and route of administration, time after use, interactions with endogenous neurotransmitters or other exogenous drugs, disease, age and other factors are important to the final effects on driving. Prescribing physicians and the public needs to be knowledgeable about the effects of therapeutic drugs and use of illicit substances on driving performance.

References

- Assessing fitness to drive for commercial and private vehicle drivers, medical standards for licensing and clinical management guidelines. National Transport Commission, Austroads, 2012.
- Bachs L, Høiseth G, Skurtveit S. Heroin-using drivers: importance of morphine and morphine-6-glucuronide on late clinical impairment. Eur J Clin Pharmacol 62:905–912; 2006.
- Bernhoft IM, Hels T, Lyckegaard A, Houwing S, Verstraete AG: Prevalence and risk of injury in Europe by driving with alcohol, illicit drugs and medicines; Procedia Soc Behav Sci 48:2907; 2012.
- Bramness JG, Skurtveit S, Mørland J, Engeland A: An increased risk of motor vehicle accidents after prescription of methadone; Addiction 107:967; 2012.
- Bramness JG, Skurtveit S, Mørland J, Engeland A: The risk of traffic accidents after prescriptions of carisoprodol; Accident Anal Prev 39:1050; 2007.
- Bramness JG, Skurtveit S, Mørland J. Testing for benzodiazepine inebriation--relationship between benzodiazepine concentration and simple clinical tests for impairment in a sample of drugged drivers. Eur J Clin Pharmacol. 59:593-601; 2003.
- Compton, R. and Berning, A. (2015) Drug and Alcohol Crash Risk. (NHTSA, Publication No. DOT HS 812 117), Washington, DC.
- Dasanayake T, Michie P, Carter G, Jones A. Effects of benzodiazepines, antidepressants and opioids on driving: a systematic review and meta-analysis of epidemiological and experimental evidence. Drug Saf. 34:125-56; 2011.
- Drummer OH, Gerostamoulos J, Batziris H, Chu M, Caplehorn J, Robertson MD, Swann P. The involvement of drugs in drivers of motor vehicles killed in Australian road traffic crashes. Accid Anal Prev 36:239-48; 2004.
- Elvik R: Risk of road accident associated with the use of drugs: A systematic review and metaanalysis of evidence from epidemiological studies. Accid Anal Prev 60:254-267;2013.
- Engeland A, Skurtveit S, Mørland J: Risk of road traffic accidents associated with the prescription of drugs: a registry-based cohort study; Ann Epidemiol 17:597; 2007.
- Giorgetti R, Marcotulli D, Tagliabracci A, Schifano F. Effects of ketamine on psychomotor, sensory and cognitive functions relevant for driving ability. Forensic Sci Int. 252:127-42; 2015.
- Gjerde H, Strand MC, Mørland J. Driving Under the Influence of Non-Alcohol Drugs An Update Part I: Epidemiological Studies. Forensic Sci Rev 27:89; 2015.
- Global status report on road safety 2015. Geneva: World Health Organization, 2005.
- Gustavsen I, Al-Sammurraie M, Mørland J, Bramness JG. Impairment related to blood drug concentrations of zopiclone and zolpidem compared to alcohol in apprehended drivers. Accid Anal Prev. 41:462-6; 2009.
- Gustavsen I, Mørland J, Bramness JG. Impairment related to blood amphetamine and/or methamphetamine concentrations in suspected drugged drivers. Accid Anal Prev. 38:490–495; 2006.
- Hels T, Bernhoft IM, Lyckegaard A, Houwing S, Hagenzieker M, Legrand SA, Isalberti C, van der Linden T, Verstraete A: Risk of injury by driving with alcohol and other drugs. DRUID Deliverable D 2.3.5.; Technical University of Denmark: Copenhagen, Denmark; 2011; http://www.druid-project.eu/Druid/EN/deliverales-list/downloads/Deliverable_2_3_5.pdf (accessed December 11, 2015).
- Li G, Brady JE, Chen Q. Drug use and fatal motor vehicle crashes: A case-control study. Accident Anal Prev. 60:205-10;2013.
- McDonald K, Trick L, Boyle J. Sedation and antihistamines: an update. Review of inter-drug differences using proportional impairment ratios. Hum Psychopharmacol Clin Exp. 2008;23(7):555–570. doi: 10.1002/hup.962.
- Meerts C, Absalom A. Anxiolytics, sedatives and hypnotics. Anesthesia and Intensive Care Medicine. 14:8;2013.

- Poklis A, Maginn D, Barr JL. Drug findings in 'driving under the influence of drugs' cases: a problem of illicit drug use. Drug Alcohol Depend 20:57–62;1987.
- Ramaekers JG, Berghaus G, van Laar M, Drummer OH. Dose related risk of motor vehicle crashes after cannabis use. Drug Alcohol Depend. 73:109-19; 2004.
- Ramaekers JG, Moeller MR, van Ruitenbeek P, Theunissen EL, Schneider E, Kauert G. Cognition and motor control as a function of Delta9-THC concentration in serum and oral fluid: limits of impairment. Drug Alcohol Depend. 85:114-22; 2006.
- Schulze H, Schumacher M, Urmeew R, Auerbach K, Federal Highway Research Institute. Final Report: Work Performed, Main Results and Recommendations. Project No: TREN-05-FP6TR-S07.61320-518404-DRUID.
- Stachel N, Jacobsen-Bauer A, Skopp G. A methoxydiphenidine-impaired driver. Int J Legal Med. 130(2):405-9; 2016.
- Terhune KW, Ippolito CA, Hendricks DL, Michalovic JG, Bogema SC, Santinga P, Blomber R, Preusser DF. 1992. The Incidence and Role of Drugs in Fatally Injured Drivers. US Department of Transportation, National Highway Traffic Safety Administration, Washington.
- Theunissen EL, Vermeeren A, Vuurman EF, Ramaekers JG. Stimulating effects of H1-antagonists. Currently Pharm Des. 12(20):2501-9; 2006.
- Verster JC, van de Loo AJ, Roth T. Mirtazapine as positive control drug in studies examining the effects of antidepressants on driving ability. <u>Eur J Pharmacol.</u> 2015 Apr 15;753:252-6.
- Vuurman E, Vuurman L, Lutgens I, Kremer B (2014). Allergic rhinitis is a risk factor for traffic safety. Allergy 69(7): 906–912.
- Walsh JM, de Gier JJ, Christopherson AS, Verstraete AG. Drugs and driving. Traffic Inj Prev. 5:241-53; 2004.

Prevalence of drug use among drivers and other road users

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Introduction

The objective of this chapter is to give an overview on the prevalence of drug use among drivers and other road users. But when it comes to matters of road safety, two aspects have to be considered: the prevalence of psychoactive substances in traffic and the risk associated with driving under the influence of these substances. A psychoactive substance that is prevalent in traffic does not always cause an increase in road traffic injuries. Similarly, a psychoactive that is not very prevalent in traffic but cause significant impairments can lead to an increase in road traffic injuries. An overview of the available studies is presented with a focus on the European research project Driving Under the Influence of Drugs, Alcohol and Medicines (DRUID) (Schulze, Schumacher, Urmeew and Auerbach, 2012).

Prevalence of drug use among drivers

Two approaches are currently used to estimate the number of people that use drugs and drive: the population survey and the roadside survey.

Roadside surveys are used to estimate the frequency of driving a motor vehicle after consuming substances other than alcohol (drug-driving) by selecting a random sample of all drivers who are not involved in a traffic-crash at the time of the survey during all days and times, at selected locations. A person has to be driving to be selected and a biological specimen sample (saliva, blood or urine) is taken to test the type and level of substances present in his or her body. No self-reported data are used to classify driving and drug use. The sampling methods vary among surveys leading to challenges in the interpretation and comparison among surveys. For example, in some surveys, only weekend nights (or other limited periods of time) are surveyed. Targeting selected group of drivers (for example, truck or commercial drivers) on specific days (Friday) and times (night) on a federal highway may be required for police purposes, however such non-random samples do not give a representative estimate of the number and relative size of the drug-driving population. Having a sample that is representative of the driver's population is needed to estimate the size of the problem and it is also gives a baseline for later estimating measures of association (relative risk) between drug-driving and crash injury or death. Box 3.1 describes how roadside surveys were conducted in the DRUID project.

Box 3.1

A roadside survey in DRUID project

Between January 2007 and July 2009 roadside surveys were conducted in 13 European countries (Belgium, Czech Republic, Denmark, Spain, Italy, Lithuania, Hungary, the Netherlands, Poland, Portugal, Finland, Sweden, Norway) according to a set of guidelines to ensure their comparability (Houwing et al., 2011). In total approximately 50 000 drivers gave a saliva or blood sample or both.

For each country, one or more regions were selected which were representative with regard to substance use and traffic distribution. At selected survey locations in these regions, drivers were

stopped at random from flowing traffic by the aid of the police. The sample was stratified into eight time periods over the week, for each of the survey areas. These time periods did not overlap and covered all days of the week and all times of the day.

After drivers were breath tested for alcohol by a police officer, they were asked to participate in the study on a voluntary basis. In some countries written informed consent was mandatory. Having agreed to participate, non-identifying information was gathered (e.g. age, gender, type of vehicle) and a saliva and/or blood sample collected by the research team. Collection, storage and lab analysis of samples was controlled and standardized. Blood and saliva samples were analysed in all countries for the same substances: alcohol, amphetamines, benzodiazepines, cannabis, cocaine, illicit opiates, medicinal opioids and Z-drugs. To achieve agreement on what should be recorded as a 'positive' sample, an analytical cut-off was defined for each substance based on the lowest limit of quantitation that could be measured by all toxicological laboratories involved in the analyses. Later in the analyses equivalent cut-offs in blood and saliva were used to be able to include data of blood and of saliva samples.

The study design of such surveys is challenging and include issues related to sampling from an unknown or ill-defined car population, a large number of roads and at-risk intersections, times of the day with larger or lower car concentrations and non-conventional hours and days of the week where the traffic concentration changes. After defining the sampling frame, logistic problems are faced related to stoping cars in streets, obtaining informed consent and collaboration from busy drivers and setting-up a convenient space for obtaining, keeping and delivering to labs samples of biological specimens . Finally, up-to-date equipment for measuring different drugs is needed. Such complexities and costs involved in roadside surveys explain why there are so few of such surveys in the international arena, and why they are mostly concentrated in developed, high-income countries. Nevertheless, some examples in low-and-middle income countries are currently available.

While one of the first roadside surveys for drug-driving was done by Krueger and colleagues in 1995 in Germany (OECD, 2010), the ever changing nature of drug use in different societies and the changes in technology to accurately measure drug use metabolites in blood, saliva or urine limits the utility of some past surveys in providing an update scenario of drug-driving. A prior review by Beirness, Swan and Logan (OECD, 2010) on past surveys is summarized in Table 3.1. For the surveys that reported any drug use, the prevalence of drug-driving varied in a range of 0.8% in Norway to a high of 10.4% in Canada. Cannabis and benzodiazepines were generally the most used drugs in these early surveys.

Country	Canada (British Columbia)	Canada (Quebec)	Denmark	Germany (Unterfranken)	Netherlands (Tilburg region)	Norway	Norway (SE Norway)	UK (Glasgow, Scotland)
Study	Beirness and Beasley (2009)	Dussault et al. (2000)	Behrensdorff and Steentoft (2003)	Kruger et al. (1995)	Mathijssen & Housing (2005)	Assum et al. (2005)	Gjerde et al. (2008)	Buttress et al. (2005)
Sample size	1533	5509	961	2234	3799	410	10816	1312
Any drugs ^a	10.4%	NR	1.3% (Illicit drugs)	1.0% (Illicit drugs)	NR	0.8% ^b	NR	NR
Amphetamines	NR	<0.1%	NR	NR	0.0%	NR	0.3%	0.5%
Benzodiazepines	NR	3.7%	0.7%	3.0%	2.1%	0.2%	1.4%	NR
Cannabis/THC	4.6%	5.2%	NR	NR	4.5%	0.5%	0.6%	3.1%
Cocaine	4.6%	1.1%	NR	NR	0.7%	NR	0.1%	1.0%
Ecstasy	NR	NR	NR	NR	0.6%	NR	NR	4.1%
Opiates	0.9%	1.1%	NR	NR	6.6%	0.2%	NR	0.0%

Table 3.1 Summary information for roadside surveys from the OECD/ITE report for 2010

NR: Not reported; ^a Any drugs: Including illicit and medicinal drugs ^b Author calculation

New roadside surveys since the publication of the report from OECD (2010) are available, including the most comprehensive effort to date, the European project DRUID (Schulze, Schumacher, Urmeew, & Auerbach, 2012) and preliminary results from a national survey in the US. For countries or communities with more than one such survey, often carried out by the same group of researchers, we present the latest results. The largest roadside survey so-far, done in the DRUID project in several countries of Europe, at a similar time, has reported overall estimates (weighted means) for Europe (Houwing et al., 2011), which we also report here when available, with or without country-specific estimates- for summary reasons.

Estimates from 10 surveys are presented in Table 3.2. While the comparison between surveys methodologies (in the US some surveys report on weekend night drivers, while in the DRUID all day/times samples were collected) and categories of drugs being reported are not always straightforward (not all surveys use the same categories and reported on summary groups that included the same drugs), the prevalence of any drug use (illicit and medicinal) ranged from a high 20.0% in the most recent US survey (Berning et al., 2015) to a low 4.0% in DRUID (Houwing et al., 2011). Four of roadside surveys in low-middle income countries are included, some of which are more limited in their representativeness (for example, professional truck drivers in Brazil) or that reported data that were collected partially on petrol stations or sobriety check-points (Thailand); some of these surveys reported overall prevalence on the high end of the spectrum, 9.3% in Brazil (Sao Paulo) and 9.7% in Thailand. THC was reported in almost all surveys, with a prevalence that raged from 12.6 (US-2015 web) to a low 0.4% in Brazil (national). The prevalence of cocaine tended to be lower than THC in most sites that reported it, with the exception of truck drivers in Brazil and in the Brazilian national sample. Box 3.2 presents an example of results prevalence of drug use from roadside surveys.

Table 3.2

Prevalence of drug use on recent roadside surveys, 2007-2015

Country	Australia (Victoria)	Australia (Brisbane, Queensland)	Brazil (Sao Paulo)	Brazil (National)	Canada (British Columbia)	Chinese Taipei	EU (13 countries) ^a	Thailand (Bangkok)	USA (National)	USA (National)
Study	Drummer et al. (2007)	Davey & Freeman (2009)	Leyton et al. (2012)	Gjerde et al. (2014)	Beasley & Beirness (2012)	Hou et al. (2012)	Houwing (2011) (DRUID)	Ingsathit et al. (2009)	Lacey et al. (2009)	NHTSA(201 5)
Year of data collection	2004	NR	2009	2008-2009	2012	2009	2007- 2009	2005-2006	2007	2013-2014
Subject	Randomly selected drivers	Randomly selected drivers during 5pm- 1am	Randoml y selected large truck (over 30t) drivers during the morning	Randomly selected drivers aged over 18 on Friday and Saturday between noon and midnight	Randomly selected drivers between 9pm-3 am from Wednesda y through Saturday night	Randoml y selected drivers	Randomly selected drivers during weekday, weeknight , weekend days and weekend nights	Randomly selected drivers including commercia l and non- commercia l, during multiple time frames	Randomly select drivers during Friday and Saturday nights 10pm-3am	Randomly selected drivers during night time weekend
Sample Size	13176	1587 (63.3% males)	452 (100% males)	3326 (94.5% males)	1757 (66.9% males)	254 (76.0% males)	48542	1635(85.8 % males)	5910 (61.5% males)	7898
Test samples	Oral fluid	Oral fluid	Urine	Oral fluid	Oral fluid	Urine or blood	Oral fluid and/or blood	Urine	Oral fluid and/or blood	Oral fluid and/or blood
Any drugs	NR	NR	9.3%	NR	7.4%	7.9%	4.0% ^c	9.7%	16.3%	20.0%
Illicit drugs	2.4%	4.6%	NR	NR	NR	NR	2.3%	2.3%	11.3%	15.2%
Medicinal drugs	NR	NR	NR	NR	NR	NR	1.4%	6.3%	3.9%	7.3%
Poly drug use	NR	0.9%	0.2%	NR	1.7% ^c	NR	0.4%	NR	2.8%	NR
Alcohol and drug	NR	NR	NR	NR	0.0%	2.0%	0.4%	0.37% ^c	NR	NR <u>31</u>

Country	Australi a (Victori a)	Australia (Brisbane, Queenslan d)	Brazil (Sao Paulo)	Brazil (Nationa l)	Canada (British Columb ia)	Chines e Taipei	EU (13 countrie s) ^a	Thailand (Bangko k)	USA (Nationa l)	USA (Nationa l)
Amphetamin es	NR	1.1%	5.8%	0.5%	1.6% ^c	0.0%	0.1%	0.02	1.0%	NR
Antidepressa nts	NR	NR	NR	NR	NR	1.0%	NR	NR	NR	NR
Analgesics	NR	NR	NR	NR	NR	NR	NR	NR	1.6%	NR
Benzodiazepi ne	NR	NR	NR	0.7% ^d	0.5% ^c	6.0%	0.9%	0.2%	NR	NR
Cannabis/TH C	0.7%	1.3%	1.1%	0.4%	5.9% [°]	NR	1.3%	1.1%	8.7%	12.6%
Cocaine	NR	0.1%	2.2%	0.7%	3.0% ^c	NR	0.4%	NR	3.9%	NR
Morphine	NR	NR	NR	0.0%	NR	NR	NR	0.1%	0.3%	NR
MDMA	1.3%	2.2%	NR	0.0%	NR	NR	NR	NR	0.1%	NR
Methamphet amine	2.1%	NR	0.0%	0.0%	NR	NR	NR	NR	1.3%	NR
Opioids	NR	NR	NR	0.0%	1.3% ^c	NR	0.07% (Illicit Opiates) and 0.35 (medical opiates)	NR	NR	NR

NR, not reported;

a. 13 countries: including Denmark, Finland, Norway, Sweden, Czech Republic, Hungary, Lithuania, Poland, Spain, Italy, Portugal, Belgium and Netherland

b. Any drugs: Including illicit and medicinal drugs

c. Authors' calculation

d. Including Z-drug

Box 3.2 Results of prevalence of drug use: an example from a roadside survey

On a European level, at the date of the assessment, 2.29% of the drivers tested positive for one or more illicit drugs. In Southern Europe (Italy, Spain, Portugal) prevalence was above this reference level. Among the participating countries, prevalence of illicit drugs (single use and combination use) was highest in Spain (8.20%), followed by Italy (3.92%), the Netherlands (2.51%), and Portugal (1.80%) (Figure 3.1). For all other countries prevalence ranged from 0.22% (Sweden) to 0.94% (Belgium) at the time, when the data was assessed (Houwing et al., 2011).

Figure 3.1



Geographical presentation of illicit drug use by car drivers in the EU

Source: Houwing et al. (2011)

The roadside surveys in DRUID showed that alcohol is by far the most prevalent psychoactive substance on European roads (Figure 3.2), followed by illicit drugs (amphetamines, cocaine, THC, and illicit opiates) and medicinal drugs (benzodiazepines, Z-drugs and medicinal opiates). At a European level alcohol³ ($\geq 0.1\%$ BAC) is estimated to be used by 3.48% of the drivers, illicit drugs¹ by 1.90% of the drivers, medicinal drugs¹ by 1.36% of the drivers. 0.39% of the drivers were driving after the consumption of combinations of drugs (two or more separate drugs). Prevalence of alcohol-drug combinations was 0.37%. Among the illicit drugs THC was most frequently detected in traffic, followed by cocaine. Amphetamines and illicit opiates were less frequently detected.

³ Single use only
Among the medicinal drugs, benzodiazepines were the most prevalent psychoactive substances while Z-drugs (e.g. Zolpidem, Zoplicone) were less prevalent (Houwing et al., 2011).

Figure 3.2

Estimated European prevalence of psychoactive substances in general traffic



Source: Houwing et al. (2011)

The average European prevalence for BAC of at least 0.5 g/L, which is the legal limit in most European countries, was 1.49%. The prevalence in Italy (5.23%) was more than twice as high as in the second and third ranked countries Lithuania (2.31%) and Belgium (2.16%). In Italy and Lithuania there was also the highest percentage of drivers with BAC of 1.2 g/L and more. In contrast there were barely any drivers under influence of such high BAC-levels in Norway and Denmark (Houwing et al., 2011).

Alcohol combined with other drugs was most prevalent in Spain (1.14%) and Italy (1.01%) while in the other countries prevalence was considerably lower. Values were between 0.00% in Poland and 0.42% in Portugal. There was no information on combined use for Sweden because alcohol data was not available from the study there (Houwing et al., 2011).

In summary, the prevalence of illicit drugs was higher than the prevalence of medicinal drugs in Spain, Italy, the Netherlands, Czech Republic, and Poland. Medicinal drugs were more frequently detected than illicit drugs in Northern Europe, Belgium, Portugal, Lithuania and Hungary. The prevalence of psychoactive substances exceeded the prevalence of alcohol in Czech Republic, Spain, Finland, Hungary, the Netherlands, and Norway. In all other countries the prevalence of alcohol was higher than the prevalence of other psychoactive substances (Houwing et al., 2011).

Population surveys are random samples of residents of a location or, sometimes, a sample of more selected populations, such as a college or high-school students. Despite differences in methodology, both approaches in population surveys use self-reported data on drug use and driving and retrospective recall of episodes of drug use and episodes of driving. Most general population surveys are carried out in high-income countries, especially in North America. Surveys on self-reported drug and driving ranging from 1998-2004 were summarized by a prior report (OECD,2010, p. 34). The main finding from these surveys was that driving after using cannabis was reported by as few as 1.9% respondents in a telephone survey in Ontario-Canada, to as much as 19.7% among high school from Ontario-Canada in a self-reported survey. This wide range of estimates from the same city, which differed in methodology and target population, exemplifies the difficulties in interpreting these results. Estimates from more recent surveys are presented in Table

3.3. Again, only surveys in high-income English speaking countries were found. These surveys also included new methodologies using internet-based surveys, together with self-reported surveys among students and telephone based surveys. Prevalence of driving after using drugs (mostly cannabis) varied between 3.5% among a UK (Scotland) population reporting usage in the prior 12months to a high of 29.9% in an Internet survey in Australia.

Table 3.3

Prevalence of drug us	e on recent population	h based self-report surv	evs from 2005-2014

Country	Australia (Queensland)	Australia (Undefined)	Australia (Victoria)	New Zealand (Undefined)	UK (Scotland)	USA (National)	USA (National)
Study	Armstrong et al. (2005)	Mallick et al (2007)	Victorian Drug and Alcohol Prevention Council (2010)	New Zealand Drug Foundation (2009)	Myant et al. (2006)	Substance Abuse and Mental Health Service Administratio n (2014)	O'Malley & Johnston (2013)
Year of data collection	2004	NR	2009	not mentioned	2005	2013	2011
Sample size	331 (27% males)	6801	1228 (55.7% males)	1124	1031 (48.7% males)	67838	6161 from 2009- 2011
Data collection	self-report survey	internet survey	telephone interviews	internet survey	computer- assisted interview	computer- assisted interview	self-report survey
Subject	Students in Queensland University of Technology	People had driven a vehicle in the past 12 months and are 16 years old or older	16-24 years old people	People who reported driving and use a substance in the previous 12 months	17-39 years old drivers	noninstitution alized population aged 12 years old or older	12th grade students in 135 schools

Percentage of drug driving within the previous 12 months:										
Country	Australia (Queensland)	Australia (Undefined)	Australia (Victoria)	New Zealand (Undefined)	UK (Scotlan d)	USA (National)	USA (National)			
Any drugs	8.2%	29.9%	15.0%	NR	3.5%	NR	NR			
Illicit drugs	NR	16.9%	NR	26.2%	NR	3.8%	14.8 ^a			
Poly drug use	NR	9.1%	NR	NR	NR	NR	NR			
Amphetamines	2.7%	NR	NR	3.8 ^b	NR	NR	NR			
Analgesics	NR	15.0%	NR	NR	NR	NR	NR			
Benzodiazepines	NR	4.0%	NR	2.8%	NR	NR	NR			
Cannabis	8.5%	12.3%	NR	24.5%	3.4% ^a	NR	12.40%			
Cocaine	0.3%	3.1%	NR	1.2%	NR	NR	NR			
Ecstasy	5.4%	5.8%	NR	3.3%	NR	NR	NR			
Hallucinogens	NR	0.8%	NR	2.3%	$0.8\%^{a}$	NR	NR			
Heroin	0.0%	0.5%	NR	0.4%	NR	NR	NR			
Ketamine	NR	0.7%	NR	0.5%	NR	NR	NR			
Methadone	NR	NR	NR	1.2%	NR	NR	NR			
Methamphetamine s	NR	6.9%	NR	NR	NR	NR	NR			
Opiates	NR	NR	NR	5.6% ^b	$0.7\%^{a}$	NR	NR			
Prescription stimulants	NR	2.3%	NR	2.3%	NR	NR	NR			
Suppressants	NR	NR	NR	NR	0.9% ^a	NR	NR			

NR: Not reported

a. Author calculation

b. Amphetamines include amphetamine and methamphetamines; Opiates includes morphine, codeine and homebake

Prevalence of drug use among persons involved in a road traffic crash

While the roadside surveys described above provide the prevalence of drug use among drivers, it is also of interest to document how much drug use is found among those that suffered a traffic-related crash. Examples of surveys of people who were involved in traffic crashes are more common to find than roadside surveys, but their results are more difficult to compare. First, most surveys are performed in emergency rooms, trauma centres or hospitals. Crashes that do not lead to medical treatment are usually not included. Most importantly, not all persons that were involved in a crash that lead to medical treatment are routinely tested for drug use and sometimes only those that are initially suspected to be under the influence of alcohol and/or drug use maybe tested. The initial threshold to be tested can be set differently for different people, such as young males from an ethnic minority, while for others, such as an middle age female, the threshold for being tested could be set very high so that only major cases of intoxication would lead to a test procedure. Surveys are performed at different days/times combination (such as weekend night only), different cut-offs may have been used and test methods are sometimes different.

The OECD report (2010) collected data from 19 surveys that reported on drug use among crash drivers carried-out in the middle 90's to middle 2000's, from Europe (Northern Sweden, Norway, UK, Spain, Denmark, France, Netherlands, Greece, Italy and Belgium), the US (Rochester, Washington State, Michigan), Canada (British Columbia, Quebec) and Australia (Melbourne, South Australia). As expected, a lot of variability was found in any drug use (range 9%-40%), with most studies reporting any drug use between the range of 14-25%; cannabis was the drug most used (range 10-11%), followed by benzodiazepines (range 5-9%).

Table 3.4 presents updated information on new studies, from the last 5-10 years, which include results from the DRUID project and also include surveys from low- and middle-income countries, which were not considered in the prior OECD/ITF review. As before, care is needed when doing this simple comparison because of the reasons outlined above. In addition some surveys did not report some summary estimates, such as any drug use. With these caveats in mind, any drug use (illicit and medical) ranged from 8.6% in Netherland (part of the DRUID project) to 50.9% in US-Maryland (Walsh et al, 2005). Any illicit drug use ranged from 0.3% in China (Shanghai and Wuxi) (Zhuo et al., 2010) to 20.8% in Brazil (Porto Alegre) (Breitenbach et al., 2011); a summary measure of any medical drug use was hardly reported but among the few surveys that used this indicator it ranged from 1.0% in the Netherlands to 15.8% in France (Mura et al., 2003). Cannabis was the drug more reported (range 0.5% to 26.9%), followed by benzodiazepines (range 0.0% to 15.7%). The last decade also witnessed a growing interest from low- and middle-income countries in performing such surveys. Examples were found in Brazil (one site), China (3 studies, 4 sites), India (one site) and Thailand (one site) - all very populated countries that witnessed a large growth of motor vehicles and traffic crashes and deaths. In the majority of studies, the indicator of any illicit drug use in LMIC tended to be in the middle-high range of the estimates. For example, in the Brazilian survey (Porto Alegre), cannabis (prevalence 15.3%) and cocaine (prevalence 9.2%) are among the highest reported in the literature, just below estimates from the US. The highest prevalence of benzodiazepine was reported in a survey in Chinese Taipei (15.7%). A survey in India (Chandigarh) reported the highest prevalence of opioids (13.0%). While the data from LMIC reported here are only examples and cannot be taken as representative of LMIC, the data acts as a warning regarding the problem of drug use in some large low and middle income metropolitan areas with large concentrations of people and cars.

Table 3.4

Prevalence of drug use on recent surveys of drivers injured in a road traffic crash, 2005-2015

Country	Australia (Victoria)	Belgium (Brussels, Flanders and Wallonia)	Brazil (Porto Alegre)	China, Hong Kong SAR	Chinese Taipei	China (Shanghai and Wuxi)	Denmark (Aalborg, Viborg, Kolding, Vejle and Odense)	Finland (Uusimaa)
Study	Drummer, et al. (2012)	DRUID (2011) & Legrand et al. (2012)	Breitenbach, et al. (2011)	Wong, et al. (2010)	Hou, et al. (2012)	Zhuo, et al. (2010)	DRUID (2011) & Simonsen et al (2013)	DRUID (2011)
Year of data collection	2009	2008-2010	2008-2011	2007	2009	2007-2008	2007-2010	2008-2010
Subject	Injured drivers admitted to a trauma unit or hospitals	Injured car or van drivers admitted to emergency department (age>18,Maxi mum Abbreviated Injury Scale ≥2, less than 3 hours between the crash and sampling)	Injured drivers (78.4% motorcycle riders) over 18 years old admitted in hospitals	Injured drivers (including motorcycle riders) admitted in hospitals	Injured car or van drivers who admitted in the selected hospitals	Non- hospitalize d drivers involved in traffic crashes or violations	Injured car or van drivers admitted to emergency department (age>18,Maxi mum Abbreviated Injury Scale ≥2, less than 3 hours between the crash and sampling)	Injured car or van drivers admitted to emergency department (age>18,Max imum Abbreviated Injury Scale ≥2, less than 3 hours between the crash and sampling)
Sample	1714	348 (68%)	361 (96%	395 (91%	254 (74%	10002	840 (65.1%	53 (81.1%
size Test	Blood	Blood	Oral fluid	Urine	Blood and	Blood	Blood	Blood or oral

samples					urine			fluid
Positive drug test	35.0%	16.7% a	NR	NR	22.8%	10.5%	20.5% с	12.9% a b
Illicit drugs	12.5%	4.9% b	20.8%	10.0%	NR	0.3%	6.7% c	4.3% a b
Medicinal drugs	NR	5.5% b	NR	NR	NR	NR	8.2% c	5.2% a b
Poly drugs	NR	2.5% d	NR	3.0%	NR	NR	2.7% b	3.1% a b
Alcohol and drugs	12.0%	13.2% d	0.6%	NR	8.0%	NR	4.3% b	5.8% a b
Ampheta mines	NR	2.6%	NR	0.3%	1.2%	NR	4.2%	3.7%
Antidepres sants	9.2%	NR	NR	NR	2.7%	0.0%	NR	NR
Barbiturat es	NR	NR	NR	0.3%	3.1%	NR	NR	NR
Benzodiaz epines	8.9%	7.3%	3.2%	NR	15.7%	0.5%	6.7%	10.2%
Cannabis/ THC	9.8%	7.6%	15.3%	1.5%	NR	NR	1.3%	5.7%
Cocaine	NR	2.3%	9.2%	1.3%	NR	NR	0.6%	0.0%
Methamph etamine	3.1%	NR	NR	1.5%	NR	0.2%	NR	NR
MDMA	0.8%	NR	NR	NR	NR	0.0%	NR	NR
Opiates	Opioids:9.4 %	Illicit Opiates: 0.6%, Medicinal Opioids: 3.3%	NR	NR	NR	NR	Illicit Opiates: 0.5%, Medicinal Opioids: 4.2%	Illicit Opiates:0.0% , Medicinal Opioids: 4.0%
Z-drugs	NR	1.7%	NR	NR	NR	NR	1.2%	3.8%

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Country	France	Greece (Southern Greece)	India (Chandigar h)	Italy (Treviso, Venezia, Padova, Rovigo)	Lithuania (Vilnius, Kaunas, Klaipeda and Alytus)	Netherland (Enschede, Nijmegen and Tilburg)	Thailand (Bangkok)	US (Maryland)
Study	Mura, et al (2003)	Papadodima et al. (2008)	Bensal, et al. (2015)	DRUID (2011)	DRUID (2011)	DRUID (2011) Legrand et al. (2012)	Woratanarat , et al.(2009)	Walsh, et al.(2005)
Year of data collection	2000-2001	1998-2004	2013-2014	2008-2009	2008-2010	2008-2010	2006	2001
Subject	Injured car drivers admitted in emergency unit in 6 hospitals	Drivers involved in traffic fatal and non- fatal crashes	Injured drivers (including bicycle and motorcycle riders) in trauma centre	Injured car or van drivers admitted to emergency department (age>18,Ma ximum Abbreviated Injury Scale ≥2, less than 3 hours between the crash and sampling)	Injured car or van drivers admitted to emergency department (age>18,Ma ximum Abbreviated Injury Scale ≥2, less than 3 hours between the crash and sampling)	Injured car or van drivers admitted to emergency department (age>18,Ma ximum Abbreviated Injury Scale ≥2, less than 3 hours between the crash and sampling)	Injured drivers (including motorcycle riders) in trauma center within 24h after the crashes	Injured drivers admitted to a level-1 trauma center
Sample size	900 (74% males)	3167 (94% males)	200 (94.5% males)	676 (76.9% males)	385 (62.1% males)	187 (80% males)	200 (94.5% males)	108 (72% males)
Test samples	Blood	Blood	Urine and blood	Blood or urine	Blood	Blood	Blood or urine	Blood and urine

Positive	NR	9.0%	NR	13.5% a b	12.7% a b	8.6% a b	27.0%	50.9%
drug test								
Illicit drugs	NR	NR	NR	6.8% b	0.95% a b	2.7% a b	19.0%	NR
Medicinal	15.8%	NR	NR	1.6% b	8.3% a	1.0% a b	8.0%	NR
drugs								
Poly drugs	NR	2.8%	NR	0.6% b	0.9% b	0.5% d	3.0%	9.0%
Alcohol and	NR	2.0%	NR	4.5% a b	2.6% b	4.3% d	8.8%	16.0%
drugs								
Amphetami	0.7% e	NR	NR	0.1%	0.5%	2.1%	16%	0.9%
nes								
Antidepress	1.8%	NR	NR	NR	NR	NR	0.5%	NR
ants								
Barbiturates	NR	NR	NR	NR	NR	NR	NR	3.7%
Benzodiazep	9.4%	4.0%	7.0%	0.7%	3.6%	0.0%	2.5% g	11.1%
ines								
Cannabis/T	10.0%	4.0%	7.0%	3.7%	0.5%	0.5%	2.0%	26.9%
HC						• • •		
Cocaine	0.1%	1.0%	NR	2.7%	0.3%	2.1%	NR	10.2%
Methamphet	NR	NR	NR	NR	NR	NR	NR	5.6%
amine								
MDMA	NR	NR	NR	NR	NR	NR	NR	NR
Opiates	2.7%	4.0%	13.0%	Illicit	Illicit	Illicit	NR	10.2%
				Opiates:	Opiates:0.3	Opiates:		
				2.1%,	%,	0.0%,		
				Medicinal	Medicinal	Medicinal		
				Opioids:	Opioids:	Opioids:		
				3.7%	7.8%	0.5%		
Z-drugs	NR	NR	NR	0.0%	0.0%	0.5%	NR	NR

Notes

NR: Not reported

- a. Authors' calculation based on country report
- b. Data on percentage of drugs and sample size for specific drugs is from the Executive Summary of DRUID, *Prevalence of alcohol and other psychoactive substances in injured and killed drivers*. (2011); Data on percentage of drugs and sample size for positive drug test, illicit drugs, medicinal drugs, poly drug combination, alcohol and drug combination are from specific country report of DRUID, *Prevalence of alcohol and other psychoactive substances in injured and killed drivers*. (2011)
- c. Data from Simonsen, et al 2003. Percentage of positive drug test is based on Limit of Quantification as cutoff; Percentages of illicit drugs and medicinal drugs are based on DRUID cutoff.
- d. Data from Legrand et al 2012
- e. Includes amphetamine, methamphetamine, MDA and MDMA
- f. Including MA and MDMA
- g. based on self-report, none has been detected through urine sample)

Prevalence of drug use among persons killed in a road traffic crash

The most serious consequence of drug-driving is a crash-related death. The simplest information for these outcomes may come from a case-series of toxicological reports (post-mortem) on a single jurisdiction, usually performed by a forensic coroner/medical examiner officer. A significant limitation of such case-series is that very few traffic fatality victims are tested for the presence of drugs with a potential sampling bias (e.g. a higher percentage of younger males may be tested). Comparison of case-series from several jurisdictions, each one with their own criteria for performing drug testing, could result in even more biased samples. For example, in Canada (Beasley et al, 2011) the mean drug test rate (% of all fatally injured drivers who were tested for presence of drugs) was 47.2% during the period 2000-2008, with a range of 30.2% to 88%. Finally, not all jurisdictions perform the same tests for the same drugs, so that differences in types of drugs being tested may affect overall estimates such as "any drug use".

The 2010 OECD/ITF report presented studies that included data before the year 2005 (with a few exceptions discussed below). In these studies that included Australia, Canada, France, Hong Kong, Italy, Spain, Sweden, the UK, the US and the DRUID, "any drug use" varied from a low 6.1% in Hong Kong to a high 26.7% in Australia, but only 5 sites reported on this overall prevalence. Only 2 sites reported the overall prevalence of illicit drug use and medicinal drugs. Cannabis was reported by almost all sites, with prevalence ranging from a low 2.0% in Hong Kong to a high 28.9% in France. Prevalence of benzodiazepines ranged from 1.0% in France to a high 9.2% in Canada.

Table 3.5 presents results from more recent reports that include Australia, Canada, Finland, France, Norway, Portugal, Sweden, the US and the combined DRUID sample. During the last 10 years, only one LMIC study was identified from Hong Kong and summarized by the previously mentioned OECD/ITF report. Again, not all studies reported overall summary prevalence. Among the ones that did, the lowest prevalence was reported in Portugal (8.8%) and highest prevalence of any drug use was found in Canada (33.5%). Cannabis varied from 0.0% in Portugal to a high 28.9% in France, while benzodiazepines varied from 1.8% in Portugal to a high 17.3% in Canada. Cocaine is very infrequently found, with the highest prevalence (3%) found in France.

DRUID roadside surveys showed that combined use of alcohol and drugs was more prevalent in Southern Europe and in Western Europe. DRUID roadside surveys showed that combined use of alcohol and drugs was more prevalent in Southern Europe and in Western Europe. There was hardly any combined use of alcohol together with drugs in Northern Europe and in Eastern Europe (Figure 3.3). Driving after consumption of more than one drug was also more frequently detected in Southern Europe (Figure 3.4).

Table 3.5

Prevalence of drug	g use on rece	nt surveys o	of drivers	killed in	a road traffi	c crash,	2003-
2014							

Coun try	Austr alia (Victo ria, New South Wales and Weste rn Austr alia)	Cana da (Nati onal)	Finla nd (Uusi maa and Pohj ois- Savo regio ns)	Fran ce (Nati onal)	Fran ce (Nati onal)	Norw ay (Nati onal)	Port ugal (cent re and south regio n)	Swed en (Nati onal)	US (14 stat es)	EU 4 countr ies (Finla nd, Norw ay, Portu gal and Swede n)
Study	Drum mer, et al.(200 3)	Beasl ey & Beirn ess (2011)	DRU ID (2011)	Laum on, et al.(20 05)	Mura , et al. (2006)	DRU ID (2011)	DRU ID (2011)	DRU ID (2011)	Bra dy and Li (201 3)	EMC DAA (2014)
Year of data collec tion	1990- 1999	2000- 2008	2006- 2008	2001- 2003	2003- 2004	2006- 2008	2009	2008	200 5- 200 9	2007- 2010
Subje ct	Fatally injured drivers	Drive rs died as a result of injuri es sustai ned in a crash invol ving a vehic le	Fatall y injure d driver s aged 18 and above	Drive rs killed imme diatel y in traffi c crash es	Fatall y injure d driver s less than 30 years old	Fatall y injure d driver s aged 18 and above	Fatall y injure d driver s aged 18 and above	Fatall y injure d driver s aged 18 and above died withi n 24 hours of the crash	Fata lly injur ed driv ers died with in one hour of the cras h	Fatally injured drivers aged 18 and above
Sampl e size	3398 (79.0 %	8135 a	483 (81.2 %	9772 (84.9 %	2003 (89.4 %	193 (78.8 %	285 (93.0 %	157 (75.8 %	201 50 (78.	1118 (83.0 %

	males)		males)	males)	males)	males)	males)	males)	1 mal es)	males)
Test sampl es	Blood	Bloo d	Bloo d	Bloo d and urine	Bloo d	Bloo d	Bloo d	Bloo d/ Urine / Musc le tissue	Blo od and/ or urin e	Blood
Any drugs	26.7%	33.5 % b	17.9 % a	NR	NR	21.8 % a	8.8% a	14.9 % a	31.8 %	15.9% а
Illicit drugs	NR	NR	NR	NR	NR	11.9 % с	5.9% c	3.4 c	NR	NR
Medic inal drugs	NR	NR	NR	NR	NR	15.0 % c	NR	3.4 c	NR	NR
Poly drug use	NR	NR	1.5%	NR	NR	7.3%	0.4%	4.3%	NR	NR
Alcoh ol and drugs	9.7%	NR	7.2%	2.9%	NR	7.9%	6.0%	4.3%	NR	NR
Amph etami nes	NR	12.4 % a	2.1%	0.5%	3.1%	7.4%	0.0%	6.6%	NR	1.6%
Benzo diaze pine	4.1%	17.3 % a	13.3 %	NR	NR	9.7%	1.8%	3.9%	NR	8.3%
Canna bis/T HC	13.5%	16.1 % a	1.3%	7.0%	28.9 %	6.1%	0.0%	1.3%	10.5 %	1.8%
Cocai ne	NR	NR	0.0%	0.2%	3.0%	0.0%	0.7%	0.7%	NR	0.3%
Depre ssants	NR	16.4 % а	NR	NR	NR	NR	NR	NR	4.0 %	NR
Narco tics	NR	б.6% а	NR	NR	NR	NR	NR	NR	5.7 %	NR
Opiat es	4.9%	NR	2.1% d	0.8%	Morp hine 1.9%	1.7% d	2.1% d	4.1% d	NR	2.3% d
Stimu lants	4.1% e	12.4 % a	NR	NR	NR	NR	NR	NR	NR	NR
Z- drugs	NR	NR	3.0%	NR	NR	4.4%	0.0%	3.2%	NR	2.5%

Notes

NR: Not reported

- a. Author calculation
- b. 33.5% during 2000-2008, 36.7% for 2008
- c. Data from specific country reports
- d. Medicinal Opioids
- e. Including pseudoephedrine/ ephedrine, methamphetamine, MDMA, and phentermine

Figure 3.3

Prevalence of combined use of alcohol and drug(s) in the general driving population in thirteen European countries



Source: Bernhoft (2011, p. 11)

Figure 3.4

Prevalence of multiple drug use in the general driving population in thirteen European countries



Source: Bernhoft (2011, p. 11)

Conclusion

Currently it is not possible to provide any single point estimate on the extent of drug-driving (illicit drugs and medicinal drugs) or on the prevalence of specific drugs in traffic, especially cannabis and benzodiazepines which are the most commonly used illicit and/or medicinal drugs among the general population of drivers, as well as among injured or killed drivers. Although no single point prevalence estimate can be formulated for the moment, the following conclusions can be drawn. First, a non-negligible part of the drivers' population does drive with traces of drugs in their body. Whether this will put them at risk for being injured or dying will be considered in subsequent chapters. Traces of drugs are found frequently among drivers injured or killed in crashes. Two substances stand out as being the most prevalent: cannabis and benzodiazepines. This fact may affect the policies surrounding this problem.

Second, studies in low and middle income countries have become more common. Although at this point the data in these countries is too sparse for any generalization, it can be assumed that the problem of drug driving in low and middle income countries is, at least, as frequent as in developed nations and therefore merits further attention. It is not clear why the few studies performed in low and middle income countries have found such high levels of drug-driving, given the usually low level of drug use reported in these countries.

Third, it is important to take into consideration, that from the prevalence of drugs among injured or killed drivers it cannot be assumed that drugs have caused these crashes. The mere presence of drugs while driving, proven by biological specimen, is not an indicator of an impairment that leads to a crash. Therefore baseline information from roadside surveys is urgently needed in more countries. A minimum set of standards for international research in roadside surveys, including reporting practices on summary measures such as "any drug use" should be adhered to.

References

- Armstrong, K. A., Wills, A. R., & Watson, B. C. Psychosocial influences on drug driving in young Australian drivers. 2005
- Assum, T., R. Mathijssen, S. Houwing, S.C. Buttress, B. Sexton, R.J. Tunbridge and J. Oliver (2005), "The Prevalence of Drug-driving and Relative Risk Estimations: A Study Conducted in the Netherlands, Norway and United Kingdom", IMMORTAL Deliverable D-R4.2. European Commission.
- Bansal, Y. S. Alcohol and Drug Use in Injured Drivers–An Emergency Room Study in a Regional Tertiary Care Centre of North West India. 2015
- Beasley, E. E., & Beirness, D. J. Alcohol and Drug Use Among Drivers Following the Introduction of Immediate Roadside Prohibitions in British Columbia: Findings from the 2012 Roadside Survey: Final Report. 2012.
- Behrensdorff, I. and A. Steentoft (2003), "Medicinal and illegal drugs among Danish car drivers", Accident Analysis & Prevention, 35:851-860.
- Beirness, D.J. and E.E. Beasley (2009a), Alcohol and Drug Use among Drivers. British Columbia Roadside Survey 2008, Ottawa: Canadian Centre on Substance Abuse
- Bernhoft, I. M. (2011). Results from epidemiological research prevalence, risk and characteristics of impaired drivers (DRUID (Driving under the Influence of Drugs, Alcohol and Medicines) Deliverable 2.4.1). Retrieved from www.druid-project.eu
- Berning, A., Compton, R., & Wochinger, K. Results of the 2013–2014 National Roadside Survey of Alcohol and Drug Use by Drivers. No. DOT HS 812 118, 2015.
- Brady, J. E., & Li, G. Prevalence of alcohol and other drugs in fatally injured drivers. Addiction. 2013. 108(1), 104-114.
- Breitenbach et al. High rates of injured motorcycle drivers in emergency rooms and the association with substance use in Porto Alegre, Brazil. Emergency medicine journal, emj-2010.
- Buttress et al. The incidence of drink and drug driving in the UK–A roadside survey in Glasgow. In Proceedings of the 17th International Conference on Alcohol, Drugs & Traffic Safety, Glasgow, UK. 2004
- Davey, J., & Freeman, J. Screening for drugs in oral fluid: drug driving and illicit drug use in a sample of Queensland motorists. Traffic injury prevention. 2009, 10(3), 231-236.
- DRUID. Prevalence of alcohol and other psychoactive substances in injured and killed drivers. 2011
- Drummer et al.Drugs in oral fluid in randomly selected drivers. Forensic Science International, 2007, 170(2), 105-110.
- Drummer, O. H., Kourtis, I., Beyer, J., Tayler, P., Boorman, M., & Gerostamoulos, D. The prevalence of drugs in injured drivers. Forensic science international. 2012, 215(1), 14-17.
- Dussault, C., A.M. Lemire, J. Bouchard, M. Brault (2000), "Drug use among Quebec drivers: The 1999 roadside survey" In: 15th International Conference on Alcohol, Drugs & Traffic Safety. May 22-26, 2000. Stockholm, Sweden. International Council on Alcohol, Drugs & Traffic Safety.
- European Monitoring Centre for Drugs and Drug Addiction (EMCDDA), & Portugal. (2014). Drug use, impaired driving and traffic accidents. Office for Official Publications of the European Communities. Access through http://www.emcdda.europa.eu/publications/insights/2014/drugs-and-driving in July 2015
- Gjerde, H., et al.A comparison of alcohol and drug use by random motor vehicle drivers in Brazil and Norway. International Journal of Drug Policy. 2014, 25(3), 393-400.
- Gjerde, H., P.T. Normann, B.S. Pettersen, T. Assum, M. Aldrin U. Johansen, L. Kristoffersen, E.L.Øiestad, A.S. Christophersen and J. Mørland (2008), "Prevalence of alcohol and drugs

among Norwegian motor vehicle drivers: A roadside survey", Accid Anal Prev. 40(5):1765-72.

- Hou, C. C. et al. Psychoactive substance use and the risk of motor vehicle crash injuries in southern Taiwan. Prevention Science. 2012, 13(1), 36-42.
- Hou, C. C., et al. Psychoactive substance use and the risk of motor vehicle crash injuries in southern Taiwan. Prevention Science. 2012, 13(1), 36-42.
- Houwing, S., Hagenzieker, M., Mathijssen, R., Bernhoft, I. M., Hels, T., Janstrup, K.(2011). Prevalence of alcohol and other psychoactive substances in drivers in general traffic (DRUID (Driving under the Influence of Drugs, Alcohol and Medicines) Deliverable 2.2.3). Retrieved from www.druid-project.eu
- Ingsathit, A., et al. Prevalence of psychoactive drug use among drivers in Thailand: a roadside survey. Accident Analysis & Prevention. 2009, 41(3), 474-478.
- Krueger, H.P., E. Schulz and H. Magerl (1995), "The German roadside survey 1992-1994: Saliva analyses from an unselected driver population: Licit and illicit drugs", In: TS-'95, Proceedings of the 13th International Conference on Alcohol, Drugs and Traffic Safety, August 13-August 18, 1995. Adelaide, Australia. Adelaide: NHMRC, Road Accident Unit, University of Adelaide.
- Lacey, J. H., et al. 2007 National roadside survey of alcohol and drug use by drivers: Drug results. No. HS-811 249, 2009.
- Laumon, B., et al. Cannabis intoxication and fatal road crashes in France: population based casecontrol study. BMJ. 2005, 331(7529), 1371.
- Legrand, S. A., et al. Prevalence of alcohol and other psychoactive substances in injured drivers: comparison between Belgium and the Netherlands. Forensic science international. 2012, 220(1), 224-231.
- Leyton et al. Amphetamine, cocaine and cannabinoids use among truck drivers on the roads in the State of Sao Paulo, Brazil. Forensic science international. 2012, 215(1), 25-27.
- Mallick et al. 2007. Drugs and driving in Australia: A survey of community attitudes, experience and understanding. Australian Drug Foundation, 2007.
- Mathijssen, M.P.M. and S. Houwing (2005), "EU research project IMMORTAL: The risk of drink and drug-driving: Results of a case-control study conducted in the Netherlands", Paper presented at the TRB Summer Workshop on Drugs and Driving, Woods Hole, MA, June 20-21.
- Mura, P., et al. Comparison of the prevalence of alcohol, cannabis and other drugs between 900 injured drivers and 900 control subjects: results of a French collaborative study. Forensic science international. 2003, 133(1), 79-85.
- Mura, P., et al. Use of drugs of abuse in less than 30-year-old drivers killed in a road crash in France: a spectacular increase for cannabis, cocaine and amphetamines. Forensic Science International. 2006, 160(2), 168-172.
- Myant, K., et al. Illicit drugs and driving.2006
- New Zealand Drug Foundation, Drug Driving in New Zealand: A survey of community attitudes, experience and understanding, 2009. Access through http://drugfoundation.org.nz/sites/default/files/Drug%20Driving%20in%20New%20Zealand, %20full%20research%20report,%20August%202009.pdf
- NHTSA, Berning, A., Compton, R., & Wochinger, K. Results of the 2013–2014 National Roadside Survey of Alcohol and Drug Use by Drivers No. DOT HS 812 118, .2015.
- OECD, Drugs and Driving: Detection and Deterrence, OECD Publishing. 2010 (http://dx.doi.org/10.1787/9789282102763-en, accessed 15 July 2015)
- O'Malley, P. M., & Johnston, L. D. Driving after drug or alcohol use by US high school seniors, 2001–2011. American journal of public health. 2013, 103(11), 2027-2034.
- Papadodima, S. A. et al. Driving under the influence in Greece: a 7-year survey (1998–2004). Forensic science international. 2008, 174(2), 157-160.

- Schulze, H., Schumacher, M., Urmeew, R., & Auerbach, K. (2012). Final report: Work performed, main results and recommendations (DRUID (Driving under the Influence of Drugs, Alcohol and Medicines) Deliverable 0.1.8). Retrieved from www.druid-project.eu
- Simonsen, K. W., et al. Presence of psychoactive substances in oral fluid from randomly selected drivers in Denmark. Forensic science international, 2012, 221(1), 33-38.
- Substance Abuse and Mental Health Services Administration. Results from the 2013 National Survey on Drug Use and Health: Summary of National Findings, NSDUH Series H-48, HHS Publication No. (SMA) 14-4863. Rockville, MD: Substance Abuse and Mental Health Services Administration, 2014.
- Victorian Drug and Alcohol Prevention Council. Victorian youth alcohol and drug survey: Final report. Victorian Drug and Alcohol Prevention Council for the Department of Health: Melbourne. 2009.
- Walsh, J. M. et al. Drug and alcohol use among drivers admitted to a Level-1 trauma center. Accident Analysis & Prevention, 2005, 37(5), 894-901.
- Wong, O. F., et al. Prevalence of drugged drivers among non-fatal driver casualties presenting to a trauma centre in Hong Kong. Hong Kong medical journal. 2010, 16(4), 246-251.
- Woratanarat, P., et al. Alcohol, illicit and non-illicit psychoactive drug use and road traffic injury in Thailand: a case-control study. Accident Analysis & Prevention. 2009, 41(3), 651-657.
- Zhuo et al. The prevalence of drugs in motor vehicle accidents and traffic violations in Shanghai and neighbouring cities. Accident Analysis & Prevention. 2010, 42, no. 6: 2179-2184.

Risk of road traffic injury associated with the use of drugs

Mark Asbridge and Rune Elvik

Introduction

A sufficient number of studies are available to quantify risk of road traffic injury associated with the use of drugs. This chapter summarises current knowledge about the risk of road traffic injury associated with the use of drugs. This summary is based on a systematic review of the available literature, including meta-analysis.

Studies often contain multiple estimates of the risk associated with a certain drug. The estimator of risk used in most studies is not an injury to the driver himself or herself, but involvement in an accident resulting in death or injury. The individual who died or was injured need therefore not be the driver, but could be another person who was involved in the accident. The terms fatal injury and non-fatal injury will nevertheless be used to refer to crashes in which the most serious injury was either a fatal injury or an injury that required medical attention. Unfortunately, most studies give few details about injury severity. Therefore only a very crude scale with three levels has been used: fatal injury, non-fatal injury and property damage only. Some studies refer to severe injury. In most cases, these studies have not been reviewed as a separate group, but treated as part of the non-fatal injury group.

Assessing the evidence

Assessing whether the results of epidemiologic studies represent causal relationships or not is complex. Several criteria of causality have been developed (Rothman and Greenland 1998; Szklo and Nieto 2014). For the purposes of this chapter only the following criteria were applied:

- a) There must be a statistically significant increase in risk associated with use of a drug (if not, one cannot rule out that there was chance variation only).
- b) There should be a severity gradient in the relationship between use of a drug and the risk of injury (use of drugs influences cognitive functions in ways that can make crashes more severe).
- c) The increase in risk found in comparatively well-controlled studies (those qualifying as best evidence) should not be much smaller than the increase in risk found in less well-controlled studies (if the opposite is found, it indicates that the estimate of risk is inflated because of poor control for confounding factors).
- d) There should be a dose-response relationship between the dose taken of a drug and the size of the increase in risk associated with the drug (a dose-response relationship is normally taken as indicative of causality).

Table 4.1 shows how the evidence regarding the risk associated with the various drugs has been assessed in terms of these criteria. It can be noted that the evidence is mixed and not as strong as one would like it to be. For some drugs, the criteria point in the direction of a causal relationship. For others, the evidence is still too limited to support claims of a causal relationship. From a policy perspective, however, it is prudent to treat the evidence of an increase in risk as showing a real increase associated with a certain drug, rather than simply a statistical artefact. It is important

to remember than when one selects the best evidence, as has been done in this report, the number of studies may become too small to show statistically significant results. The absence of a statistically significant increase in risk for some of the drugs should therefore not be interpreted as evidence of no increase in risk but rather as indicating that the increase is still quite imprecisely known.

Table 4.1

Assessing evidence for causality in studies of the risk of traffic injury associated with the use of drugs

Drug	Statistically significant association with risk	Severity gradient in increase in risk	Increase in risk remains when confounders are controlled for	Dose-response relationship between drug and increase in risk
Amphetamines	Yes	Yes	Yes	Not assessed
Cannabis	Yes (fatal)	Yes	Yes	Yes
Cocaine	No	Yes (weak)	Yes	Yes
Opiates	No	No	Yes	Not assessed
Analgesics	Yes	Yes	Yes	Not assessed
Antidepressants	No	No evidence	No	Yes (weak)
Antihistamines	Yes	No evidence	Yes	Not assessed
Anti-asthmatics	Yes	No evidence	Yes	Not assessed
Benzodiazepines	Yes	Yes	Yes	Yes
Zopiclone	No	Yes	Yes	Yes

Findings

Results are presented in a standardised format for each drug for which there is a sufficient number of studies to estimate risk.

Illicit drugs

Amphetamine

There were 18 estimates of risk in total. Eight estimates satisfied the criteria for best evidence. Six of these applied to the risk of fatal injury, two applied to the risk of non-fatal injury. Summary estimates of risk were (95 % confidence interval in parenthesis):

Fatal injury:	9.61 (4.28; 21.56)
Non-fatal injury:	5.89 (1.61; 21.64)

No study had probed for a dose-response relationship.

Cannabis

There were 72 estimates of risk in total. Twenty-two estimates satisfied the criteria for best evidence; 21 of these applied to fatal injury, only 1 to non-fatal injury. Summary estimates of risk were (95 % confidence interval in parenthesis):

Fatal injury:	1.32 (1.18; 1.48)
Non-fatal injury:	1.22 (0.55; 2.72)

Three studied provided evidence on a dose-response relationship. Based on these studies, the following estimates of risk were developed (the estimates combine fatal and non-fatal injury):

Low dose:	1.36 (0.89; 2.07)	
Medium dose:	1.55 (0.92; 2.61)	
High dose:	1.85 (1.16; 2.95)	

It should be noted that the summary estimates of risk are not identical to those reported for fatal and non-fatal injury, as the sample of studies is not the same in the two cases.

Cocaine

There were 17 estimates of risk in total. Four estimates satisfied the best-evidence criteria. Two of these estimates referred to fatal injury, the other two to non-fatal injury. Summary estimates of risk were (95 % confidence interval in parenthesis):

Fatal injury:	1.99 (0.77; 5.16)
Non-fatal injury:	1.80 (0.89; 3.64)

Only one study reported different levels of use of the drug. The levels were less than weekly use and weekly use. The risk of non-fatal injury associated with weekly use was 2.80; the risk associated with less than weekly use was 1.10. This is consistent with the presence of a dose-response relationship.

Opiates

There were 31 estimates of risk in total. Six of these satisfied the best-evidence criteria. There were four best-evidence estimates of the risk of fatal injury and two estimates of the risk of non-fatal injury. Summary estimates of risk were (95 % confidence interval in parenthesis):

Fatal injury:	1.87 (0.97; 3.61)
Non-fatal injury:	1.87 (0.65; 5.40)

No study had probed for a dose-response relationship.

Prescription drugs

Analgesics

The analysis reported by Elvik (2013) was updated by adding two recent studies (Hels et al. 2011, Meuleners et al. 2011). This brought the total number of estimates to 18. 14 estimates satisfied the criteria for best evidence; 10 estimates referred to non-fatal injury, 4 to fatal injury. Summary estimates of risk is as follows:

Fatal injury:	4.20 (2.19; 8.05)
Non-fatal injury:	1.56 (1.18; 2.05)

No study provided evidence on a dose-response relationship.

Antidepressants

There were 26 estimates of risk in total. Eight estimates satisfied the best-evidence criteria. Estimates of risk based on these 8 estimates are as follows:

Fatal injury:	No evidence
Non-fatal injury:	0.88 (0.61; 1.26)

There seems to be a slight tendency, not statistically significant, for risk to be lower when antidepressant drugs are used than when they are not used.

One study (Barbone et al. 1998) assessed a dose-response relationship. A distinction was made between low, medium and high dose. Estimates of risk were:

Low dose:	0.90 (0.66; 1.22)		
Medium dose:	0.90 (0.54; 1.43)		
High dose:	1.39 (0.56; 3.48)		

None of these estimates of risk is statistically significant. A tendency for risk to increase is only found at a high dose.

Antihistamines

There were seven estimates of risk in total; three of these satisfied criteria for best evidence. Based on these, the summary estimate of risk is:

Fatal injury:	No evidence
Non-fatal injury:	1.13 (1.03; 1.24)

There is a small increase in risk. No study reported on a dose-response relationship.

Anti-asthmatics

There were only six estimates of risk, four of which satisfied the best-evidence criteria. The summary estimate of risk of non-fatal injury was 1.34 (1.08; 1.67). There was no evidence

regarding the risk of fatal injury. There was no evidence regarding the presence of a doseresponse relationship.

Benzodiazepines

A total of 65 estimates of risk have been identified (Elvik 2013). 28 estimates were selected according to the best-evidence criteria. 23 of these estimates referred to non-fatal injury, 5 to fatal injury. Summary estimates of risk are:

Fatal injury:	1.85 (0.98; 3.49)
Non-fatal injury:	1.40 (1.21; 1.61)

Regarding a dose-response relationship, Ray et al. (1992) reported that the risk of non-fatal injury increased from about 1.1 at the lowest dose to about 2.4 at the highest dose. The findings were, however, only reported in a figure and were not stated with sufficient precision to be combined with other studies.

Barbone et al. (1998) reported the following dose-response relationship:

Low dose:	1.27 (0.80; 2.01)
Medium dose:	1.68 (1.13; 2.49)
High dose:	2.67 (1.33; 5.39)

There is a clear dose-response relationship. These findings are supported by Orriols et al. (2011), who, however, only defined two levels for the use of the drug.

Zopiclone

There are only six estimates of risk in the literature that has been reviewed (Elvik 2013). All these estimates satisfy the best-evidence criteria. Summary estimates of risk are:

Fatal injury:	2.60 (0.89; 7.56)
Non-fatal injury:	1.42 (0.87; 2.31)

Orriols et al. (2011), using two levels for use of the drug, find support for a dose-response pattern.

New psychoactive substances

New psychoactive substances (NPS) is the label assigned to a relatively new, and ever-changing group of drugs. According to the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA), NPS are defined as 'a new narcotic or psychotropic drug, in pure form or in preparation, that is not controlled by the United Nations drug conventions, but which may pose a public health threat comparable to that posed by substances listed in these conventions' (European Monitoring Centre for Drugs D. A., 2006). As of 2015, the EMCDDA was monitoring more than 450 different NPS, but NPS come and go into the market indicating that not all are present at the same time. Four of the most prevalent NPS of abuse that have the potential to affect driving performance include: 1) synthetic cannabinoids, (e.g., spice, K2), 2) synthetic cathinones (e.g., bath salts, plant fertilizer), 3) phenylethylamine (e.g., MDMA, Ecstasy) and 4) piperazine/benzylpiperazine (e.g., BZP, Legal X, A2). The synthetic cannabinoids in spice are

high-potency, high-efficacy, cannabinoid receptor full agonists, meaning that both the scope and intensity of its effects have the potential to be greater (Spaderna, 2013).

Jurisdictions are struggling to capture the prevalence of NPS use and the long- and short-term implications of use, such as addictiveness, withdrawal trajectories, psycho-physical impairment, and the resulting risk to road safety. There are three commonly noted challenges when assessing the impact of new psychoactive substances on psycho-physical impairment, and thus driving performance and crash risk; inconsistent drug composition, multi-substance use, and drug testing capability:

- a) Inconsistent drug composition: One of the defining features of the new psychoactive substances (NPS) is that there is a total absence of consistency in their chemical makeup, not only between doses of the "same" drug (Davies S, 2010) but within doses (European Monitoring Centre for Drugs D. A., 2009). The concentration of psychoactive substance can vary immensely within a sealed package of drugs, such as Spice. The variation in concentration of psychoactive agents within the packet can result in different outcomes with each use/user. The same inconsistency exists with "legal high" products such as bath salts plant food, or research chemicals, with various compositions including synthetic cathinones, piperazines, caffeine, benzocaine, paracetamol, and/or lidocaine (Davies S, 2010; Zuba, 2013). The inconsistency in psychoactive substances within the "same" product makes it not only challenging, but dangerous to assert a specific level of impairment from consumption.
- b) Multi-substance use: Previous studies investigating the impairment implications of driving under the influence of NPS have consistently come across the same challenge. When assessed, drivers rarely have just one substance in their system, making it impossible to attribute the driver's impairment to a sole substance (Kriikku, 2011; Tuv, 2014).
- c) Drug testing capability: Creating a linkage between driver impairment and specific drug usage requires that law enforcement be able to confirm that a driver has consumed a given drug, resulting in impairment. Part of the appeal of NPS is the inability for these substances to be detected through routine drug screening (European Monitoring Centre for Drugs D. A., 2009). This has made NPS, such as spice and bath salts, especially attractive to individuals who undergo regular routine drug testing, such as those on probation or military personnel (Cristobal S. Berry-Caban, Paul E. Kleinschmidt, & al., 2012). The development of effective drug testing protocols is challenging with relatively consistent substances, such as THC and cocaine, but becomes much more challenging in the context of NPS, which evolve quickly to circumvent drug testing and law enforcement (Marinetti, 2013; Seely, 2012). Considerable work is being done to enable the testing of NPS and their metabolites, and will support a broader testing spectrum moving forward (Helander, 2013).

The impact of synthetic cathinone on driving performance has not been sufficiently investigated. However, the study of the impact of stimulant drugs on driving performance has resulted in varied conclusions. In low doses, the nature of impairment appears minimal; whereas at higher dose stimulants may produce increased driver inattention and impatient, and the adoption of more risky driving maneuvers. Where stimulants are particular risky is when used in combination with other drugs, including alcohol, that impair driving performance more directly (Walsh J. M., 2004; Ramaekers J. G., 2012; Bogstrand, 2012). Hels and colleagues (2013) also found that the crash risk associated with consuming psychoactive substances was greatest for alcohol, followed by multi-drug use (Hels, Lyckegaard, Simonsen, Steentoft, & Bernhoft, 2013), a practice which is prevalent among NPS users. Recent work investigating the impact of synthetic cannabinoids on

driving performance concluded that the impact was similar to that of consuming cannabis, with negative impacts on fine motor skills and sedation (Musshoff, 2014).

A recent study of fatally injured drivers in Victoria Australia found that NPS were identified in 2.4% of fatally injured drivers, whereas 29% of fatally injured drivers were found to have some psychoactive drug in their system during this time period (Yap, 2015). A study of drivers in Finland found that of the 208 drivers found with MDPV (cathinones) in their system, 7% were found to be severely impaired, while a total of 84% were found to be functionally impaired through a psycho-physical assessment (e.g., speech patterns, walking a straight line). It should be noted that many drivers had other substances of abuse in their systems at the time of testing (Kriikku, 2011).

With insufficient study data to support definitive conclusions and three major challenges that exist in generating these data in the near future, it is impossible to state the absolute crash risk associated with NPS. However, based upon their known and desired effects, it is reasonable to postulate that they would certainly impair driver performance and increase crash risk akin to other psychoactive substances in the same drug class. Extreme caution should be taken with these substances until definitive evidence is available.

Conclusion

Studies reviewed in this chapter show that the consumption of some illicit drugs prior to driving is associated with an increased risk of traffic injury, particularly amphetamines and, to a lesser extent, cannabis. This increase in risk is, however, considerably smaller than what is observed for alcohol. Risk estimates for the simultaneous consumption of drugs and alcohol, though few in number, show substantially higher crash likelihood than the use of either alone.

There is good evidence from epidemiological studies showing that the use of certain prescription medicines or classes increases road traffic crash risk. The most consistent evidence is observed for analgesics, antihistamines, anti-asthmatics, and benzodiazepines. There is also evidence of dose-response relationship with road traffic crash risk for several prescription medications, including benzodiazepines, zopiclone and to a lesser extent, antidepressants. The widespread, and growing, use of prescription medicines globally, particularly among seniors, suggests this to be an important road safety and public health issue. Limited evidence exists regarding the impact of new psychoactive substances on road traffic crash risk. However, the unpredictable composition and outcomes associated with the use of these drugs points toward an elevated crash risk.

In sum, while several illicit and prescription medications have been shown to increase traffic crash risk, it is clear that the use of alcohol prior to driving remains a greater burden to road safety. Continued research on drug use and driving is needed.

References

Barbone, F., McMahon, A. D., Davey, P. G., Morris, A. D., Reid, I. C., McDevitt, D. G., MacDonald, T. M. 1998. Association of road-traffic accidents with benzodiazepine use. The Lancet, 352, 1331-1336.

- Berry-Cabán CS, Kleinschmidt PE, Rao DS, Jenkins J.2014. Synthetic Cannabinoid and Cathinone Use Among US Soldiers. United States Army Medical Department Journal, 19-24.
- Bogstrand ST, Gjerde H, Normann PT, Rossow I, Ekeberg Ø. 2012. Alcohol, psychoactive substances and non-fatal road traffic accidents-a case-control study. BMC public health, 12: 734.
- Davies S, Wood DM, Smith G, Button J, Ramsey J, Archer R, Holt DW, Dargan. 2010. Purchasing 'legal highs on the Internet--is there consistency in what you get? QJM, 103: 489-493.
- Elvik, R. 2013. Risk of road accident associated with the use of drugs: A systematic review and meta-analysis of evidence from epidemiological studies. Accident Analysis and Prevention, 60, 254-267.
- European Monitoring Centre for Drugs, Drug Addiction (EMCDDA). 2009. Understanding the 'Spice' phenomenon. Lisbon: EMCDDA.
- Helander A, Beck O, Hagerkvist R, Hulten P. 2013. Identification of novel psychoactive drug use in Sweden based on laboratory analysis--initial experiences from the STRIDA project. Scand J Clinical Investigation, 73(5): 400-406.
- Hels T, Lyckegaard A, Simonsen KW, Steentoft A, Bernhoft IM. 2013. Risk of severe driver injury by driving with psychoactive substances. Accident Analysis & Prevention, 59: 346-356.
- Hels, T., Bernhoft, I. M., Lyckegaard, A., Houwing, S., Hagenzieker, M., Ugent, S-A., Isalberti, C., Van der Linden, T., Verstraete. A. 2011. Risk of injury by driving with alcohol and other drugs. DRUID Deliverable D2.3.5. Copenhagen, DTU Transport.
- Kriikku P, Wilhelm L, Schwarz O, Rintatalo J. 2011. New designer drugs of abuse: 3,4-Methylenedioxypyrovalerone (MDPV). Findings from apprehended drivers in Finland. Forensic Sci Int, 201: 195-200.
- Marinetti LJ, Antonides HM . 2013. Analysis of Synthetic Cathinones Commonly Found in Bath Salts in Human Performance and Postmortem Toxicology. Journal of Analytical Toxicology, 1-12.
- Meuleners, L. B, Duke, J., Lee, A. H., Palamara, P., Hildebrand, J., Ng, J. Q. 2011. Psychoactive medications and crash involvement requiring hospitalisation for older drivers: A populationbased study. Journal of the American Geriatrics Society, 59, 1575-1580.
- Musshoff, F, Madea B, Kernbach-Wighton G, Bicker W, Kneisel S, Hutter M, Auwärter, V.2014. Driving under the influence of synthetic cannabinoids ("Spice"): a case series. Int J Legal Med, 128: 59-64.
- Orriols, L., Philip, P., Moore, N., Gadegbeku, B., Delorme, B., Mallaret, M., Lagarde, E. 2011. Benzodiazepine-like hypnotics and the associated risk of road traffic accidents. Clinical Pharmacology and Therapeutics, advanced online publication 2 March 2011.
- Ramaekers JG, Kuypers KPC, Bosker WM, Brookhuis KA, Veldstra JA, Simons R, Knoche A. 2012. Effects of stimulant drugs on actual and simulated driving: perspectives from four experimental studies conducted as part of the DRUID research consortium.. 3, s.l. : Psychopharmacology, 2012, Vol. 222. 413-418.
- Ray, W. A., Fought, R. L., Decker, M. D. 1992. Psychoactive drugs and the risk of injurious motor vehicle crashes in elderly drivers. American Journal of Epidemiology, 136, 873-883.
- Rothman, K. J., Greenland, S. 1998. Modern epidemiology. Second edition. Philadelphia, Lippincott Williams and Wilkins.
- Seely K A, Lapoint J, Moran JH, Fattore L. 2012. Spice drugs are more than harmless herbal blends: A review of the pharmacology and toxicology of synthetic cannabinoids s.l. : Progress in Neuro-psychopharmacology & Biological Psychiatry, 39, 234-2, 2012, Vol. 39. 234.
- Spaderna M, Addy PH, D'Souza DC. 2013. Spicing things up: Synthetic cannabinoids. Psychopharmacology, 228: 525-540.
- Szklo, M., Nieto, F. J. 2014. Epidemiology. Beyond the basics. Third edition.

- Tuv SS, Krabseth H, Karinen R, Olsen KM, Øiestad EL, Vindenes V. 2014. Prevalence of synthetic cannabinoids in blood samples from Norwegian drivers suspected of impaired driving during a seven weeks period. Accident Analysis & Prevention, 62: 26-31.
- Walsh JM, Gier JJ, Christopherson, AS, Verstraete AG. 2004. Drugs and driving. Traffic injury prevention, 5: 241-253.
- Yap S, Drummer OH. 2015. Prevalence of new psychoactive substances in Victorian fatallyinjured drivers. Australian Journal of Forensic Sciences, 48(2): 230-243.
- Zuba D., Bogumila, B. 2013. Prevalence and co-existence of active components of 'legal highs'. Drug Testing and Analysis, 5: 420-429.

Testing of drugs in road traffic injury

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Introduction

Drug presence testing ascertains whether a particular drug is present and in some cases at what concentration. An important factor is whether the legal framework allows random testing or requires a suspicion of drug impairment before a drug test can be administered. This chapter discusses the approaches to drug testing at the roadside and in hospital emergency rooms.

Approaches and issues in testing of drugs in road traffic injury settings

The first step in understanding and addressing drug-related driving involves ascertainment of the presence of drugs in the driver. The ability to determine presence of drugs has evolved greatly in recent years. Nevertheless, there are a variety of important issues to consider in determining the most appropriate and feasible methods of drug testing for use in specific situations.

Legal context

The legal context within which drug testing occurs can provide very important constraints on what tests are used and how they are used. Use of certain procedures can be enabled in law, for example in the case of a *per se* law which allows a specific test result by itself to be considered evidence of an offence. In the case of alcohol, *per se* laws are considered the basis of modern and effective deterrence-based approaches to preventing drink driving (Wickens et al, 2013). Additionally, evidence from drug tests can be used to make a case for drug-impaired driving in the absence of a specific *per se* law. Some jurisdictions provide for mandatory testing of injured drivers, including those who are fatally injured, which can yield important information for both medical and legal interventions, while other jurisdictions require approval processes, which are sometimes lengthy, to be followed.

Duration of action

The time over which drugs exert their effects, and also within which drug use can be detected play important roles in considerations of the most appropriate test for specific situations. In general, blood levels are considered the gold standard for assessing whether a drug is present, if recent use has occurred, or if behaviour has been affected by the drug. For legal purposes, research demonstrating skills impairment, altered driving behaviour and increased collision risk is necessary to support a *per se* law, for example, or more generally for use in court. Thus, an understanding of the pharmacodynamics and pharmacokinetics of individual drugs is needed, and correspondingly how various measures of drug presence relate to duration of action.

Accuracy of measurement: sensitivity and specificity

The accuracy of measures of drug presence and drug effects are key considerations. The sensitivity of a measure is the likelihood that the measure can detect actual use of a drug. In road safety context, sensitivity is also amended to include ability to detect use of a drug that has impaired driving skills. Thus, measures with high sensitivity are able to detect use or impairment with low rates of false negative responses. The specificity of a measure is the likelihood that it accurately identifies non-use of a drug, or lack of impairment. Measures with high specificity are

able to identify no drug use, or no use resulting in impairment, with a low rate of false positive responses. Ideal measures have both high sensitivity and high specificity.

Implementation and cost

There are several issues involved in implementing drug testing programs, including the costs associated with them. For example, routine drug testing of injured drivers (including those fatally injured) in most jurisdictions is not carried out, and important reasons for this are cost and availability of resources. Similarly, there are costs associated with implementing roadside drug testing programs, including those associated with purchase of equipment and also training of police officers that have been seen as prohibitive in some jurisdictions.

Introduction of new drugs

New psychoactive medicinal drugs are being introduced regularly, and the effects of these drugs on driving behaviour often takes time to ascertain. Similarly, development of the ability to detect these drugs takes time as well. Additionally, the development of new or related drugs for illicit drug users, in attempts to circumvent drug detection methods, is ongoing as well. Thus, detection methods must consider these developments and respond to them accordingly.

Measures of drug presence

Drug tests most commonly used are behavioural detection, urine, saliva and blood tests. Other means for testing presence of drugs exist, including hair and sweat analysis, but these are currently seldom used in a road safety context.

Behavioural tests

The first indication that a driver is under the influence of drugs is often through behavioural observation. Psychoactive drugs can create a variety of visible signs of their effects. Several standardized schedules of behavioural observations and tests have been created to assist in judgements of drug involvement, and in assessing which class of drugs may be involved. In North America, Standardized Field Sobriety Tests (SFST) and the Drug Evaluation Classification (DEC) Program was developed by the Los Angeles Police Department and implemented in the United States, Canada, as well as parts of Europe and Australia (Owusu-Bempah, 2014). Police officers who have been trained in the DEC program are called Drug Recognition Experts (DREs). In the United Kingdom, police officers can be trained to administer the Field Impairment Tests (FIT), a set of five tests that can provide a basis for a judgement of impairment by drugs (Jackson, Tunbridge and Rowe, 2000). These behavioural tests have the benefit of being able to assess impairment at or near the time a driver is apprehended. They identify classes of drugs that may be affecting driver performance. For example, the DRE examination identifies six classes of drugs: cannabis, hallucinogens, opiates, inhalants, CNS stimulants and CNS depressants. Porath-Waller and Beirness (2014) assessed the ability of the SFSTs to identify drug impaired drivers and concluded that they provided a valuable screening tool for this purpose. Owusu-Bempah (2014) reviewed evaluations of DEC classifications for cannabis specifically in both field and laboratory studies and found that sensitivity measures ranged from 30.4% to 93.8%, and specificity measures ranged from 59.1% to 98.2%.

Urine

Drugs or their metabolites can be detected in urine, and these measures have been and continue to be used to assess drug involvement in road safety and traffic enforcement contexts. Urine measures of drug use in general have excellent ability to detect recent use of a drug, with sensitivity and specificity measures exceeding 90%, and in the context of employment and sports testing, urine tests are considered widely acceptable for determining use of a drug (e.g., Phan et al, 2012). Some drugs or metabolites can be detected in urine for extended periods following use. For example, THC and metabolites can be detected for more than a month after use under some circumstances (Huestis et al, 1996). For this reason, urine drug measures may remain positive after the time when drug effects on driving skills have dissipated. Collection of urine samples at the roadside presents logistical challenges, and concerns about privacy, sample integrity, and potential exposure of police officers to health risks have been identified (Owusu-Bempah, 2014).

Saliva

Drug tests using saliva have been developed in recent decades in response to a desire for accurate and reliable test that can be easily administered at the roadside (Verstraete, 2005). A variety of saliva measures are now available and have been evaluated, and many jurisdictions now permit their use for screening and evidentiary purposes. These measures involve a sample obtained from a wipe of the tongue, or from collection of a specified amount of oral fluid, and results can be obtained at roadside. These measures are well-accepted by drivers and police and preferred over urine tests (Verstraete, 2005). Current saliva tests typically assess the presence of five or more drug classes (e.g., THC, cocaine, amphetamine, methamphetamine, benzodiazepines, morphine) and can detect at specified cutoffs (e.g., 5 ng/ml of THC). Following drug use, saliva tests can be positive for a period of several hours, which corresponds well to the period when impairment is observed (Verstraete, 2005). Evaluations of early versions of saliva tests found that sensitivity and specificity were too variable to recommend their routine use (Verstraete, 2005). However, the technology has advanced in recent years. In the DRUID study, 3 of the devices assessed were found to meet the criteria of >80% sensitivity and specificity for detecting the presence of any drug (Shulze et al. 2012). Kelley-Baker et al (2014) compared drug detection in blood and oral fluid in data from the U.S. 2007 National Roadside Survey. They found, for THC, amphetamine, cocaine, opiates and PCP, that sensitivity ranged from 44.4% to 100% and specificity ranged from 97.6% to 99.9%, and concluded that oral fluid measures were a reliable alternative to blood for testing.

Blood

Measures of drug levels in blood (serum, whole blood) are considered the gold standard for assessing recent drug use and impact (Walsh et al., 2008). Obtaining these measures involves drawing a sample of blood and submitting it for laboratory analysis. Pharmacodynamic studies have linked drug levels to behavioural effects and have been instrumental for establishing *per se* levels in jurisdictions where these have been identified (e.g., Wolff et al, 2013). Because of the procedures required to obtain blood samples, and the time and expense of conducting the tests, blood measures are most commonly used for confirmatory purposes. Often, the time required to obtain approval to take a blood sample, including finding appropriately trained personnel to obtain the sample, is a deterrent to their use. For example, blood THC levels can drop very rapidly after use. Wood et al (2016) reported that the time between request for a blood sample and the actual draw in a sample of traffic arrests in Colorado ranged between .83 and 8 hours, and perhaps as a result between 42% and 70% of all cases tested fell below the Colorado limit of 5 ng/ml THC in blood. In an effort to reduce the time required to obtain and process these samples, the state of Arizona has recently introduced a programme to train and certify police officers as phlebotomists.

Roadside drug testing

Roadside drug testing is the term given to the procedures used by enforcement bodies to identify and take action against road users that operate a vehicle after using drugs. The roadside drug testing procedures are usually defined and governed by a structured framework within the legal system of the jurisdiction in which the procedure operates. The types of legal frameworks introduced vary according to the social, legal and economic characteristics of a particular jurisdiction as well as the historical context of the development of laws designed to increase road user safety in that jurisdiction. Acknowledging the varying approaches taken to roadside drug testing, the approaches generally involve either testing for the presence of impairment or testing for the presence of a drug and, in some cases, a combination of both approaches is used. The use of the combination of the two approaches is often the result of a drug presence testing procedure being added to an existing impairment testing procedure.

The use of impairment testing has been the traditional approach used to identify and take action against road users that operate a vehicle after using drugs. Impairment testing may be used to identify impairment caused by drug use as part of the evidence gathering process for what is commonly referred to as driving under the influence (DUI) type laws. DUI type laws are focused on identifying drivers impaired by drug use to such an extent as to be incapable of controlling a vehicle safely. Impairment testing may also be used as a mechanism to identify drivers impaired by drug driving laws. In comparison to the DUI laws, *per se* type drug driving laws are primarily concerned with the concentration of a drug found present in a driver at the time of driving rather than the presence of impairment. A *per se* law sets the maximum level of a drug permitted to be present when driving. When the level of drug found present in a driver at the time of driving exceeds the permissible legal level, a breach of the *per se* law occurs. Alternatively, the level of a drug permitted to be present may be set at zero creating a total prohibition or 'zero tolerance' approach. In this case, the detection of the presence of the drug is sufficient to establish a breach of the *per se* law.

Impairment testing

The impairment testing procedures used to enforce DUI type laws and per se type laws are often similar. Impairment testing procedures usually involves a driver undergoing a number of psychomotor tests that are conducted in a structured and systematic manner. The psychomotor tests are used to identify impairment by assessing the psychomotor function of the driver and the presence of physiological signs of drug affect. In the Australian State of Victoria, a procedure known as a Drug Impairment Assessment (DIA) is used (see Box 5.1). The effectiveness of the Victorian DIA process to correctly identify of drug impaired drivers has been found to be comparable to the DEC program at 89% (Boorman and Papafotiou 2007).

The use of impairment testing procedures is considered to be effective for the identification of drug impaired drivers. An advantage of impairment testing is the ability to identify the presence of impairment caused by the use of a wide group of psychoactive drugs, both illegal and medicinal. However, comprehensive training is needed to administer impairment testing procedures correctly and the skills needed to administer the tests correctly, once acquired, need to be practiced frequently. The level of training and skills required to carry out the impairment tests usually confines the testing capability to select groups of enforcement personnel. In addition, the timeframe to complete impairment testing procedures correctly can be substantial. The training,

skillset and time needed to carry out impairment testing limits the use of impairment testing as a mechanism for screening large numbers of drivers for the presence of drugs or drug impairment.

Box 5.1

Roadside Drug Testing in Victoria, Australia

The drug testing of drivers at the roadside in the Australian State of Victoria is an example of an approach to roadside drug testing that involves both impairment testing and drug presence testing using oral fluid sampling. The drug driving countermeasures in Victoria largely follow the countermeasures implemented to tackle drink driving. Both the drink driving and drug driving procedures have an impairment based DUI type law component and a drug presence per se type law component. The DUI type law component is concerned with the identification of the actual effect of drugs on safe driving ability. The per se type law component is concerned with the increased risk of crash involvement as a result of the presence of an illicit drug in comparison to the risk of crash of a drug free driver. The active element is the prohibition of the presence of particular illicit drugs above a prescribed level. The prescribed drug level in Victoria is zero, creating a 'zero tolerance' approach to driving with the particular illicit drugs present.

Victoria has had a DUI type drug law since 1949. The law created a DUI drug offence but did not prescribe procedures for the collection of evidence to prove a DUI drug charge. Consequently, only cases where severe impairment was present were prosecuted. The recognition of drugs as a significant road safety concern prompted the introduction of a new offence of drive while impaired by a drug and a roadside drug impairment testing procedure in 2000. The impairment testing procedure is a comprehensive and structured evidence gathering procedure known as a Drug Impairment Assessment or DIA. The DIA procedure consists of a roadside impairment assessment, an evidential breath analysis, a standard impairment assessment involving an interview and observation, SFST psychomotor tests and an information review process. Where the DIA indicates impairment is present, body samples are taken for laboratory analysis. In cases where no drugs are found, the matter is referred to the licensing authority for medical assessment of the driver. Figure 1 illustrates the DIA procedure.

Figure 5.1 DIA impairment testing procedure



DIA Impairment Testing Procedure

Figure 5.1 DIA impairment testing procedure

The DIA procedure has been found to be effective in identifying and prosecuting drug impaired drivers as indicated above. However, the DIA procedure primarily operates as a specific deterrence program. It allows drug impaired drivers to be detected and sanctioned but it is largely unseen by the general population. The DIA procedure does not operate as an effective general deterrence mechanism to influence the behaviour of the actual and potential drug driving population. The DIA procedure is also enforcement time and resource intensive.

Random roadside breath alcohol screening has been a feature of the alcohol related road trauma reduction strategy in Victoria since 1976. The implementation of a visible - high volume roadside alcohol testing program to achieve a high level of general deterrence and driver behaviour change has seen the involvement of alcohol in road trauma decrease substantially (e.g., Homel, 1990). The number of driver deaths with an alcohol concentration at or above .05 present has decreased from 187 in 1977 to 35 in 2012. The success of the roadside alcohol testing program led to the introduction of a new per se zero tolerance law in 2004. The new per se law prohibits driving with prescribed illicit drugs present at any level. Initially, the drugs prescribed were methylamphetamine (MA) and the active metabolite of cannabis, delta-9-tetrahydrocannabinol (THC). The illicit drug, 3, 4-methylenedioxymethamphetamin (MDMA) was added in 2006. The law also authorised use of oral fluid testing to screen drivers at the roadside for the presence of the prescribed illicit drugs without any suspicion of impairment at random. The roadside drug testing procedure was integrated into the roadside alcohol screening program to achieve a highly

visible - high volume roadside testing program to achieve general deterrence and driver behaviour change in both alcohol and drug using populations.

The roadside oral fluid drug testing procedure is a three stage process that commences after an alcohol screen test has been carried out. An oral fluid screening test is conducted while the driver remains with their vehicle. If the result of the test is negative, no further action is taken. If the test is positive, the driver provides a second sample that is tested at the roadside. If the second test is negative the driver is not detained further. If the second test is positive, the driver is prohibited from driving and a portion of the second sample is sent to a laboratory for confirmatory analysis. If the laboratory analysis is negative, the driver is not prosecuted. If the analysis is positive the driver is prosecuted. The roadside oral fluid testing procedure has been found to be effective in detecting drivers with one or more of the three prescribed illicit drugs present (Boorman and Owens 2009). Figure 5.2 illustrates the roadside oral fluid drug testing procedure.

Figure 5.2

Roadside oral fluid testing procedure



Roadside Oral Fluid Testing Procedure

Figure 5.2 Roadside Oral Fluid Testing Procedure

In 2005, the first full year of roadside testing for the presence of drugs, 13,158 drivers were roadside drug tested with 2.3 percent (n=300) found to have one or more of the three prescribed illicit drugs present. The number of drivers tested each year progressively increased. In 2009, the number of drivers screened for drugs reached 27,881 with 15% (n=296) found to have one or more of the three prescribed illicit drugs present. Over the same period, 2005 to 2009, the percentage of driver deaths with the target illicit drugs present progressively decreased from 24% in 2005 to 15% in 2009. In 2010 the roadside drug testing moved away from being primarily a general deterrence program to having a more detection specific deterrence focus. The number of

drivers tested continued to increase and so did the number of drivers detected with drugs present. In 2013, 39,471 drivers were roadside drug tested with 6.4% (n=2,522) found to have drugs present. Over the same period, 2009 to 2013, the percentage of driver deaths with the target illicit drugs present progressively increased from 15% in 2009 to 32% in 2013. The roadside screening of drivers for the presence of alcohol continued to operate as a highly visible – high volume general deterrence program over the period 2005 to 2013. The percentage of driver deaths with an alcohol concentration at or above .05 present decreased from 32% in 2005 to 20% in 2013.

As of 2015, the roadside drug testing program in Victoria is returning to a primarily prevention based general deterrence program. The number of drivers to be roadside drug tested has been increased to 100,000 with 80% of tests to be carried out in highly visible - high volume general deterrence operations and the remaining 20% of tests carried out in detection focused specific deterrence operations.

Drug presence testing

Drug presence testing is not concerned with the presence of impairment. The key issue is whether a particular drug is present and in some cases at what level. Drug presence testing is only concerned with the identification of drivers that are driving with a drug present in their body. An important factor in drug presence testing is whether the legal framework requires a suspicion of drug impairment before a drug test can be administered or whether a driver can be required to undergo a drug test at random. Another important factor is the location a drug test can be administered. In some cases testing for impairment at the roadside is required to give rise to a suspicion of drug impairment before progressing to another location for further testing and the taking of body samples for laboratory analysis. In other cases, body samples are obtained for drug screening at the roadside or subsequent laboratory analysis. Traditionally, urine samples have been the main roadside sampling medium with blood sampling being used less often. More recently, oral fluid sampling is being used for roadside drug screening of drivers and confirmatory laboratory analysis. In comparison to blood and urine, oral fluid has the advantage of being relatively non-invasive, can be collected anywhere and without medical or specialist qualifications.

Drug testing in injured road users in an emergency room

Pre-injury drug use tends to be associated with higher infection and complication rates, resulting in greater length of stay and higher hospitalisation costs (Cowperthwaite and Burnett, 2011). This may be from impaired systemic responses by the central nervous, cardiovascular, and the respiratory system in particular to the trauma, as well as from a general predisposition to infectious diseases such as HIV and tuberculosis (De Wit et al., 2008; Centre for Substance Abuse Treatment, 1995), which may be underpinned by risky lifestyles, immune-suppression, and nutritional deficiencies. Signs and symptoms of drug impairment may mimic that of traumatic brain injury and hence lead to misdiagnosis of serious injuries. For example, the signs and symptoms of cervical spine injury could be masked in patients exhibiting an exaggerated threshold to pain from their drug usage. As a result, pain management and the use of anaesthetics may be complicated. Withdrawal symptoms such as fever may also mimic other conditions, and agitation may aggravate existing trauma such as spinal cord injury (Centre for Substance Abuse Treatment, 1995).

The Emergency Room (ER) provides a vital contact with the healthcare system, and a window of opportunity deemed a "teachable moment" whereby the patient makes the connection between the injury event and his/ her drug use, rendering them more receptive to brief interventions and

referrals related to their drug use (Centre for Substance Abuse Treatment, 1995; Gentilello et al., 1998, Reyna, Hollis Jr and Hulsebus, 1985, Soderstrom and Cowley, 1987).

From a public health and epidemiological surveillance perspective, routine ER screening allows for monitoring the nature, extent and emerging drug-driving priorities to inform targeted population-based interventions for preventing future drug driving injuries. In recognition of the importance for treatment and prevention, some ER settings, for example the University of Maryland Medical Centre in the US, require for all patients presenting with trauma to be tested for alcohol and other drugs as part of the clinical protocol (Walsh et al., 2005, Walsh, et al., 2004).

Methodological challenges with research and testing

Methodological challenges faced in drug research and testing are discussed below.

Research methods and representativeness of cases tested in the ER

From a research perspective, routine epidemiological data from ERs tend to suffer from a range of biases and lack of standardisation. Methodological challenges with drug testing may relate to methods adopted, drug types considered, cut-off values used, and time lapse between substance use and presentation to the ER. Design related challenges may relate to sample selection bias where samples are not randomly selected, and thus not being representative and comparable; disparate inclusion and exclusion criteria adopted; and non-response bias due to varying levels and reasons for non-participation. Further to routine epidemiological screening, clinical trials trend to suffer from difficulties with identifying adequate non-injured drug-using controls that represent the general population. Consistency in reporting findings is also a challenge such as in the case of percentages that may be calculated for all drivers in the sample versus all that were tested.

Methods for testing

The use of blood samples provides a better estimate of drug levels in the central nervous system and an indication of recent intake as compared to urine samples, and when the time of intake is known, the dosage may also be estimated (Bogstrand, et al., 2011). The varying half lives would need to be considered, as some with very short half lives may be missed when the presentation time to the ER is delayed.

Half lives of drugs vary considerably. Reported half lives range from 1 to 30 hours for psychoactive drugs, except for THC that has a half-life of 20–57 hours for infrequent users and 3–13 days for heavy users (Baselt, 2008). Gas chromatography/ mass spectrometry methods are generally regarded as the gold standard for confirmation analysis (Wong, et al., 2010, Walsh et al., 2008). With urine samples, it is generally difficult to link injuries with the use of drugs due to some tests being sensitive to the inactive metabolites of illicit drugs. As a result, a positive test finding from a urine immunoassay may merely be an indication of prior exposure to the illicit drug. Urine specimens could however provide the basis for identifying and excluding a history of prior drug usage (Walsh et al. 2008) and may be of benefit for epidemiology and interventions, including brief interventions and referrals.

Challenges with multiple drug usage

Testing and managing patients with drug-related trauma from the use of multiple substances including alcohol proves to be a challenge due to the potential widespread synergistic effects,
which are largely not known. Some drug combinations are unique to certain settings, for example, the smoking of mandrax (methaqualone) mixed with cannabis, known as "white-pipe" in South Africa (Peden, et al., 2000). Unique to the South African context is also a novel cocktail drug called *nyaope*, also commonly known as *whoonga*, which is sold in powder form, and smoked with cannabis (Mokwena, 2015). Analysis of samples have shown the presence of a wide range of substances in the cocktail, including caffeine, illicit drugs (opiates, codeine, morphine, methyl-dioxy amphetamine (MDA) and heroin); stimulants, various central nervous system depressants, antibiotics, and antiretroviral drugs (zidovudine). Of concern is that untreated HIV-infected patients that use antiretroviral drugs recreationally are at risk for developing resistance to these drugs that would otherwise help treat their HIV-AIDS infection (Larkan, Van Wyk and Saris, 2010).

Ethical and legal considerations with screening ER patients for drugs

Many countries or regions such as South Australia (Ch'ng, et al., 2007; Christophersen et al., 1995) and several OECD countries (Beirness, Swan and Logan, 2010) have laws and clinical management protocols allowing for the compulsory blood testing of trauma patients that includes checking for the presence of illicit drugs. Many states of the US have provisions in their insurance policies such as the Alcohol Exclusion Clause, embedded in the Uniform Accident and Sickness Policy Provision Law (UPPL) allowing insurers to deny payment for medical care if an injured patient is found to be under the influence of drugs or alcohol (Rivara et al., 2000). Such laws and practices are a major barrier to screening injured patients for drug and alcohol impairment, and also have implications for the anonymity and confidentiality of patient care data.

A further ethical dilemma from a research perspective is the requirement of obtaining prospective informed consent from patients. ER patients may be considered a special category of vulnerable persons due to their diminished capacity to provide consent as a result of post injury factors such as physical and emotional distress or a depressed level of consciousness (Morrison, Horwitz and Carrick, 2009) and thus surrogate consent may be required.

Conclusion

Testing and/or detecting drugs can be done at the roadside and in hospital emergency rooms to determine the extent of drug use among drivers and other road users. It is important to continuously detect and monitor the trend in the use of drugs among drivers and other road users to determine the scale of the problem and to develop appropriate measures. However, legal and ethical factors are important considerations in routine screening, and should be given sufficient attention.

References

- Babor TF, Kadden RM. Screening and interventions for alcohol and drug problems in medical settings: what works? Journal of Trauma and Acute Care Surgery. 2005; 59(3): S80-S87.
- Baselt RC. Disposition of Toxic Drugs and Chemicals in Man. Biomedical Publications, Foster City, CA. 2008.
- Beirness D, Swan P, Logan B. Drugs and driving: Detection and deterrence. 2010.
- Bernstein E, Woodall WG. Changing perceptions of riskiness in drinking, drugs, and driving: An emergency department-based alcohol and substance abuse prevention program. Annals of emergency medicine, 1987; 16(12): 1350-1354.
- Bogstrand ST, Normann PT, Rossow I, Larsen M, Morland J, Ekeberg O. Prevalence of alcohol and other substances of abuse among injured patients in a Norwegian emergency department. Drug Alcohol Depend. 2011; 117:132–138.
- Boorman, M and Owens, K 2009, 'The Victorian Legislative Framework for the Random Testing Drivers at the Roadside for the Presence of Illicit Drugs: An Evaluation of the Characteristics of Drivers Detected from 2004 to 2006', Traffic Injury Prevention, vol. 10, no. 1, pp. 16-22.
- Boorman, M and Papafotiou, K 2007, 'The Victorian Legislative Framework for Testing Drivers for Impairment Caused by Drugs Other than Alcohol: An Evaluation of the Characteristics of Drivers Detected from 2000 to 2005', Traffic Injury Prevention, vol. 8, no. 3, pp. 217-223.
- Center for Substance Abuse Treatment. Alcohol and other drug screening of hospitalised trauma patients (Vol. 16). US: Dept of Health and Human Services, Public Health Service, Substance Abuse and Mental Health Services Administration; 1995.
- Ch'ng CW, Fitzgerald M, Gerostamoulos J, Cameron P, Bui D, Drummer OH, et al. Drug use in motor vehicle drivers presenting to an Australian, adult major trauma centre. Emergency Medicine Australasia. 2007; 19(4): 359-365.
- Christophersen AS, Beylich KM, Bjorneboe A, Fosser G, Glad A, Morland J. Prevalence of alcohol and drugs in blood samples from Norwegian drivers involved in road traffic accidents. Alcohol, Drugs and Traffic Safety-T95. Adelaide. 1995; 34.
- Compton, RP 1986, Field evaluation of the Los Angeles Police Department drug detection program, U. S. Department of Transportation, National Highway Traffic Safety Administration, DOT HS 807 012
- Cowperthwaite MC, Burnett MG (2011). Treatment course and outcomes following drug and alcohol-related traumatic injuries. J Trauma Manag Outcomes. 2011; 5(3).
- De Wit M, Gennings C, Zilberberg M, Burnham EL, Moss M, Balster RL. Drug withdrawal, cocaine and sedative use disorders increase the need for mechanical ventilation in medical patients. Addiction. 2008; 103(9): 1500-1508.
- Gentilello LM, Duggan P, Drummond D, Tonnesen A, Degner EE, Fischer RP, et al. Major injury as a unique opportunity to initiate treatment in the alcoholic. The American Journal of Surgery. 1998; 156(6): 558-561.
- Hels T, Lyckegaard A, Simonsen KW, Steentoft A, Bernhoft IM. Risk of severe driver injury by driving with psychoactive substances. Accident Analysis and Prevention. 2013; 59: 346-356.
- Homel, R. Random breath testing and random stopping programs in Australia. In R.J. Wilson and R.E. Mann (eds.), Drinking and Driving: Advances in Research and Prevention, Guilford Press, New York, 1990, 159-202.
- Huestis MA, Mitchell JM, Cone EJ (1996). Urinary excretion profiles of 11-nor-9-carboxy-delta 9-tetrahydrocannabinol in humans after single smoked doses of marijuana. J Anal Toxicol. 20:441–52.
- Jackson PG, Tunbridge RJ, Rowe, DJ (2000). Drug recognition and field impairment testing: Evaluation of trials. In Alcohol, drugs and traffic safety. Proceedings of the 15th International Conference on alcohol, drugs and traffic safety, Stockholm, Sweden.

- Kelley-Baker T, Moore C, Lacey JH, Yao, J (2014). Comparing drug detection in oral fluid and blood: data from a national sample of nighttime drivers. Traf Inj Prev. 15: 111-118.
- Larkan F, Van Wyk B, Saris J. Of remedies and poisons: recreational use of antiretroviral drugs in the social imagination of South African carers. African Sociological Review. 2010; 14(2): 62-73.
- Lowenstein SR, Koziol-McLain J. Drugs and traffic crash responsibility: a study of injured motorists in Colorado. Journal of Trauma and Acute Care Surgery. 2001; 50(2): 313-320.
- Madras BK, Compton WM, Avula D, Stegbauer T, Stein JB, Clark HW. Screening, brief interventions, referral to treatment (SBIRT) for illicit drug and alcohol use at multiple healthcare sites: comparison at intake and 6 months later. Drug and alcohol dependence, 2009; 99(1): 280-295.
- Marais S, Sukhai A, Donson H. Monitoring alcohol and other substance use in South Africa: The alcohol and drug injury nexus. Crime, violence and injury prevention in South Africa: developments and challenges; 2004.
- Martin G, Copeland J. The adolescent cannabis check-up: randomized trial of a brief intervention for young cannabis users. Journal of substance abuse treatment. 2008; 34(4): 407-414.
- Mokwena KE. The Novel Psychoactive Substance 'Nyaope' Brings Unique Challenges to Mental Health Services in South Africa. International Journal of Emergency Mental Health and Human Resilience. 2015; 17(1): 251-252.
- Morrison CA, Horwitz IB, Carrick MM. Ethical and legal issues in emergency research: barriers to conducting prospective randomized trials in an emergency setting. Journal of Surgical Research, 2009; 157(1): 115-122.
- Owusu-Bempah A (2014). Cannabis impaired driving: An evaluation of current modes of detection. Can J Criminol. 56: 219-240.
- Peden M, Van der Spuy J, Smith P, Bautz P. Substance abuse and trauma in Cape Town. South African Medical Journal. 2000; 90(3): 251-255.
- Phan HM, Yoshizuka K, Murry D.J, Perry PJ (2012). Drug testing in the workplace. Pharmacotherapy. 32: 649-656.
- Porath-Waller A J, Beirness DJ. (2014), An examination of the validity of the standardized field sobriety test in detecting drug impairment using data from the drug evaluation and classification program. Traf Inj Prev. 15: 125-131.
- Pulido J, Barrio G, Lardelli P, Bravo MJ, Regidor E, de la Fuente L. Association between cannabis and cocaine use, traffic injuries and use of protective devices. The European Journal of Public Health. 2011; 21(6): 753-755.
- Reyna TM, Hollis Jr HW, Hulsebus RC. Alcohol-related trauma. The surgeon's responsibility. Annals of surgery. 1985; 201(2): 194.
- Rivara FP, Tollefson S, Tesh E, Gentilello LM. Screening trauma patients for alcohol problems: are insurance companies barriers? Journal of Trauma and Acute Care Surgery. 2000; 48(1): 115.
- Schulze H, Schumacher M, Urmeew R, Alvarez J, Bernhoft IM, de Gier, Hagenzieker M, Houwing S, Knoche A, Pilgerstorfer M, Zlender B (2012). Driving under the influence of drugs, alcohol and medicines in Europe—findings from the DRUID project.Lisbon, European Monitoring Centre for Drugs and Drug Addiction.
- Schulze H, Schumacher M, Urmeew R, Alvarez J, Bernhoft, de Gier, H DG, et al. Driving under the influence of drugs, alcohol and medicines in Europe—findings from the DRUID project. European Monitoring Centre for Drugs and Drug Addiction. 2012.
- Soderstrom CA, Cowley RA. A national alcohol and trauma center survey: missed opportunities, failures of responsibility. Archives of Surgery. 1987; 122(9): 1067-1071.
- The Drug Evaluation and Classification Program, viewed 16 July 2015, http://www.theiacp.org/portals/0/pdfs/DECProgramHandout.pdf

- Verstraete AG. (2005), The results of the roadside drug testing assessment project. In Wong, RC and Tse HY, editors, Drugs of Abuse (pp. 271-292). Humana Press.
- Walsh JM, Flegel R, Atkins R, Cangianelli LA, Cooper C, Welsh C, et al. Drug and alcohol use among drivers admitted to a Level-1 trauma center. Accident Analysis and Prevention. 2005; 37(5): 894-901.
- Walsh JM, Flegel R, Cangianelli LA, Atkins R, Soderstrom CA, Kerns TJ. Epidemiology of alcohol and other drug use among motor vehicle crash victims admitted to a trauma center. Traffic injury prevention. 2004; 5(3): 254-260.
- Walsh JM, Verstraete AG, Huestis MA, Morland J. Guidelines for research on drugged driving. Addiction. 2008; 103: 1258–1268.
- Wickens CM, Mann RE, Stoduto G, Flam-Zalcman R, Butters J. (2013). Alcohol control measures and traffic safety. In Boyle P, Boffetta P, Zatonski W, Lowenfels A, Brawley O, Burns H, Rehm J, editors, Alcohol: Science, policy and public health, Oxford, Oxford University Press, 378-88.
- Wolff K, Brimblecombe R, Forfar JC, Forrest AR, Gilvarry E, Johnston A, Morgan J, Osselton MD, Read L, Taylor D (2013). Driving under the influence of drugs: Report from the expert panel on drug driving. London, Department for Transport.
- Wong OF, Tsui KL, Lam T S, Sze NN, Wong SC, Lau FL, et al. Prevalence of drugged drivers among non-fatal driver casualties presenting to a trauma centre in Hong Kong. Hong Kong medical journal. 2010; 16(4): 246-251.
- Wood, E., Brooks-Russell, A., & Drum, P. (2016). Delays in DUI blood testing: Impact on cannabis DUI assessments. *Traffic injury prevention*, *17*(2), 105-108.
- Woolard R, Baird J, Longabaugh R, Nirenberg T, Lee CS, Mello MJ, et al. Project reduce: reducing alcohol and marijuana misuse: effects of a brief intervention in the emergency department. Addictive behaviours. 2013; 38(3): 1732-1739.
- Woratanarat P, Ingsathit A, Suriyawongpaisal P, Rattanasiri S, Chatchaipun P, Wattayakorn K., et al. Alcohol, illicit and non-illicit psychoactive drug use and road traffic injury in Thailand: a case-control study. Accident Analysis and Prevention. 2009; 41(3): 651-657.

Conclusion

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There is a growing concern about the contribution of drug use to road traffic injury risk. Specifically, the background working papers presented in this appendix show that drug use has serious consequences for road safety, and is a contributory factor in several road traffic deaths. The working papers also show that there is more to be done in research, legislation and enforcement of drug-driving laws. This section provides a summary of the main findings of working papers and draws up conclusions.

Drug use among the driving population

While levels of reported drug taking vary from country to country, and it should be noted that this data often relies on self-reporting, which itself may be inaccurate, it can be concluded from the evidence presented that a non-negligible part of the driving population drives with some level of drugs in their body. This has led to growing concern across the globe about this growing trend, and many countries have made efforts to tighten their laws around drug driving to try to address this issue.

Drug driving is of concern to many countries, not only due to the dangers arising from individuals driving under the influence of drugs, but also because the use itself of these drugs is, in many cases, illegal. While the types of illicit drugs used across the world vary according to the particular country, cannabis is most commonly associated with drug taking in most countries that have been looked at in the working papers, followed by cocaine.

The effects of drug use on driving ability

To understand the dangers posed by driving while under the influence of these substances, it is important to fully evaluate the effect taking these drugs has on a driver's perception, judgment and overall driving ability. A number of studies have shown that cannabis use impairs cognition, including lateral vehicle control time, time estimation, balanced decision making and sustained attention. In practice, this could mean a driver under the influence of THC may not be able to judge and maintain a safe distance between their vehicle and other vehicles on the road, may not be able to accurately judge the time it will take for them to complete a manoeuvre (for example emerging from a junction or entering a roundabout) before another vehicle crosses their path, and may not be paying due attention to the road.

The use of other psychoactive drugs has an equally negative effect on driver behaviour. Taking psychoactive drugs can alter reaction times (in most cases delaying the time a driver will take to react to a situation on the road), reduce perceptual-motor coordination, reduce a driver's ability to control their vehicle, and increase risk-taking behaviour. A further complication when considering the effect of drug use on driver behaviour is that different substances will affect driving ability in different ways. For example, hallucinogens may induce in a driver psychosis or catatonia, and ketamine can alter eye movement, visual perception and decreasing ability to trace the road and associated objects. Studies have also made a significant link between opioid use and road traffic collisions, and several studies have found amphetamine and methamphetamine posed the highest road traffic crash risk of all drugs. It is not only psychoactive drugs that can pose a problem to the safety of roads. It has also been observed that depressants or sedatives can hamper driving ability by inducing in a driver drowsiness, cognition impairment, and decreased motor function.

Poor awareness of the effects of psychoactive drugs on driving ability is common. In many cases, drivers are unaware of the effect that drug use has on their driving ability, and may choose to continue to drive under the influence of drugs, sometimes even believing that drug taking will enhance their driving performance. This can have serious, and sometimes fatal, consequences for the driver and others on the road.

A significantly increased risk of road traffic collisions has been found among those who have used drugs. Those who had been involved in a collision while driving under the influence of THC, the drug most commonly associated with illicit drug use, were between three and seven times more likely to be responsible for the collision, particularly where they had consumed high doses of the drug, when compared to drivers that had not used drugs or alcohol. There is also a significantly increased risk of fatal collision involvement when a driver is under the combined influence of drugs and alcohol.

Given that the potential impacts of driving under the influence of drugs can have catastrophic and longlasting consequences, many countries have chosen to establish laws to control driving under the influence of drugs, often adopting a 'zero tolerance' approach to the use of illicit drugs when driving.

Detection and enforcement of drug use in the driving population

The detection of drug influence on a driver is often made by observation of a driver's behaviour. As already noted, the effects of drug use on driving ability are varied and wide-ranging, and can lead to a driver making a number of errors. Often, drug use is detected when there has been a collision, and one or more parties is suspected of being under the influence of drugs.

Roadside detection methods vary, with some countries using tests designed to identify physical and mental impairment to detect those likely to have used drugs, and others, such as the United Kingdom and Australia, also using roadside screening equipment to test for the presence of certain substances.

To ascertain the precise levels of a substance in a driver's body (and to determine whether there is a drug present in the absence of a roadside screening device), tests must be undertaken on a driver's blood, oral fluid or urine. This is usually done at a location other than the roadside, for example, in a police station or a hospital setting. It is widely acknowledged that blood represents the 'gold standard' testing matrix; however, it is not without its challenges. In particular, the time taken between a driver being identified as suspected of driving under the influence of drugs, and a sample of blood (or an alternative matrix) being taken can vary widely. This can be due to the need for a specialist practitioner, for example, a nurse or other healthcare professional, to take the sample, as in the case of blood. This can pose problems as the delay in obtaining the sample may mean the amount of drug present in the body has decreased, and may not provide an accurate representation of the state of the driver when stopped.

Testing a driver who has been injured or killed in a collision can also prove problematic, with some jurisdictions providing for mandatory testing of such driver and others requiring approval. This may further be masking the true extent to which drug use plays a role in road traffic collisions.

Securing a conviction can often be difficult, especially when a country's laws rely on the ability of the prosecuting authority to prove that the driver was impaired, and that this impairment was due to drugs. *Per se* laws can help to make the route to conviction easier, as they rely only on the presence of the drug in the driver's body, provided it is above a specified level. This can be a less time-consuming and costly way to secure a conviction when compared with the 'proof of impairment' laws.

However, testing for drugs is often still very costly. This is an area that is relatively new in comparison to drink-driving law, and as such the costs of testing are significantly higher than those associated with drinking and driving. To reduce costs, some countries have chosen to focus testing on those drugs that are commonly associated with illicit drug use in their particular jurisdictions.

Deterring drug impaired drivers from committing the same offence is an important opportunity in reducing drug-driving rates. Some countries require drivers convicted of drink- or drug-driving offences to complete rehabilitation or educational programmes before being able to reacquire their driving licence. This is the case in Ontario, Canada. Use of this type of programme for drug-driving is fairly recent; at this stage it is too early to evaluate its efficacy. However, similar programmes targeted at alcohol impaired drivers have proven to be effective, and so it is reasonable to assume drug-driving behaviour may follow a similar pattern.

Areas for further research and action

It is clear that the presence on the roads of drivers who are under the influence of drugs presents a serious threat to road safety. To effectively combat this threat, increased understanding is needed on the effects of driving under the influence of psychoactive drugs on the performance of drivers.

Better understanding of the global problem

In many countries fatally injured drivers are not routinely tested for the presence of psychoactive drugs. This disparity in testing and reporting practices means that the extent of the impact of driving under the influence of drugs is not yet fully understood, and how this varies from country to country. It is likely, therefore, that the true extent of this problem is grossly understimated.

Further knowledge gaps exist, including on risk of collision by dose of drugs taken, the thresholds at which drug use impairs driving ability, and the causal link between drug use and collision rate. More research is needed in these areas.

Legal drugs and medicinal marijuana

There is also further research to be done into the effects prescription medications can have on driving ability and collision risk, and how to legislate to cover impairment by both licit and illicit psychoactive substances. This issue is crucial as there has been an increase in the number of people using prescribed psychoactive drugs that can impair driving ability, such as psychoactive medicines, particularly in high-income countries.

The effects of drug taking in conjunction with alcohol consumption

One area which has received little attention thus far, but will be crucial to understanding the full extent of the risks posed by drug driving, is the effects of combining drug use and alcohol consumption. It has been shown that the effects of drug use on driving ability are amplified when the driver has also consumed alcohol, but more research is needed into the thresholds at which this amplification occurs, and the effects this has on driver impairment.

Consideration should also be given to how legislative regimes are tailored to deal with combination alcohol and drug use when driving. The state of Victoria, Australia, enforces a lower blood alcohol limit when a driver also tests positive for drugs. At present, most countries do not have separate blood alcohol limits for drivers who also have drugs in their system.

More research is also needed into the effects of using multiple drugs on driving ability, and the levels at which consumption of more than one substance alters the effect on driver impairment.

New technologies

As new technologies emerge, for instance in the medical sector, it will be important to consider their potential use in drug testing and enforcement. Work is already underway in a number of countries to consider alternative testing matrices for drug-driving, including the use of oral fluid as a potential alternative to blood, and to consider alternative ways of detecting drug use among drivers.

Overall conclusion

While great advances in drug driving policy, legislation and enforcement have occurred over recent years, there is still a significant amount of knowledge to be gained on the true extent and effect of drug use on road safety. The background working papers have identified several key issues of public health relevance known to date, and highlighted areas for future research to facilitate better understanding of the issues, which can then be used to inform policy formation, implementation and enforcement practices.