



European
Commission



Thematic Report
Alcohol and drugs



This document is part of a series of 20 thematic reports on road safety. The purpose is to give road safety practitioners and the general public an overview of the most important research questions and results on the topic in question. The level of detail is intermediate, with more detailed papers or reports suggested for further reading. Each report has a 1-page summary.

Contract:	This document has been prepared in the framework of the EC Service Contract MOVE/C2/SER/2022-55/SI2.888215 with National Technical University of Athens (NTUA), SWOV Institute for Road Safety Research and Kuratorium für Verkehrssicherheit (KFV).
Version	30 January 2024
Author	Original and update: Charles Goldenbeld (SWOV)
Internal Review:	Katerina Folla (NTUA)
External Review:	Uta Meesmann (Vias institute)
Referencing:	Reproduction of this document is allowed with due acknowledgement. Please refer to the document as follows: <i>European Commission (2023). Road safety thematic report – Alcohol and drugs. European Road Safety Observatory. Brussels, European Commission, Directorate General for Transport.</i>

Disclaimer

Whilst every effort has been made to ensure that the matter presented in this document is relevant, accurate and up to date, the (sub)contractors cannot accept any liability for any error or omission, or reliance on part or all of the content in another context.

Any information and views set out in this document are those of the author(s) and do not necessarily reflect the official opinion of the European Commission. The Commission does not guarantee the accuracy of the data included in this study. Neither the Commission nor any person acting on the Commission's behalf may be held responsible for the use that may be made of the information contained therein.

© European Commission, 2024.

The EU does not own the copyright in relation to the following elements:

- Cover page photos, © www.shutterstock.com

Contents

Summary	4
1. What is the problem?	5
1.1 Definition and measurement	5
1.2 Extent of problem.....	5
1.3 Effects of impairment.....	6
1.4 What is the prevalence of impaired driving?	7
2. How dangerous is impaired driving?	8
2.1 Share of impairment-related crashes.....	8
2.2 Cognitive effects	8
2.3 Crash risk	9
2.4 Features of impairment-related crashes.....	11
3. Why do drivers drive while impaired?.....	12
4. Rules and legislation	13
5. Counter measures.....	13
5.1 Decreasing alcohol and drugs consumption	13
5.2 Regulation and police enforcement	14
5.3 Responsible driving with medicines	15
5.4 Alternative means of transport	15
5.5 Campaigns, rehabilitation, safety culture	16
5.6 Vehicle technology.....	16
6. Further reading	18
7. References.....	18

Summary

Impairment due to alcohol and/or drugs is a major cause of motor vehicle crashes worldwide. Alcohol, illegal drugs and various prescribed drugs (medicines) impair driver's functional capabilities including reaction time, tracking ability, vision, divided attention and vigilance, which leads to increased crash risk.

The crash risk for drivers with a blood alcohol concentration (BAC) of 0.5 g/L is estimated to be 1.4 times higher than that of a sober driver; at 1.0 g/L nearly 5 times higher; and at 1.5 g/L around 20 times higher. For fatal crashes, the risk curve is even steeper. The crash risk associated with drugs depends on the type of drug. The greatest risk increases for illegal drugs - at least 5 times higher - were found for amphetamines, multiple drug use, and combined alcohol-drugs use. For medicines, risk increases were found for barbiturates (used for headaches/insomnia), benzodiazepines (for anxiety/insomnia), anti-depressants, and opioids/opiates (for pain/sleeping problems).

It has been estimated that 1.5 to 2% of kilometres travelled in the EU are driven with an illegal BAC. This equates to millions of drivers under the influence of alcohol. Around 25% of all road deaths in the EU are alcohol-related. On the positive side, alcohol-related fatalities have decreased somewhat faster than the number of other fatalities. The evidence on the development of drug-related traffic fatalities in EU-countries is scarce. Recent roadside surveys among randomly stopped drivers in EU-countries show alcohol prevalence rates between 0.3-2.7% and drug prevalence rates between 6.0 - 11%.

The reasons people engage in impaired driving reflect the opportunities that society provides for this, as well as personal choice or motivation. In regard to the repeat offenders group, medical (psychiatric) problems related to problematic alcohol and drugs use often underly their habitual pattern of impaired driving.

Countermeasures against impaired driving include: Policies to decrease the consumption of alcohol/drugs, to reduce drink/drug use before driving, strict legislation backed by police enforcement, provision of alternative transport means, awareness campaigns, rehabilitation courses, safety culture in companies, alcohol interlocks, and in-vehicle technology that warns/intervenes when impairment leads to critical events. Measures often work better in combination than when implemented individually, e.g. enforcement combined with campaigns, alcohol interlock combined with medical and psychological guidance.

1. What is the problem?

1.1 Definition and measurement

Impaired driving can be defined as a reduction in the performance of critical driving tasks due to the effects of alcohol or other drugs (Baker, 2007). In this report the term 'drugs' refers to alcohol, illegal drugs, and medical treatment (medicines¹). In most countries the presence of alcohol or drugs is initially tested at the roadside by a screening device and/or field sobriety test. Subsequent evidence for court prosecution is determined by measuring blood alcohol concentration (BAC) or the presence of (illegal) drugs in the blood. The BAC is generally reported in terms of grams of alcohol per litre blood (g/L). To assist European countries in collecting Key Performance Indicators (KPIs) on road safety, guidelines have been given in the EC funded Baseline project for obtaining information on the KPI "Driving under the influence (DUI) of alcohol" (Yannis & Folla, 2023).

1.2 Extent of problem

Impairment due to alcohol and/or drugs is a major cause of motor vehicle crashes world-wide (Brubacher et al., 2018; Fell, 2019; Hels et al., 2011; Marillier & Verstraete, 2019). Most information is available for alcohol. It has been estimated that 1.5 to 2% of kilometres travelled in the EU are driven with an illegal BAC, while around 25% of all road deaths in the EU are alcohol-related (EC, 2018). On the positive side, in many EU countries progress in reducing alcohol-related road deaths has been faster than the overall reductions in road deaths (Le Lièvre et al., 2019; Podda & Meinero, 2022). On average, between 2011 and 2021, in the EU-23² alcohol-related road fatalities decreased by 37% while other road fatalities decreased by 30% (Podda & Meinero, 2022). Self-reports on drink-driving in Europe confirm the overall positive trend (Goldenbeld et al., 2020a).

In the framework of the SMART project (2020-2022) ETSC has produced thirty European country reports on drink-driving. The estimates of alcohol-related road deaths (2017-2020 data) in these reports range from high estimates for Portugal (37% killed drivers), Slovenia (37% all road deaths), Ireland (36% of road users), France (32% all road deaths), Spain (29% killed drivers), Croatia (27% all road deaths), Norway (25% all road deaths) to lower figures for Czechia (10% all road deaths), Lithuania (17% all road deaths), and Finland (20% all road deaths).

1. Note that medicines also may be necessary to restore the patient's ability to drive.
2. Excluding Bulgaria, Ireland, Italy and Malta.

There is less information on how drug-related traffic injuries and fatalities in Europe is developing. Comparing data of drivers killed in road crashes in Norway within the periods 2001-2010 and 2011-2020, Gjerde & Frost (2023) found a decrease in the prevalence of alcohol but no change in prevalence of illegal drugs and medicines. There is certainly concern about the general development of illegal drug consumption in Europe: "An overarching conclusion I draw from this year's report is that we are now facing a more complex drug situation, characterised by high availability and greater diversity in patterns of drug consumption. We see from our reporting on the new psychoactive substances phenomenon that almost anything that has psycho-active potential is now at risk of appearing on the market, often mislabelled, meaning that those consuming these substances may be unaware of what they are actually using." (Alexis Goosdeel director EMCDDA, 2022, p. 4).

In conjunction with this thematic report, a separate document has been prepared on the most recent safety performance indicators for drink-driving and drug driving in the EU (European Commission, 2023).

1.3 Effects of impairment

Both alcohol and drugs (legal and illegal) impair several of the driver's functional capabilities, including reaction time, tracking ability, proper speed management, vision, divided attention, and vigilance. This leads to increased crash risk (e.g. Ogden & Moskowitz, 2004; Martin et al., 2013; Marillier & Verstraete, 2019).

The mechanisms through which alcohol and drugs affect the body, the extent to which they impair driving, and the duration of the impairment differ greatly among drugs (Compton, 2017; Blandino et al., 2022). Álvarez (2011) classified medicines into different risk groups according to their influence on driving ability. Other factors, including patterns of use, reasons for use, dose ingested, mode of administration, tolerance, and driver characteristics, also affect the crash risk level (Beirness et al., 2021).

Several studies have compared impairment by alcohol and cannabis. It appears that drivers under the influence of cannabis tend to compensate for increased task demands or risk while driving, whereas drivers under the influence of alcohol do not (Simmons, 2020; Simmons et al., 2021). The ICADTS cannabis factsheet explains these differences in impairment as follows: "Unlike cannabis, alcohol tends to decrease inhibition, inflate self-confidence, and increase risk-taking behaviour, such as speeding and risky driving manoeuvres. While cannabis does impair several important driving-related skills, it is often associated

with slower driving, increased headway, and a reduced willingness to drive. These results suggest cannabis consumers have a heightened awareness of their impairment and engage in potential compensatory mechanisms but results do not preclude cannabis use impairing driving performance.” (ICADTS, 2022; p. 3).

1.4 What is the prevalence of impaired driving?

In 2021-2022 roadside measurements of drinking and driving among randomly stopped drivers in 8 European countries (Belgium, Greece, Ireland, Latvia, Luxembourg, Netherlands, Poland, and Portugal) indicate that in all these countries, more than 97% of drivers drive within the legal limit for blood alcohol concentration (BAC), with the highest percentages being recorded for Poland (99.7%) and Portugal (99.2%) (Yannis & Folla, 2023). During night-time more drivers exceeded the BAC limit in these countries, with most drivers exceeding the BAC limit in weekend nights (Yannis & Folla, 2023). While compliance appears relatively high, it is nevertheless estimated that within the EU this equates to millions of drivers driving billions of kilometres under the influence of alcohol.

Alternatively, roadside surveys among drug use of randomly stopped drivers in European countries³ tend to show higher prevalence rates (Netherlands: 6% (Goldenbeld et al., 2021); Spain: 8.2% (Alcañiz et al., 2021); Switzerland: 10.5% all drugs and 4.9% illicit drugs (Joye et al., 2022)).

In 2018-2019, the prevalence of drugs and alcohol use was studied by self-reports (the [ESRA-study](#)), asking about impaired driving in the previous 30 days (Achermann Stürmer et al., 2021; Meesmann et al., 2021). Amongst European drivers, 21% reported they had driven after drinking alcohol, 13% with a BAC over the legal limit, 15% after taking medicines that may affect driving ability, and 5% within 1 hour after taking drugs other than medication. In 2024 these data will be updated by a new ESRA study (ESRA3; see https://www.esranet.eu/about-the-project#esra_3).

³ These surveys were held as part of a pilot study. Therefore, these data might not be representative for the entire countries.

2. How dangerous is impaired driving?

2.1 Share of impairment-related crashes

It has been estimated on the basis of 2007-2009 data that about one quarter of road fatalities in Europe are alcohol-related (European Commission, 2018). There is no recent overall estimate of the number of drug-related casualties in Europe. Based on data in more recent years, in US and Canada slightly over half of injured or killed road users are found to have consumed an impairing substance - alcohol and/or legal/illegal drugs (US: Thomas et al., 2022; Canada: Brubacher et al., 2021b). In both these studies the share of drug use among injured or killed drivers was higher than alcohol use. In Europe, a recent Norwegian study provided toxicological findings on substance use (alcohol and/or drugs) among fatally injured road users: about a quarter of fatally injured road users had consumed an impairing substance, with slightly higher share of (illegal or medicinal) drug use (17.4%) than alcohol use (16.0%) among fatally injured road users (Gjerde & Frost 2023).

Most studies on drug-related traffic fatalities have focused on car drivers, but there is also evidence of high levels of illicit drug use among cyclists and pedestrians involved in fatal crashes (McKinley & Tillman, 2021; Pasnin & Gjerde, 2021; Schumann et al., 2021; Tonellato et al., 2021).

2.2 Cognitive effects

Alcohol and drug consumption before driving impairs several of the driver's functional capabilities. In a general review of the effects of alcohol intoxication on cognitive driving tasks, Garrisson et al. (2021) conclude that:

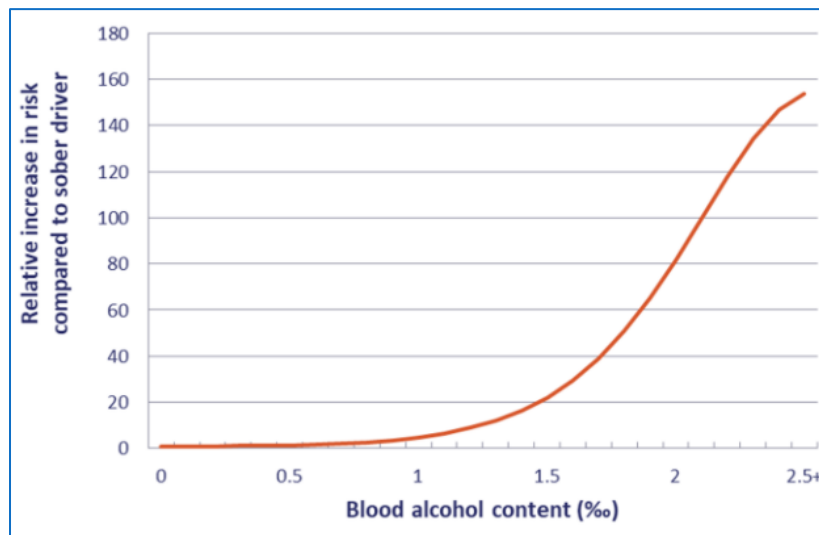
- deficits in aspects of visual perception begin at a BAC of 0.3 g/L
- impairments in vigilance start at a BAC of 0.3 g/L
- deficits in divided attention and sustained attention commence at BACs between 0.5 g/L and 0.8 g/L
- problems with dividing attention over several tasks begin at a BAC of 0.8 g/L.

In a review on cognitive impairment by alcohol and drugs, Blandino et al. (2022) conclude that, in contrast to alcohol, for many psychoactive substances there is no good evidence to establish a clear relationship between dose/concentration and degree of cognitive impairment (Blandino et al., 2022).

2.3 Crash risk

For alcohol, the crash risk for drivers with a BAC of 0.5 g/L is estimated to be about 1.4 times higher than that of a sober driver; at 1.0 g/L the risk is nearly 5 times higher, and at 1.5 g/L around 20 times higher (see Figure 1; Blomberg et al., 2005). In general, the risk of a crash increases considerably when a driver is impaired by combined alcohol and drugs. A recent meta-analysis by Høyve & Storesund Hesjevoll (2023) confirmed the relationship between BAC level and crash risk as found by Blomberg et al. (2005, 2009).

Figure 1. Relative increase in risk at increasing blood alcohol content (Blomberg et al., 2005).



Looking at fatal crash data from both the USA and Great Britain, Allsop (2020) reported that the risk of being involved in a fatal crash is almost doubled at a BAC of 0.3 g/L, 5 times higher at a BAC of 0.5 g/L, and 10 times higher at a BAC of 0.8 g/L. The increase in risk differs for different age and gender groups. For example, for young male drivers (16-19 years), the risk of being involved in a single vehicle fatal crash is already 4 times higher at BACs between 0.2 and 0.5 g/L (Zador et al., 2000).

Table 1 shows the crash risk increase for illegal drugs (Els et al., 2019; Elvik, 2013; Hels et al., 2011; Rogeberg & Elvik, 2016; Rogeberg, 2019). The largest risk increase was found for amphetamines, multiple drug use, and combining alcohol and drugs. The effects of cannabis on driving and crash risk have received a lot of research attention. On a critical note, White & Burns (2021) present evidence that crash risk of cannabis-influenced driving may be overestimated in several studies. Concerning the particular combination of alcohol and cannabis, White

& Burns (2023) argue, that there is no good evidence from epidemiological studies that the co-use of cannabis exacerbates the effect of alcohol on the risk of crashing.

Table 1. Risk increase for several groups of illegal drugs

Drug	Crash severity (source)	Risk increase
Amphetamines	Fatal (Elvik, 2013)	5.2
	Injuries (Elvik, 2013)	6.2
Cannabis	Fatal (Elvik, 2013)]	1.3
	Injuries (Elvik, 2013)	1.1
	Fatal and injuries (Rogeberg & Elvik, 2016)	1.4
	Fatal and injuries (Els et al., 2019)	2.5
	Fatal and injuries (Rogeberg, 2019)	1.3
	Crashes (China-Meyyappan et al., 2023)	1.15
Cocaine	Fatal (Elvik, 2013)	3.0
	Injuries (Elvik, 2013)	1.7
Opiates*	Fatal (Elvik, 2013)	1.7
	Injuries (Elvik, 2013)	1.9
Multiple drugs	Crashes (Hels et al., 2011)	5 - 30
Combination alcohol & drugs	Crashes (Hels et al., 2011)	20 - 200

*Opiates are a subset of opioids comprising the various products derived from the opium poppy plant, including opium, morphine and heroin (UNODC, 2018).

Table 2 gives an overview of the increase in risk due to different medicines reported in various studies (Chihuri & Li, 2017; Elvik, 2013; LeRoy & Morse, 2008; Olesen et al., 2022). Significant risk increases have been found for driving under the influence of barbiturates (used for treating headaches, insomnia, and seizures), benzodiazepines (used to relieve anxiety and insomnia), antidepressants (used to alleviate depression). and opiates (used to treat pain or sleeping problems).

Some qualifying remarks can be made concerning the overview in Table 2. First, the studies in Table 2 do not always yield consistent findings. For example, findings on the relationship between attention-deficit/hyperactivity disorder (ADHD) medication and crash risk are not in agreement (Chang et al., 2017; Olesen et al., 2022). Also, the studies in Table 2 have grouped specific medicines into general classes of medicines. In a general review and meta-analysis, Rudisill et al. (2018) have looked more specifically at the relationship between specific single medicines and crash risk. Finally, Table 2 is limited to studies on medication use and crash risk, it omits studies that have looked into the relationship between medication and crash responsibility (or culpability) (Brubacher et al., 2021a; Kedia et al., 2023).

Table 2. Risk increase for various medicine groups

Medicine	Crash severity (source)	Risk increase
ADHD medication	Motor vehicle crashes (Chang et. al, 2017)	0.86 (women) – 0.88 (men)
ADHD medication	Injury crashes (Olesen et al., 2022)	1.62
Antidepressants	Injury crashes (Elvik, 2013)	1.3
Antidepressants	Injury crashes (Olesen et al., 2022)	1.3
Antihistamines	Injury crashes (Elvik, 2013)	1.1
Antipsychotics	Injury crashes (Olesen et al., 2022)	0.86
Barbiturates	Crashes motorised (LeRoy & Morse, 2008)	7.5
Benzodiazepines	Fatal crashes (Elvik, 2013)	2.3
Benzodiazepines	Injury crashes (Elvik, 2013)	1.2
Benzodiazepines and z-hypnotics	Injury crashes (Olesen et al., 2022)	1.29
Sedatives incl. z-hypnotics	Motor vehicle crashes (Hansen et al., 2015)	1.9
Narcotics (strong painkillers)	Crashes motorised (LeRoy & Morse, 2008)	2.2
Analgesics (mild painkillers)	Injury crashes (Elvik, 2013)	1.0 (none)
Prescription opioids	Crashes motorised (Chihuri & Li, 2017)	2.3
Prescription opioids	Motor vehicle collisions (Leon et al., 2022)	Increased*

2.4 Features of impairment-related crashes

An in-depth investigation of just over 1,500 fatal passenger car crashes in Norway from 2005 to 2015 revealed a number of driver, road and vehicle features associated with impairment-related crashes (Høye, 2020):

- Night-time and weekends are over-represented in alcohol-impaired and alcohol/ drug-impaired crashes.
- Young drivers are under-represented among drug- and drug/alcohol-impaired drivers, but not among alcohol-impaired drivers.
- Old cars and cars without electronic stability control (ESC) are over-represented in alcohol-related crashes, but not in alcohol/drug-related crashes.
- Road curves are over-represented in impairment-related crashes, except in drug-related crashes.
- Alcohol-related crashes are over-represented on roads with high-speed limits and under-represented on roads with low-speed limits.
- The average annual daily traffic (AADT) is lower on roads with alcohol-related crashes than on roads with crashes involving sober drivers.

Based on the Norway case-study, alcohol-related crashes are strongly correlated with being unbelted, unlicensed and male, and with single-vehicle crashes in conditions of low traffic volumes.

3. Why do drivers drive while impaired?

People engage in impaired driving because they want to do so (motivation), have the capability to do so, and have the opportunity to do so (Michie et al., 2011). Opportunity factors such as retail availability of alcohol, alcohol serving and sales practices, and the price of alcohol have a great impact on actual drinking patterns and on subsequent drink-driving (PIRE, 2012).

According to the theory of planned behaviour (TPB), the intention to engage in impaired driving can be explained by attitudes towards the particular behaviour, the subjective norms, and the perceived difficulty of performing the behaviour (Marcil et al., 2001; Parker et al., 1992). Additional variables, including personality characteristics such as sensation-seeking, sense of invulnerability, and impulsiveness, provide a fuller explanation of impaired driving (Chan et al., 2010; Cestac et al., 2011; Moan & Rise, 2011; Vankov & Schroeter, 2021). Other studies have highlighted the unplanned nature of impaired driving and have shown how peer pressure and the social situation (e.g. others around you drinking) can change a person's original plan not to drink and drive (Sykes et al., 2010; Keatly et al., 2016).

For the repeat alcohol offenders group, medical (psychiatric) problems related to problematic alcohol and illegal drug use often underly a habitual pattern of impaired driving (Streff et al., 2001; Nochajski & Stasiewicz, 2006; Goldenbeld et al., 2016). Looking at drivers who use illegal drugs, an Australian study found that 95% reported problematic drug use, i.e. showing indications of addiction (Hasan et al., 2023). People using illegal drugs before driving consider some of these drugs (e.g. cannabis) as producing less impairment than other drugs or alcohol (Kelly et al., 2004; Watson et al., Goodman et al., 2019).

For drivers driving under the influence of medicines, the personal, social, and legal setting is different and therefore the underlying motivation is also different. Many of the drivers who use (multiple) medicines are not fully aware of the possible risks. Information on medicines and driving does not reach all users, or users do not read or understand the information (SWOV, 2020). Also, health professionals may lack sufficient knowledge of the risk of driving with medication (Artime et al., 2019; SWOV, 2020). In addition, information on the effects of medicines seems to lead to only temporary behavioural effects (Orriols et al., 2016). Experience with medicines may even lead a patient to overestimate their ability to drive (Sargent-Cox et al., 2011).

4. Rules and legislation

Most EU countries apply a legal blood alcohol limit of 0.5g/L, but Lithuania has a legal limit of 0.4g/L; Poland, Sweden and Norway of 0.2g/L. The Czech Republic, Hungary, Romania, and Slovakia have a zero limit⁴. Calinescu & Adinaite (2018) report that 22 EU countries apply a lower legal limit for novice drivers and 19 EU countries for professional drivers; in both cases 0.0g/L or 0.2g/L.

Legislation against drugged driving in EU countries has applied 'per se' laws that establish a fixed substance limit or zero tolerance laws. These laws are often combined with legislation that defines how the impairment should be proven (Atchison, 2017).

The EU Driving Licence Directive 2006/126/EC states that '*Driving licences shall not be issued to or renewed for applicants or drivers who are dependent on psychotropic substances or who are not dependent on such substances but regularly abuse them, whatever category of licence is requested*' (Article 15). In a European Commission proposal in March 2023 to update licence requirement, the EU proposed to introduce a zero tolerance law for novice drivers, i.e. novice drivers should be subject to a zero-tolerance alcohol limit for a minimum of two years after passing their test. The proposals will be considered by the European Parliament and the Council under the ordinary legislative procedure (EC, 2023).

Seven EU countries (Denmark, Finland, Hungary, Ireland, Lithuania, Spain and Sweden) have national guidelines on how patients should be informed of the impact of a prescribed medicine on their fitness to drive (ETSC, 2021).

5. Counter measures

5.1 Decreasing alcohol and drugs consumption

General health policies that decrease the (excessive) consumption of alcohol contribute effectively to the reduction of impaired driving (PIRE, 2012). For example, policies which set a minimum price and increase taxes for alcohol beverages, and which set strict marketing regulations and limit availability of alcohol beverages for children and young adults have been effective in reducing alcohol-related harm (Burton et al.,

4. The following link shows drink-driving limits in European countries, updated 1 December 2021: <https://etsc.eu/issues/drink-driving/blood-alcohol-content-bac-drink-driving-limits-across-europe/>

2016; Teutsch et al., 2018). Less is known about how health policies may affect drug-impaired driving (Razaghizad et al., 2021)⁵. The EU has formulated a common drug policy strategy for 2021-2025, including targeting high-risk crime groups, counteracting digitally enabled illicit drug markets, evidence-based prevention interventions, and provision of alternatives to coercive sanctions (Official Journal of the European Union, 2021).

5.2 Regulation and police enforcement

The adoption of legal measures and enhanced enforcement, as well as changing public attitudes towards drink-driving, have contributed to a decrease of road deaths attributed to alcohol in a number of EU countries (Modijefsky et al., 2021; Podda & Meinero, 2022). It is recommended that enforcement of drink-driving is intensified by setting annual targets for the number of police roadside alcohol checks (Podda & Meinero, 2022).

As part of a proposal in March 2023 for updated driving licence requirements, the European Commission has proposed that novice drivers should be subject to a zero-tolerance alcohol limit for a minimum of two years after passing their test (EC, 2023). In practice this could mean an enforcement limit of 0.2g/L (Calinescu & Adminaite, 2018). The main arguments for a 0.2g/l enforcement limit (rather than zero) are to take account of the possibility of inaccuracy in breath testing devices at these low levels, and to avoid (falsely) prosecuting drivers who only have some small amount of alcohol in the mouth without having consumed alcohol.

Evidence worldwide (see SWOV, 2021 for an overview) shows that lowering the general legal blood alcohol limit from 0.5/0.6 g/L to 0.2/0.3 g/L as well as lowering the legal limit for novice drivers to 0.0 or 0.2 g/L would have a favourable effect on road safety. However, lowering legal limits has an effect only when combined with highly publicised, visible, and frequent police enforcement, preferably deploying random breath-testing methods (Erke et al., 2009; Fell, 2019). There is no clear evidence that more severe penalties are effective in reducing alcohol offences when rather severe penalties already exist (SWOV, 2021).

In an evidence review on interventions on drug driving (illegal and legal), Razaghizad et al. (2021) conclude that state sanctions, including traffic offence criminalization, license withdrawal, and per se drugged

⁵ The policies to legalize cannabis have been subject to research but the evidence on effects on drug-impaired driving is not conclusive (González-Sala et al., 2023)

driving laws⁶, may have little or no effect on drug-related fatalities or injuries. Drug driving is a complex problem with many more general social, medical and psychological aspects that cannot be ignored. Hence, there is no single simple solution.

5.3 Responsible driving with medicines

ETSC (2021) has proposed several policy measures which may improve responsible driving with medicines, including (p. 8-9):

- Within national medical-fitness-to-drive guidelines and regulations, stress the role of General Practitioners (GPs) as the primary point of call for identifying those who may be at-risk in terms of their fitness to drive, initiating an assessment of a person's fitness to drive, and influencing how long and under what circumstances a person continues driving.
- As part of their initial and continuous training, inform and/or remind doctors of their duty to advise their patients on the impact of prescription medicines on driving.
- Apply the DRUID categorisation and labelling of medicines – as described in De Gier et al., 2011 – that affect driving ability and support information campaigns promoting awareness among medical professionals and among the general population.
- Regarding the latter: the European DRUID project showed that physicians and pharmacists play a key role in informing patients about the effects of medication on driving. The DRUID categorisation and medicine labelling as well as integrated patient information into the daily software packages of physicians and pharmacists have proven to be effective in providing information to the patient (Meesmann et al., 2011; Toulou et al., 2011).

5.4 Alternative means of transport

Promoting the use of alternative means of transport – e.g. free or subsidised taxi and ride-sharing services, voluntary or paid designated driver programmes, or more accessible public transport – is a possible strategy for reducing impaired driving (Fell et al., 2020). However, the evidence regarding effectiveness in terms of drink-driving, drink-driving offences, or crashes is inconclusive. The lack of transport options in rural areas is often cited as a barrier to preventing drink-driving (Howard et al., 2020).

6. Under 'per se' drug driving laws it is an offence to operate a vehicle with a concentration of alcohol or drugs in the body above a specified threshold value. If a per se law sets the threshold value at zero, then it is often called a 'zero tolerance' law.

5.5 Campaigns, rehabilitation, safety culture

Road safety campaigns on drink-driving can help to increase awareness, change social norms and inform people how to change behaviour (Delhomme et al., 2009; SWOV, 2017). However, general publicity campaigns as a stand-alone measure without related police enforcement cannot be expected to actually change behaviour and reduce alcohol-related crashes (Fell, 2019). According to a review by Razaghizad et al. (2021) there is only low certainty evidence that targeted drug-driving campaigns can increase deterrent attitudes and knowledge.

Rehabilitation courses provide an alternative treatment for alcohol or (illegal) drug driving offenders, aiming at reducing recidivism (Boets et al., 2008). The courses are educational or psychologically oriented, typically organised in small groups (Slootmans et al., 2017). Rehabilitation programmes are commonly provided by private organisations, following national guidelines, and can be voluntary or compulsory, depending on the country and offence in question (Houwing, 2016; Atchison, 2017). There is evidence that rehabilitation can decrease recidivism (Slootmans et al., 2017). However, not all studies show positive results. According to Razaghizad et al. (2021) for adolescents, young adults, and previous (illegal) drug offenders, there is "...moderate-certainty evidence that motivational interviewing⁷ can prevent drugged driving and that driver education programs can increase deterrent attitudes and knowledge regarding drugged driving" (Razaghizad et al., 2021; p. 276).

For professional drivers, employers can play an important role. As part of a safety culture approach, employers must clearly set, communicate, and monitor company policies for impaired driving through education, testing, and employee assistance programmes (Transport Safety Group, 2006). Periodically in-company screening drivers for alcohol/illegal drugs has shown positive results in US transport companies (Camden et al., 2019).

5.6 Vehicle technology

Alcohol interlocks are automatic control systems to prevent driving with excess alcohol by requiring the driver to blow into an in-car breathalyser before starting the ignition. Research has shown that alcohol-interlock programmes (AIPs) reduce the risk of recidivism by 75% during the period when the interlock is operational (Bax et al., 2001; Elder et al., 2011; Nieuwkamp et al., 2017; Modijefsky et al.,

⁷ Motivational interviewing is a counselling approach aimed at helping people to find the motivation to make a positive behavioural change.

2021), they reduce alcohol-related fatalities (McGinty et al., 2016; Teoh et al., 2018) and they have favourable cost-benefits (Goldenbeld et al., 2020b). For some AIPs the effects continued after removal of the alcohol interlock device (Bjerre & Thorsson, 2008; Gustafsson & Forsman, 2016; Voas et al., 2016). These AIPs included medical and psychological guidance that was continued after removal of the interlock. In 2022 (new vehicle types) and 2024 (new vehicles) an alcohol interlock installation facilitation will be mandatory for cars, vans, trucks, and buses (Official Journal of the European Union, 2019).

Advanced driver assistance systems (ADAS) can help to warn or intervene in timely manner when a critical driving situation arises, e.g. due to alcohol or drug impairment. The most promising ADAS for alcohol-impaired drivers are lane departure warning systems and forward collision warning systems (Teutsch et al., 2018).

Driver monitoring systems (DMS) collect observable driving information to make real-time assessments of drivers' capacity to perform the driving task (Haley et al, 2021). DMS are recommended as a primary safety feature for European vehicles seeking a 5-star EuroNCAP safety rating (EuroNCAP, 2020). According to Haley et al. (2021), these systems can be functionally adapted and expanded to reliably detect driving impaired by alcohol or drugs.

6. Further reading

- Fell, J.C. (2019). Approaches for reducing alcohol-impaired driving: evidence-based legislation, law enforcement strategies, sanctions, and alcohol-control policies. *Forensic Science Reviews*, 31(2), 161-184.
- Hasan, R., Watson, B., Haworth, N., & Oviedo-Trespalacios, O. (2022). A systematic review of factors associated with illegal drug driving. *Accident Analysis & Prevention*, 168, 106574, <https://doi.org/10.1016/j.aap.2022.106574>.
- ICADTS (2022). Cannabis & driving. Recent experimental evidence. International Council on Alcohol, Drugs & Traffic Safety. Accessed 23 May 2023 at: <https://www.icadtsinternational.com/Fact-Sheets>.
- Modijefsky, M., Janse, R., Spit, W., Jankowska-Karpa, D., Buttler, I., Eikefjord, B. (2021). Prevention of driving under the influence of alcohol and drugs. Brussels, European Commission. <https://op.europa.eu/en/publication-detail/-/publication/a0ec8db9-8ed8-11ec-8c40-01aa75ed71a1>
- Podda, F & Meneiro, M. (2022). *Progress in drink driving and other alcohol-related road deaths in Europe*. Brussels, European Transport Safety Council.
- Razaghizad, A., Windle, S.B., Gore, G., Benedetti, A., Ells, C., Grad, R., Filion, K.B., Eisenberg, M.J. (2021). Interventions to Prevent Drugged Driving: A Systematic Review. *American Journal of Preventive Medicine*, 61 (2), 267-280. <https://doi.org/10.1016/j.amepre.2021.03.012>.
- Yannis, G., & Folla K. (2023). *Baseline report on the KPI Driving under the Influence of Alcohol*. Baseline project. Brussels: Vias institute.

7. References

- Achermann Stürmer, Y., Meesmann, U. & Berbatovci, H. (2021). *Driving under the influence of alcohol and drugs. ESRA2 Thematic report Nr. 5. ESRA project (E-Survey of Road users' Attitudes)*. Bern, Switzerland: Swiss Council for Accident Prevention. <https://www.esranet.eu/en/publications-2/>
- Alcañiz, M., Guillen, M., Santolino, M. (2021). Differences in the risk profiles of drunk and drug drivers: Evidence from a mandatory roadside survey. *Accident Analysis & Prevention*, 151, 105947. <https://doi.org/10.1016/j.aap.2020.105947>.
- Allsop, R. (2020). Drink Driving as the commonest drug driving—A perspective from Europe. *International Journal of Environmental Research and Public Health*, 17(24), 9521. <https://dx.doi.org/10.3390%2Fijerph17249521>.
- Álvarez, F.J. (2011). *Classification of medicinal drugs and driving: a synthesis report*. DRUID (Driving under the Influence of Drugs, Alcohol and Medicines). 6th Framework programme. Deliverable 4.4.1.
- Artime, E., Qizilbash, N., Garrido-Esteba, M., Vora, P., et al. (2019). Are risk minimization measures for approved drugs in Europe effective? A systematic review. *Expert Opinion on Drug Safety*, 18 (5), 443-454. <https://doi.org/10.1080/14740338.2019.1612875>.
- Atchison, L. (2017). *Preventing drug driving in Europe*. Policy measures for national and EU Action. Brussels, European Transport Safety Council.

- Baker, E. (2007). State of Maryland Annual Report 2007. Baltimore, National Highway Traffic Safety Administration, Mid-Atlantic Region.
- Bax, C., Käri, O., Evers, C., Bernhoft, I.M. & Mathijssen, R. (2001). Alcohol interlock implementation in the European Union: feasibility study. Final report of the European research project. D-2001-20. SWOV Institute for Road Safety Research, Leidschendam.
- Beirness, D.J., Gu, K.W., Lowe, N.J., Woodall, K.L., & Desrosiers, N.A., Cahill, B., Porath, A.J. & Peaire, A. (2021) Cannabis, alcohol and other drug findings in fatally injured drivers in Ontario. *Traffic Injury Prevention*, 22 (1), 1-6.
<https://doi.org/10.1080/15389588.2020.1847281>.
- Bjerre, B. & Thorsson, U. (2008). Is an alcohol ignition interlock programme a useful tool for changing the alcohol and driving habits of drink-drivers? *Accident Analysis & Prevention*, 40 (1) 267-273. <https://doi.org/10.1016/j.aap.2007.06.008>.
- Blandino, A., Cotroneo, R., Tambuzzi, S., Di Candia, D., Genovese, U., Zoja, R. (2022). Driving under the influence of drugs: Correlation between blood psychoactive drug concentrations and cognitive impairment. A narrative review taking into account forensic issues. *Forensic Science International: Synergy*, 4, 100224.
<https://doi.org/10.1016/j.fsisyn.2022.100224>.
- Blomberg, R.D., Peck, R.C., Moskowitz, H., Burns, M., et al. (2005). *Crash risk of alcohol involved driving: A case-control study*. Contract Number DTNH22-94-C-05001 Dunlap and Associates, Inc., Stamford, CT.
- Blomberg, R.D., Peck, R.C., Moskowitz, H., Moskowitz, H., Burns, M., & Fiorentino D. (2009). The Long Beach/Fort Lauderdale relative risk study. *Journal of Safety Research*, 40(4), p.285–292. <https://doi.org/10.1016/j.jsr.2009.07.002>.
- Boets, S., Meesmann, U., Klipp, S., Bukasa, B., et al. (2008). *State of the art on driver rehabilitation; Literature analysis & provider survey. DRUID: "Driving under the influence of Alcohol, Drugs and Medicines"*. Brussels, Belgian Institute for Road safety BIVV.
- Brubacher, J.R., Chan, H., Erdelyi, S., Asbridge, M., Mann, R.E., Pursell, R.A., & Solomon, R. (2018). Police documentation of drug use in injured drivers: implications for monitoring and preventing drug-impaired driving, *Accident Analysis & Prevention*, 118, 200–206.
<https://doi.org/10.1016/j.aap.2018.02.018>.
- Brubacher, J.R., Chan, H., Erdelyi, S., Zed, P.J., Staples, J.A., Etmnan, & M. (2021a). Medications and risk of motor vehicle collision responsibility in British Columbia, Canada: a population-based case-control study. *Lancet Public Health* published online April 19.
[https://doi.org/10.1016/S2468-2667\(21\)00027-X](https://doi.org/10.1016/S2468-2667(21)00027-X).
- Brubacher, J.R., Chan, H., Masud, M., Yuan, Y., Erdelyi, S., & Likhodi S, and the National Drug Driving (2021b). Research Group. The 2021 National Drug Driving Study. Vancouver, BC. Department of Emergency Medicine, University of British Columbia. <https://med-fom-rsph.sites.olt.ubc.ca/files/2021/06/National-Drug-Driving-Study-June-2021-Final.pdf>
- Burton, R., Henn, C., Lavoie, D., O'Connor, R., Perkins, C., Sweeney, K., Greaves, F., Ferguson, B., Beynon, C., Belloni, A., Musto, V., Marsden, J., & Sheron, N. (2016). A rapid evidence review of the effectiveness and cost-effectiveness of alcohol control policies: an English perspective. *Lancet*, 389(10078), 1558-1580. [https://dx.doi.org/10.1016/S0140-6736\(16\)32420-5](https://dx.doi.org/10.1016/S0140-6736(16)32420-5).
- Calinescu, D. & Adminaitet, D. (2018). *Progress in reducing drinking and driving in Europe*. Brussels, European Transport Safety Council ETSC. https://etsc.eu/wp-content/uploads/report_reducing_drink_driving_final.pdf
- Camden, M.C., Hickman, J.S. & Hanowski, R.J. (2019). *Effective strategies to improve safety case studies of commercial motor carrier safety advancement*. Blacksburg, Virginia, National Surface Transportation Center for Excellence, Blacksburg, Virginia.

https://vtechworks.lib.vt.edu/bitstream/handle/10919/89323/NSTSCCE_Case_Studies_Final_Report.pdf?sequence=1&isAllowed=y

- Cestac, J., Paran, F. & Delhomme, P. (2011). Young drivers' sensation seeking, subjective norms, and perceived behavioral control and their roles in predicting speeding intention: How risk-taking motivations evolve with gender and driving experience. *Safety Science*, 49 (3), 424-432. <https://doi.org/10.1016/j.ssci.2010.10.007>.
- Chan, D.C., Wu, A.M., & Hung, E.P. (2010). Invulnerability and the intention to drink and drive: an application of the theory of planned behavior. *Accident Analysis and Prevention*, 42(6), 1549-55. <https://doi.org/10.1016/j.aap.2010.03.011>.
- Chang, Z., Quinn, P.D., Hur, K., Gibbons, R.D., Sjölander, A., Larsson, H. & D'Onofrio, B.M. (2017). Association Between Medication Use for Attention-Deficit/Hyperactivity Disorder and Risk of Motor Vehicle Crashes. *JAMA Psychiatry*, 74(6),597-603. <https://doi.org/10.1001/jamapsychiatry.2017.0659>
- Chihuri, S. & Li, G. (2017). Use of prescription opioids and motor vehicle crashes: A meta-analysis. *Accident Analysis & Prevention*, 109, p. 123-131. <https://doi.org/10.1016/j.aap.2017.10.004>
- Compton, R. (2017). *Marijuana-Impaired Driving - A Report to Congress*. (DOT HS 812 440). Washington, DC, National Highway Traffic Safety Administration.
- Delhomme, P., Dobbeleer, W. de, Forward, S. & Simões, A., (eds.) (2009). *Campaigns and Awareness raising Strategies in Traffic safety (CAST). Manual for designing, implementing, and evaluating road safety communication campaigns*. Brussels, Belgian Institute for Road safety BIVV.
- De Gier, J.J., Ravera, S., Monteiro, S.P., & Alvarez, F.J. (2011). *Establishment of criteria for a European categorisation system for medicines and driving. Deliverable D.4.2.1. of the EU FP6 project DRUID*. Brussels, European Commission.
- Downey, L.A., & Hayley, A.C. (2021). Prescription medication use and crash risk: taking responsibility for a new global challenge. *The Lancet Public Health*, 6 (6), p. e349-e350. [https://doi.org/10.1016/S2468-2667\(21\)00045-1](https://doi.org/10.1016/S2468-2667(21)00045-1)
- EC (2018). *Alcohol*. Brussels, Directorate General for Transport. <https://road-safety.transport.ec.europa.eu/system/files/2021-07/ersosynthesis2018-alcohol-summary.pdf>
- EC (2023). *Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on driving licences, amending Directive (EU) 2022/2561 of the European Parliament and of the Council, Regulation (EU) 2018/1724 of the European Parliament and of the Council and repealing Directive 2006/126/EC of the European Parliament and of the Council and Commission Regulation (EU) No 383/2012*. Brussels, European Commission. https://transport.ec.europa.eu/system/files/2023-03/COM_2023_127.pdf.
- European Commission (2023). *Safety Performance Indicator report – Alcohol and drugs*. European Road Safety Observatory. Brussels, European Commission, Directorate General for Transport.
- Elder, R.W., Voas, R.B., Beirness, D.J., Shults, R.A., et al. (2011). Task force on community preventive services. Effectiveness of ignition interlocks for preventing alcohol-impaired driving and alcohol-related crashes: a Community Guide systematic review. *American Journal of Preventive Medicine*, 40, 362–376. <https://doi.org/10.1016/j.amepre.2010.11.012>.
- Els, C., Jackson, T.D., Tsuyuki, R.T., Aidoo, H., et al. (2019). Impact of cannabis use on road traffic collisions and safety at work: Systematic review and meta-analysis. *Canadian Journal of Addiction*, 10 (1), 8-15. <http://dx.doi.org/10.1097/CXA.0000000000000046>.

- 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 & Prevention*, 60, 254-267. <https://doi.org/10.1016/j.aap.2012.06.017>.
- EMCDDA (2022). *European Drug Report. Trends and developments*. Luxembourg, Publications Office of the European Union. https://www.emcdda.europa.eu/publications/edr/trends-developments/2022_en
- Erke, A., Goldenbeld, C., & Vaa, T. (2009). The effects of drink-driving checkpoints on crashes – A meta-analysis. *Accident Analysis and Prevention*, 41(5), 914-923. <http://dx.doi.org/10.1016/j.aap.2009.05.005>.
- ETSC (2021). Are medical fitness to drive procedures fit for purpose? PIN Flash Report 40. Brussels, European Transport Safety Council. <https://etsc.eu/are-medical-fitness-to-drive-procedures-fit-for-purpose-pin-flash-40>.
- EuroNCAP (2020). Assessment Protocol - Safety Assist. <https://cdn.euroncap.com/media/58229/euro-ncap-assessment-protocol-sa-v903.pdf>
- Fell, J.C. (2019). Approaches for reducing alcohol-impaired driving: Evidence-based legislation, law enforcement strategies, sanctions, and alcohol-control policies. *Forensic Science Reviews*, 31(2), 161-184. <https://pubmed.ncbi.nlm.nih.gov/31270060/>
- Fell, J.C., Scolese, J., Achoki, T., Burks, C., Goldberg, A., & DeJong, W. (2020). The effectiveness of alternative transportation programs in reducing impaired driving: A literature review and synthesis. *Journal of Safety Research*, 75, 128-139. <https://doi.org/10.1016/j.jsr.2020.09.001>
- Garrison, H., Scholey, A., Ogden, E., & Benson, S. (2021). The effects of alcohol intoxication on cognitive functions critical for driving: A systematic review. *Accident Analysis & Prevention*, 154, <https://doi.org/10.1016/j.aap.2021.106052>.
- Gjerde, H. & Frost, J. (2023). Prevalence of alcohol and drugs among drivers killed in road traffic crashes in Norway during 2011–2020. *Traffic Injury Prevention*, 24(3), 256-261. <https://doi.org/10.1080/15389588.2023.2174801>.
- Goldenbeld, Ch., Blom, M. & Houwing, S. (2016). *Zware alcoholovertreders in het verkeer* [Severe alcohol offenders in traffic – summary in English]. R-2016-12. SWOV Institute for Road Safety Research, the Hague. <https://swov.nl/system/files/publication-downloads/r-2016-12.pdf>
- Goldenbeld, Ch., Torfs, K., Vlakveld, W., & Houwing, S. (2020a). Impaired driving due to alcohol or drugs: International differences and determinants based on E-Survey of Road Users' Attitudes first-wave results in 32 countries. *IATSS Research*, 44, 188- 196. <https://doi.org/10.1016/j.iatsr.2020.07.005>.
- Goldenbeld, Ch., Houwing, S., Wijnen, W, Decae, R., & Eenink, R. (2020b). Cost benefit analysis of the Irish alcohol interlock program. R-2020-31. The Hague, SWOV. <https://swov.nl/nl/publicatie/cost-benefit-analysis-irish-alcohol-interlock-program>.
- Goldenbeld, Ch., Stelling, A., & Kint, S.T. van der (2021). *Het meten van alcohol- en drugsgebruik in het verkeer tijdens reguliere politieursurveillances. Pilotstudie in drie politieregio's*. [Measuring alcohol and drug use in traffic during regular police surveillance. Pilot study in three police districts – summary in English]. R-2021-30. SWOV Institute for Road Safety Research, the Hague. <https://swov.nl/nl/publicatie/het-meten-van-alcohol-en-drugsgebruik-het-verkeer-tijdens-reguliere-politieursurveillances>
- Goodman, S.E., Leos-Toro, C., & Hammond, D. (2019). Risk perceptions of cannabis- vs. alcohol-impaired driving among Canadian young people. *Drugs: Education, Prevention and Policy*, 27(3), 205-2012. <https://doi.org/10.1080/09687637.2019.1611738>.

- González-Sala, F., Tortosa-Pérez, M., Peñaranda-Ortega, M., & Tortosa, F. (2023). Effects of Cannabis Legalization on Road Safety: A Literature Review. *International Journal of Environmental Research and Public Health*, 20(5), 4655. <https://doi.org/10.3390/ijerph20054655>
- Gustafsson, S. & Forsman, A. (2016). Utvärdering av alkoholås efter rattfylleri: enkätstudie [Evaluation of a Swedish alcohol interlock program for drink driving offenders: questionnaire study]. VTI-code: 35-2016; summary in English. VTI, Linköping. <http://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1059198&dsid=-2057>
- Hansen, R.N., Boudreau, D.M., Ebel, B.E., Grossman, D.C., & Sullivan, S.D. (2015). Sedative Hyp-notic Medication Use and the Risk of Motor Vehicle Crash. *American Journal of Public Health*, 105(8):e64-9. <https://doi.org/10.2105/AJPH.2015.302723>.
- Hasan, R., Watson, B., Haworth, N., & Oviedo-Trespalacios, O. (2022). A systematic review of factors associated with illegal drug driving. *Accident Analysis & Prevention*, 168, 106574, <https://doi.org/10.1016/j.aap.2022.106574>.
- Hasan, R., Watson B, Haworth, N., & Oviedo-Trespalacios, O. (2023). What contributes to drug driving? An exploratory investigation into the influence of problematic substance use, roadside testing and alternative transport options. *Accident Analysis & Prevention*, 184, 106990. <https://doi.org/10.1016/j.aap.2023.106990>.
- Hayley, A.C., Shiferaw, B., Aitken, B., Vinckenbosch, F., Brown, T.L. & Downey, L.A. (2021). Driver monitoring systems (DMS): The future of impaired driving management? *Traffic Injury Prevention*, 22(4)., 313-317. <https://doi.org/10.1080/15389588.2021.1899164>.
- Hels, T., Bernhoft, I.M., Lyckegaard, A., Houwing, S., et al. (2011). *Risk of injury by driving with alcohol and other drugs. Deliverable D2.3.5 of the EU FP6 project DRUID*. Brussels, European Commission.
- Houwing, S. (2016). *Alcohol interlocks and drink driving rehabilitation in the European Union. Best practice and guidelines for Member States*. Brussels, European Transport Safety Council. <https://etsc.eu/alcohol-interlocks-and-drink-driving-rehabilitation-in-the-eu-guidelines-for-member-states/>
- Howard, E., Harris, A. & McIntyre, A. (2020). *Effectiveness of Drink Driving Countermeasures: National Policy Framework. Research Report AP-R613-20*. Austroads, Sydney, Australia. http://www.grsroadsafety.org/wp-content/uploads/2023/05/AP-R613-20-Effectiveness_of_Drink_Driving_Countermeasures.pdf
- Høyve, A. (2020). Speeding and impaired driving in fatal crashes—Results from in-depth investigations. *Traffic Injury Prevention*, 21 (7), 425-430. <https://doi.org/10.1080/15389588.2020.1775822>.
- Høyve, A.K. & Storesund Hesjevoll, I. (2023). Alcohol and driving—How bad is the combination? A meta-analysis. *Traffic Injury Prevention*, 24 (5), 373-378. <https://doi.org/10.1080/15389588.2023.2204984>.
- ICADTS (2022). Cannabis & driving. Recent experimental evidence. International Council on Alcohol, Drugs & Traffic Safety. Accessed 23 May 2023 at: <https://www.icadtsinternational.com/Fact-Sheets>.
- Joye, T., Déglon, J., Donzé, N., Gilardi, F., Sidibé, J., Favrat, B., Augsburg, M., & Thomas, A. (2022). Randomly controlled drivers using minimally invasive sampling: assessment of drug prevalence in Western Switzerland over two time periods. *BMC Public Health*, 28;22(1), 2446. <https://doi.org/10.1186/s12889-022-14883-2>.
- Kedia, S., Mahmood, A., Xie, L., Jiang, Y., Dillon, P., Ahuja, N., Arshad, H., & Entwistle, C. (2023) Driving under the influence of substances and motor vehicle fatalities among older adults in the United States. *Traffic Injury Prevention*, 24 (5), 379-386. <https://doi.org/10.1080/15389588.2023.2188435>.

- Kelly, E., Darke, S., & Ross, J. (2004). A review of drug use and driving: epidemiology, impairment, risk factors and risk perceptions. *Drug Alcohol Review*, 23(3), 319-44. <https://doi.org/10.1080/09595230412331289482>.
- LeRoy, A.A. & Morse, L.M. (2008). *Multiple medications and vehicle crashes: analysis of databases*. Washington, U.S. Department of Transportation, National Highway Traffic Safety Administration (NHTSA).
- Le Lièvre, P., Adminaite, D., Jost, G., & Podda, F. (2019). *Progress in reducing drink-driving and other alcohol-related road deaths in Europe*. Brussels, European Transport Safety Council.
- Leon, S.J., Trachtenberg, A., Briscoe, D., Ahmed, M., Hougen, I., Askin, N., Whitlock, R., Ferguson, T., Tangri, N., Rigatto, C., Komenda, P. (2022). Opioids and the Risk of Motor Vehicle Collision: A Systematic Review. *Journal of Pharmacy Technology*, 38(1), 54-62. <https://doi.org/10.1177/87551225211059926>.
- Marcil, I., Bergeron, J., Audet, T. (2001). Motivational factors underlying the intention to drink and drive in young male drivers. *Journal of Safety Research*, 32 (4), 363-376. [https://doi.org/10.1016/S0022-4375\(01\)00062-7](https://doi.org/10.1016/S0022-4375(01)00062-7).
- Marillier, M., & Verstraete, A.G. (2019). Driving under the influence of drugs. *WIREs Forensic Science*. e1326. <https://doi.org/10.1002/wfs2.1326>.
- Martin, T.L., Solbeck, P.A., Mayers, D.J., Langille, R.M., Buczek, Y., & Pelletier, M.R. (2013). A review of alcohol-impaired driving: the role of blood alcohol concentration and complexity of the driving task. *Forensic Science*, 58, 1238-1249. <https://doi.org/10.1111/1556-4029.12227>.
- Meesmann U., Boets S., De Gier J.J., Monteiro S., Álvarez F.J., & Fierro I. (2011). *Main DRUID results to be communicated to different target groups*. DRUID (Driving under the Influence of Drugs, Alcohol and Medicines). 6th Framework programme. Deliverable 7.3.2.
- McGinty, E.E., Tung, G., Shulman-Laniel, J., Hardy, R., et al. (2016). Ignition Interlock Laws: Effects on Fatal Motor Vehicle Crashes, 1982-2013. *American Journal of Preventive Medicine*, 52 (4), 417-423. <http://dx.doi.org/10.1016/j.amepre.2016.10.043>.
- McKinley, T. & Tillman, P. (2021). The Presence of Drug Substances among Pedestrian Fatalities in the United States, 2008-2017. *Journal of Alcohol & Drug Education*, 65 (2), 42+. <https://www.proquest.com/docview/2578203954>
- Meesmann, U., Torfs, K., Wardenier, N. & Van den Berghe, W. (2021). *ESRA2 methodology. ESRA2 report Nr. 1 (updated version)*. ESRA project (E-Survey of Road Users' Attitudes). Brussels, Belgium: Vias institute. <https://www.esranet.eu/en/publications-2/>
- Michie, S., van Stralen, M.M. & West, R. (2011). The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implementation Science*, 6, 42. <https://doi.org/10.1186/1748-5908-6-42>.
- Moan, I.S., & Rise, J. (2011). Predicting intentions not to "drink and drive" using an extended version of the theory of planned behaviour. *Accident Analysis and Prevention*, 43, 1378-1384. <https://doi.org/10.1016/j.aap.2011.02.012>.
- Modijefsky, M., Janse, R., Spit, W., Jankowska-Karpa, D., Buttler, I., Eikefjord, B. (2021). Prevention of driving under the influence of alcohol and drugs. Brussels, European Commission. <https://op.europa.eu/en/publication-detail/-/publication/a0ec8db9-8ed8-11ec-8c40-01aa75ed71a1>
- Nieuwkamp, R., Martensen, H. & Meesmann, U. (2017). Alcohol interlock, European Road Safety Decision Support System, developed by the H2020 project SafetyCube. Retrieved from www.roadsafety-dss.eu on 28 April 2021.

- Nochajski, T.H. & Stasiewicz, P.R. (2006). Relapse to driving under the influence (DUI): A review. *Clinical Psychology Review*, vol. 26, 179-195.
<https://doi.org/10.1016/j.cpr.2005.11.006>.
- Official Journal of the European Union (2019). *Regulation (EU) 2019/2144 of the European Parliament and the Council of 27 November 2019*. <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R2144&from=EN>.
- Official Journal of the European Union (2021). EU Drugs Strategy 2021-2025 (2021/C 102 I/01).
- Ogden, E.J.D. & Moskowitz, H. (2004). Effects of alcohol and other drugs on driver performance. *Traffic Injury Prevention*, 5, 185-198.
<https://doi.org/10.1080/15389580490465201>.
- Olesen, A.V., Madsen, T.K.O., Lahrmann, H., Nielsen, J. (2022). Use of psychotropic medication and risk of road traffic crashes: a registry-based case-control study in Denmark, 1996-2018. *Psychopharmacology*, 239(8), 2537-2546.
<https://doi.org/10.1007/s00213-022-06146-0>.
- Orriols, L., Luxcey, A., Contrand, B., Gadegbeku, B., et al. (2016). Road traffic crash risk associated with benzodiazepine and z-hypnotic use after implementation of a colour-graded pictogram: a responsibility study. *British Journal of Clinical Pharmacology*, 82 (6), 1625-1635. <https://doi.org/10.1111/bcp.13075>.
- Parker, D., Manstead, A.S.R., Stradling, S.G., & Reason, J.T., (1992). Determinants of intention to commit driving violations. *Accident Analysis & Prevention*, 24, 117-131.
[https://doi.org/10.1016/0001-4575\(92\)90028-H](https://doi.org/10.1016/0001-4575(92)90028-H).
- Pasnin, L.T. & Gjerde, H. (2021). Alcohol and drug use among road users involved in fatal crashes in Norway. *Traffic Injury Prevention*, 22(4), p. 267-271.
<https://doi.org/10.1080/15389588.2021.1887854>.
- PIRE (2012). Scientific evidence for developing a local logic model on alcohol-related motor vehicle crashes: A reference guide for community environmental prevention. Calverton, Pacific Institute for Research and Evaluation. Accessed 7 April 2021 at:
https://www.pire.org/wp-content/uploads/2020/12/Alcohol_Crashes_Guide_V2.1.pdf
- Podda, F & Meneiro, M. (2022). Progress in drink driving and other alcohol-related road deaths in Europe. Brussels, European Transport Safety Council. <https://etsc.eu/progress-in-reducing-drink-driving-and-other-alcohol-related-road-deaths-in-europe/>.
- Razaghizad, A., Windle, S.B., Gore, G., Benedetti, A., Ells, C., Grad, R., Filion, K.B., & Eisenberg, M.J. (2021). Interventions to Prevent Drugged Driving: A Systematic Review. *American Journal of Preventive Medicine*, 61 (2), 267-280.
<https://doi.org/10.1016/j.amepre.2021.03.012>.
- Rogeberg, O. & Elvik, R. (2016). The effects of cannabis intoxication on motor vehicle collision revisited and revised. *Addiction*, 111 (8), 1348-1359.
<https://doi.org/10.1111/add.13347>.
- Rogeberg, O. (2019). A meta-analysis of the crash risk of cannabis-positive drivers in culpability studies—Avoiding interpretational bias. *Accident Analysis & Prevention*, 123, 69-78. <https://doi.org/10.1016/j.aap.2018.11.011>.
- Rudisill T.M., Zhu, M., Kelley, G.A., Pilkerton, C., & Rudisill, B.R. (2016). Medication use and the risk of motor vehicle collisions among licensed drivers: A systematic review. *Accident Analysis and Prevention*, 96, 255-270. <https://doi.org/10.1016/j.aap.2016.08.001>.
- Sargent-Cox, K.A., Windsor, T., Walker, J., & Anstey, K.J. (2011). Health literacy of older drivers and the importance of health experience for self-regulation of driving behaviour.

- Accident Analysis & Prevention*, 43 (3), 898-905.
<https://doi.org/10.1016/j.aap.2010.11.012>.
- Schumann, J., Perkins, M., Dietze, P., Nambiar, D., Mitra, B., Gerostamoulos, D., Drummer, O.H., Cameron, P., Smith, K., & Beck, B. (2021). The prevalence of alcohol and other drugs in fatal road crashes in Victoria, Australia. *Accident Analysis & Prevention*, 153, 105905.
<https://doi.org/10.1016/j.aap.2020.105905>.
- Simmons, S.M. (2020). *The Effects of Cannabis and Alcohol on Driving Performance and Driver Behaviour: A Systematic Review and Meta-Analysis*. Doctoral thesis, University of Calgary, Calgary, Canada). <https://prism.ucalgary.ca/items/d680010f-c14d-4a79-a328-3808fa24f2c8>
- Simmons, S.M., Caird, J.K., Sterzer, F., & Asbridge, M. (2021). The effects of cannabis and alcohol on driving performance and driver behaviour: a systematic review and meta-analysis. *Addiction*, 117(7).1843-1856. <https://doi.org/10.1111/add.15770>
- Slootmans, F., Martensen, H., Kluppels, L., Meesmann, U (2017). *Rehabilitation courses as alternative measure for drink-driving offenders*. European Road Safety Decision Support System, developed by the H2020 project SafetyCube. Retrieved from www.roadsafety-dss.eu on 26 April 2021.
- Streff, F.M., Spradlin, H.K. & Eby, D.W. (2001). *Repeat alcohol offenders: A review of the literature*. University of Michigan, USA.
<https://ntlrepository.blob.core.windows.net/lib/18000/18300/18343/PB2001108197.pdf>.
- SWOV (2017). *Public service advertising*. SWOV fact sheet, November 2017. SWOV, The Hague. <https://swov.nl/en/fact-sheet/public-service-advertising>.
- SWOV (2020). *Drugs and Medicines, Scientific Factsheet, the Hague*, <https://www.swov.nl/en/facts-figures> March 2020. <https://swov.nl/en/fact-sheet/drugs-and-medicines>.
- SWOV (2021). *Driving under the influence of alcohol*. SWOV Factsheet, May 2021. The Hague, SWOV. <https://swov.nl/en/fact-sheet/driving-under-influence-alcohol>.
- Sykes, W., Groom, C., Kelly, J. & Hopkin, J (2010). *Qualitative Study of Drinking and Driving: Report of Findings*. London, Department for Transport.
- Teoh, E.R., Fell, J.C., Scherer, M. & Wolfe, D.E.R. (2018). *State alcohol ignition interlock laws and fatal crashes*. Insurance Institute for Highway safety, Arlington, Virginia.
- Teutsch, S.M., Geller, A. & Negussie, Y. (2018, eds). *Getting to zero alcohol-impaired driving fatalities: A comprehensive approach to a persistent problem*. Washington, DC, The National Academies Press. <https://doi.org/10.17226/24951>.
- Thomas, F.D., Darrah, J., Graham, L., Berning, A., Blomberg, R., [.....] & Moore, C. (2022). *Drug prevalence among seriously or fatally injured road users (Report No. DOT HS 813 399)*. Washington, National Highway Traffic Safety Administration.
- Touliou K., Margaritis D., Spanidis P., Monteiro S., Ravera S., De Gier J.J., [.....] & Álvarez F.J. (2011). Report on the implementation, evaluation and new technologies of practice guidelines and information materials. DRUID (Driving under the Influence of Drugs, Alcohol and Medicines). 6th Framework programme. Deliverable 7.4.2.
- Tonellato, D.J., Ransohoff, J.R., Nash, C., Melanson, S.E.F., Petrides, A.K., Tolan, N.V., Goldberg, S.A., Boyer, E.W., Chai, P.R., & Erickson, T.B. (2021). Traumatic pedestrian and bicyclist injuries associated with intoxication. *American Journal Emergency Medicine*, 45, 192-195. <https://doi.org.10.1016/j.ajem.2020.08.024>.
- Transport Safety Group (2006). *A Guide to Occupational Health and Safety Transport Industry*. Victoria, Transport Industry Safety Group.

- UNODC (2018). *World Drug Report 2018 (United Nations publication, Sales No. E.18.XI.9)*. Vienna, United Nations Office on Drugs and Crime.
- Vankov, D., & Schroeter, R. (2021) Driving under the influence of drugs or alcohol: Predicting the intentions of young drivers. *Traffic Injury Prevention, 22(2)*, 97-101. <https://doi.org/10.1080/15389588.2020.1869953>.
- Voas, R.B., Tippetts, A.S., Bergen, G., Grosz, M., et al. (2016). Mandating treatment based on interlock performance: Evidence for effectiveness. *Alcoholism: Clinical and Experimental Research, 40 (9)*, 1953-1960. <https://doi.org/10.1111/acer.13149>.
- Watson, T.M., Mann, R.E., Wickens, C.M., & Brands, B. (2019). "Just a Habit": driving under the influence of cannabis as ordinary, convenient, and controllable experiences according to drivers in a remedial program. *Journal of Drug Issues, 49(3)*, 531-544. <https://doi.org/10.1177/0022042619842375>.
- White, M.A. & Burns, N.R. (2021). The risk of being culpable for or involved in a road crash after using cannabis: A systematic review and meta-analyses. *Drug Science, Policy and Law, 7*, 1-20. <https://doi.org/10.1177/20503245211055381>.
- White, M. A., & Burns, N. R. (2023). Does the co-use of cannabis exacerbate the effect of alcohol on the risk of crashing? A systematic review and meta-analysis. *Drug Science, Policy and Law, 9*, 1-10. <https://doi.org/10.1177/20503245231177334>.
- Yannis, G., & Folla K. (2023). *Baseline report on the KPI Driving under the Influence of Alcohol*. Baseline project. Brussels, Vias institute. <https://www.baseline.vias.be/en/publications>.
- Zador, P.L., Krawchuk, S.A., & Voas, R.B. (2000). *Relative Risk of Fatal Crash Involvement by BAC, Age and Gender*. Washington, National Highway Traffic Safety Administration NHTSA.

