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Impaired driving and road safety

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Summary

Impaired driving is related to considerable increases in crash risk. This report describes measures against impaired driving, based on literature reviews. Measures that were found to be potentially effective in empirical studies are DUI-enforcement (checkpoints), vehicle impoundment and alcolock. However, the effects depend on the design and implementation of the measures. For example, alcolock and vehicle suspension may be effective for some drivers, but the effects depend on the specific implementation and tend not to last beyond the period during which the vehicle is impounded or alcolock installed. For other measures, there is no evidence of any direct effects on DUI, DUI-involved crashes or future DUI-offences among convicted drivers. However, BAC-limits, random breath testing laws and sanctions are essential requirements for effective police enforcement.

Kort sammendrag

Kjøring under påvirkning av alkohol, narkotika eller medikamenter medfører betydelige økninger av ulykkes- og skaderisikoen. Denne rapporten beskriver tiltak mot ruspåvirket kjøring, basert på gjennomganger av internasjonal litteratur. Tiltak som har vist seg å være effektive, er politikontroll, inndragelse av kjøretøy og alkolås. Virkningene av disse og andre tiltak avhenger imidlertid av hvordan de er utformet og implementert. For eksempel er alkolås og inndragelse av kjøretøy ikke like effektive for alle førere og når slike tiltak brukes som sanksjon har de som regel kun effekt i den perioden hvor de er i bruk (mens alkolås er installert / kjøretøyet inndratt), men ikke utover det. For de fleste andre tiltak er det vanskelig å påvise direkte effekter på promillekjøring eller promilleulykker. Likevel er mange slike tiltak, f.eks. promillegrenser og sanksjoner, nødvendige forutsetninger for effektiv politikontroll.

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Preface

This report contains long versions of six chapters of the Handbook of Road Safety Measures. All chapters describe measures against impaired driving or sanctions for impaired driving or other traffic violations. The report also contains an introduction chapter with general information about impaired driving and its effects on road safety. Shorter versions of all chapters are published online in Norwegian language (https://www.tshandbok.no/).

The Handbook of Road Safety Measures is a compendium of 145 different types of road safety measures that has been under continuous development since 1980. It is supported by the Norwegian Public Roads Administration and the Ministry of Transport.

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Institute of Transport Economics

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ENGLISH **Summary**

Impaired driving and road safety

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This report summarizes findings from literature reviews that have been conducted as a part of the revision of the Handbook of Road Safety Measures (last published version in English: Elvik et al., 2009).

This report presents long versions of all chapters that describe measures against impaired driving, including all relevant references and descriptions of the statistical analyses. Short versions focusing on the main conclusions are published in Norwegian language on www.tshandbok.no.

The chapters in the Handbook of Road Safety Measures that are covered by this report are the following:

- 8.6 DUI legislation (chapter 3 in this report)
- 8.7 DUI enforcement (chapter 4 in this report)
- 8.8 DUI-specific sanctions (chapter 5 in this report)
- 8.9 Treatment and educational programs for DUI-convicted drivers (chapter 7 in this report)
- 8.10 Demerit point systems (chapter 8 in this report)
- 8.12 Fines and imprisonment (chapter 6 in this report).

Background

Alcohol impairs driving skills already at very low levels and the impairment increases strongly with increasing blood alcohol concentration (BAC). Drivers are generally poor in judging their actual level of impairment.

In Norway, only about 0.2% of the general driver population are impaired by alcohol, but alcohol is strongly overrepresented among crash involved drivers, especially among fatal crash involved drivers. The most common illicit drugs in Norway are stimulant drugs, followed by cannabis. The use of cannabis has increased over time, while the use of benzodiazepines has decreased.

Among impaired drivers, several other factors that are related to increased crash and injury risk, are strongly overrepresented, amongst other things: Young males, low socioeconomic status, convictions for other traffic violations, criminal history, and alcohol and addiction problems.

However, there are several differences between drunk drivers and drivers impaired by illegal or legal substances and between countries. For example, drunk driving is far less common among heavy vehicle drivers than among car drivers in Norway. In the USA, alcohol is more common among pedestrians and motorcycle riders than among car drivers.

Compared to sober drivers, alcohol impairment leads to substantial increases in crash risk, even when controlling for confounding variables such as those listed above. Relative crash risk increases about exponentially with increasing BAC, from 2.3 at BAC .05-.08 to about twenty times the risk of a sober driver at BAC above .12. The relative risk of being killed or seriously injured in a crash is about 3.6 at BAC .05-.08 and increases to more than 100 at BAC above .12.

Other substances were also found to increase crash risk. The increase is on average somewhat larger for illicit drugs, especially amphetamine, than for prescription drugs. Relative risk estimates are difficult to compare because the degree of impairment is mostly unknown for illicit and prescription drugs. Average relative risk estimates for amphetamine correspond to a BAC around .10. Average relative risk estimates for other illicit drugs correspond for the most part to a BAC between .01 and .08.

DUI legislation

This chapter describes road safety effects of legislation that aims to reduce DUI and related crashes.

BAC-limits contribute to crash reductions when combined with effective police enforcement, but are unlikely to be effective without enforcement.

Among laws regulating the availability of alcohol, only minimum legal drinking age has been found to be related to alcohol- related crashes.

Inconsistent or no relationships with alcohol-related crashes were found for regional bans on alcohol sales, alcohol taxes and prices, outlet density, state monopoly, limited days or hours of sales, and open-container laws.

Other types of legislation for which no or inconsistent effects were found, are: Random breath testing laws (unless combined with police enforcement), implied consent, anti-plea bargaining, dram shop, social host liability, and child endangerment laws.

Although most studies fail to demonstrate the effectiveness of individual types of legislation in reducing DUI or DUI-related crashes, several types of legislation are still effective in combination with police enforcement and sanctions. Among such laws are BAC-limits, random breath testing laws, and administrative license revocation laws.

For the legalization of cannabis, highly inconsistent effects were found on cannabis-related crashes.

DUI enforcement

DUI enforcement may be conducted from checkpoints or by mobile controls (patrolling). Checkpoints were found to reduce alcohol-related crashes by 17% on average. However, this effect may be overestimated and it differs depending on the type of checkpoint program. Greater effects were found for short-term programs, programs that include paid publicity and checkpoints in Australia. Moreover, highly visible checkpoints with a high control frequency were found to increase the effectiveness.

For mobile enforcement, the results from empirical studies are highly inconsistent. On average, no crash reducing effect was found.

DUI enforcement in general, studies show that increased intensity of enforcement can be expected to improve its effectiveness. However, for individual drivers, having been arrested for DUI, has not been found to reduce the likelihood of future DUI-arrests or DUI-related crashes.

DUI-specific sanctions

DUI-specific sanctions may have different aims: To deter DUI-convicted drivers from new DUI-offences; to deter the general driver population from DUI; to remove DUI-convicted drivers from traffic or to prevent them from committing new DUI-offences.

Effects on accidents have been investigated for the following types of sanctions:

(**1) License suspension and revocation:** These were not found to have any deterrent effects, neither among the general driver population or among drivers who had their license suspended. Drivers with a suspended or revoked license have for the most part fewer accidents than other drivers (but still far more than if they had completely stopped driving).

(2) Vehicle impoundment: There may be a deterrent effect among drivers who have got their vehicle impounded, either for DUI or other offences (such as unlicensed driving). However, the results from empirical studies are inconsistent. Amongst other things, the measure may have little or no effect among drivers with very old cars.

(3) Alcohol ignition interlock (alcolock): Alcolock for DUI-convicted drivers mostly reduces DUI and DUI-related crashes as long as alcolock is installed in their cars. No effects were found on non-alcohol-related crashes and offences.

A common finding for all three types of sanctions is that both DUI-offences and DUI-related crashes return to the same level as before conviction once the restrictions have been lifted (license reinstated, vehicle returned, alcolock removed).

Treatment and educational programs for DUI-convicted drivers

Treatment and educational programs for DUI-convicted drivers (or other traffic offences) are meant to reduce either alcohol problems or driver behavior. Such programs can be either alternatives or supplements to classical sanctions (such as penalties or license suspension).

Treatment for alcohol problems has in empirical studies mostly not been found to reduce neither recidivism nor crashes. Some programs may still be effective, especially if they focus on drivers without addiction problems, criminal records, or cognitive impairments.

Educational measures are maily targeted at drivers who have commited serious traffic offences but not alcohol- og dependency-problems. Empirical studies have found at best small and short-term effects. However, some recent studies of educational measures targeting specific types of driver behavior have found relatively large effects on recidivism and crash involvement.

Educational measures that are offered as an alternative to license suspension, were mostly found to increase reoffence rates and crash involvement among participating drivers (relative to license suspension).

For **Victim Impact Panels**, results from empirical studies are inconsistent and do not allow generalizable conclusions.

Demerit point systems

Demerit point systems are meant to reduce traffic offences that are related to crash involvement, but not in themselves sufficient for severe sanctions.

After the introduction of demerit point systems, relative large crash reductions were found in several countries, on average by about 15%. However, the effect decreases over time and long-term effects are unknown.

For those types of driver behavior that are included in demerit point systems, improvements were in several studies. However, in Norway, no effect was found in the general driver population.

Among individual drivers, a demerit point system may have a specific deterrent effect, i.e. drivers may commit fewer offences after having accumulated demerit points. On the other hand, accumulating demerit points is related to a generally risky driving style and thus, drivers with accumulated points may also be more likely to accumulate more points.

Fines and imprisonment

Fines and imprisonment are sanctions for the most serious traffic offences. In Norway, imprisonment is mainly used for DUI and the most severe speeding offences.

Empirical studies have for the most part not found any effects on total crash numbers of the introduction or increase of minimum fines or lengths of imprisonment. However, this does not mean that crash numbers would remain unchanged if fines and imprisonment were abandoned as sanctions for traffic offences.

Studies that have compared the effects of imprisonment and other sanctions among convicted drivers (mostly for DUI), did not find systematic differences. This means that imprisonment is not necessarily more effective in preventing future offences than other sanctions (such as fines, license suspension or DUI-treatment programs).

Transportøkonomisk institutt
Stiftelsen Norsk senter for samferdselsforskning

NORSK **Sammendrag**

Promillekjøring og ulykker

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Kjøring under påvirkning av alkohol, narkotika eller medikamenter medfører betydelige økninger av ulykkes- og skaderisikoen. Denne rapporten beskriver tiltak mot ruspåvirket kjøring, basert på gjennomganger av internasjonal litteratur. Tiltak som har vist seg å være effektive, er politikontroll, inndragelse av kjøretøy og alkolås. Virkningene av disse og andre tiltak avhenger imidlertid av hvordan de er utformet og implementert. For eksempel er alkolås og inndragelse av kjøretøy ikke like effektive for alle førere og når slike tiltak brukes som sanksjon har de som regel kun effekt i den perioden hvor de er i bruk (mens alkolås er installert / kjøretøyet inndratt), men ikke utover det. For de fleste andre tiltak er det vanskelig å påvise direkte effekter på promillekjøring eller promilleulykker. Likevel er mange slike tiltak, f.eks. promillegrenser og sanksjoner, nødvendige forutsetninger for effektiv politikontroll.

Denne rapporten oppsummerer resultater fra litteraturstudier som er gjort i forbindelse med revisjonen av Trafikksikkerhetshåndboken (sist publisert på engelsk av Elvik et al., 2009; online på norsk med regelmessige oppdateringer på www.tshandbok.no).

Rapporten inneholder lange versjoner av kapitlene i Trafikksikkerhetshåndboken som handler om ruskjøring og tiltak mot ruskjøring, i tillegg til noen mer generelle tiltak mot ulike typer trafikklovbrudd:

- 8.6 Lovregulering av promillekjøring (kapittel 2 i denne rapporten)
- 8.7 Promillekontroller (kapittel 3 i denne rapporten)
- 8.8 Sanksjoner og restriksjoner for promillekjøring (kapittel 4 i denne rapporten)
- 8.9 Behandling og opplæring (kapittel 5 i denne rapporten)
- 8.10 Prikkbelastningsordninger (kapittel 6 i denne rapporten)
- 8.12 Bøter og felgselsstraff (kapittel 7 i denne rapporten).

Korte versjoner på norsk av alle kapitlene finnes på www.tshandbok.no.

Bakgrunn

Alkohol påvirker kjøreferdighetene allerede fra relativt lave promillenivåer. Også førernes evne til å vurdere egen kjøreevne er som regel svak.

I Norge kjøres kun omtrent 0,2% av kjøretøykilometer under påvirkning av alkohol. Likevel er alkohol sterkt overrepresentert blant førere som er involvert i ulykker, spesielt i dødsulykker. De mest vanlige typer narkotika i trafikken i Norge er stimulanser, fulgt av cannabis.

Blant førere som er påvirket av alkohol eller narkotika, er en rekke andre faktorer sterkt overrepresentert som har sammenheng med økt ulykkes- og skaderisiko: Unge menn, lav sosioøkonomisk status, andre trafikklovbrudd, involvering i straffesaker, samt alkohol- og avhengighetsproblemer. Det finnes imidlertid også forskjeller mellom ulike substanser, trafikantgrupper og land. Eksempelvis er promillekjøring i Norge mer utbredt blant bilførere og langt mindre blant førere av tunge kjøretøy. I USA er alkohol mer vanlig blant fotgjengere og motorsyklister og mindre vanlig blant bilførere.

Promillekjøring medfører betydelige økninger i ulykkesrisikoen allerede ved forholdsvis lav promille, og risikoen øker omtrent eksponentielt med økende promille. Sammenlignet med en upåvirket fører, er den relative ulykkesrisikoen på rundt 2,3 ved 0,5-0,8 promille og på rundt 20 ved 1,2 eller mer promille. Den relative risikoen for å bli drept eller hardt skadd, er på rundt 3,6 ved 0,5-0,8 promille og på over 100 ved 1,2 eller høyere promille.

Narkotika og medikamenter medfører også økt risiko. Gjennomsnittlige risikoøkninger er noe større for narkotika, spesielt amfetamin, enn for medikamenter. Relative risikotall er vanskelige å sammenligne da graden av påvirkningen i de fleste studiene av medikamenter og narkotika ikke er oppgitt. Den gjennomsnittlige risikoøkningen som ble funnet for amfetamin tilsvarer omtrent én promille. Den gjennomsnittlige risikoøkningen som ble funnet for andre typer narkotika tilsvarer en promille på mellom 0,1 og 0,8.

Lovregulering for promillekjøring

Det finnes ulike lover som har som formål å redusere forekomsten av promillekjøring og alkoholrelaterte ulykker. For promillegrenser er det ikke funnet noen generell effekt på antall alkoholrelaterte ulykker, men i forbindelse med politikontroll kan reduserte promillegrenser bidra til å redusere antall alkoholrelaterte ulykker. Når det gjelder regulering av tilgjengeligheten til alkohol, er det kun skjenkerettsalder som har vist seg å ha sammenheng med antall alkoholrelaterte ulykker: Høyere skjenkerettsalder medfører færre alkoholrelaterte ulykker blant unge førere. For følgende typer reguleringer er det funnet inkonsistente eller ingen sammenhenger: Totalforbud mot alkoholsalg i enkelte regioner, alkoholavgifter eller -priser, tetthet av utsalgssteder, statlig alkoholmonopol, begrensninger på tider for alkoholsalg og lover som forbyr åpne alkoholbeholdere eller alkoholkonsum i bilen. Øvrige lover har heller ikke vist seg å ha noen effekt: Samtykkelover for promilleprøver, «anti-plea bargaining», å kunne stille skjenkesteder eller privatpersoner som serverer alkohol til ansvar for skader som berusede personer påfører andre, samt lover om strengere straffer for å sette barn i fare i trafikken (f.eks. kjøre med promille med barn i bilen). Alt i alt tyder resultatene på at lovregulering i svært liten grad kan påvirke promillekjøring og alkoholrelaterte ulykker. Dette gjelder imidlertid kun når man ser isolert på enkelte lover. Flere av lovene, især promillegrenser, og lover som tillater tilfeldige politikontroller og inndragelse av førerkort etter administrative prosedyrer, er nødvendige forutsetninger for effektive politikontroller.

Promillekontroller

Promillekontroller kan gjennomføres med stasjonære kontrollposter (ofte med tilfeldige kontroller) eller som mobile kontroller (som regel kontroller ved konkret mistanke om promillekjøring). For stasjonære kontroller ble det funnet ulykkesreduksjoner på rundt 10% og noe større når man kun ser på alkoholrelaterte ulykker. Resultatene tyder på at synlige og hyppige kontroller er mest effektive. For mobile kontroller spriker resultatene. I gjennomsnitt ble det ikke funnet noen ulykkesreduserende effekt. For promillekontroller generelt viser en rekke studier at et høyere kontrollomfang medfører større ulykkesreduksjoner. Enkelte førere som opplever å bli tatt i kontroll, har imidlertid ikke redusert risiko for hverken promillekjøring eller ulykker i framtiden.

Sanksjoner og restriksjoner for promillekjøring

Sanksjoner og restriksjoner for promilledømte førere kan ha ulike formål: Å avskrekke førere som har blitt dømt for promillekjøring fra å promillekjøre på nytt; å avskrekke førere generelt fra promillekjøring; å fjerne promilledømte førere fra trafikken eller forhindre at de kan kjøre med promille, for å unngå at de utgjør en fare for andre trafikanter og seg selv i trafikken. Virkningen på antall ulykker er som følgende for ulike typer sanksjoner og restriksjoner: (1) Inndragelse av førerkort har som regel ikke vist seg å ha noen avskrekkende effekt, verken generelt eller på førere som har fått inndratt førerkortet. Førere med inndratt førerkort har i perioden med inndratt førerkort færre ulykker enn ellers (men langt flere enn de ville hatt dersom de ikke hadde kjørt uten gyldig førerkort). (2) Inndragelse av kjøretøy kan ha en avskrekkende effekt på førere som får kjøretøyet sitt inndratt som sanksjoner for promillekjøring (eller andre forseelser, i hovedsak kjøring uten gyldig førerkort), men resultater fra empiriske studier er inkonsistente og spriker en del. (3) Alkolås for promilledømte førere reduserer som regel promillekjøring og alkoholrelaterte ulykker mens alkolåsen er installert i bilene. På ikke-alkoholrelaterte ulykker og forseelser ble det imidlertid ikke funnet noen effekt. Både ved inndragelse av førerkort/kjøretøy og alkolås er det vanlig at promillekjøring og innblanding i ulykker går tilbake til samme nivå som før inndragelsen/alkolåsen når førerne får førerkortet og/eller bilen tilbake eller alkolåsen fjernet fra bilen.

Behandling og opplæring

Behandlings- og opplæringstiltak for førere som er dømt for ruspåvirket kjøring eller andre trafikklovbrudd skal redusere førernes alkoholproblemer eller generelt endre førernes atferd. Slike tiltak kan være alternativer eller supplementer til klassiske sanksjoner (som f.eks. bøter og førerkortinndragelse). Behandlingstiltak har i hovedsak førere med alkohol- og avhengighetsproblemer som målgruppe. Det er ikke funnet noen reduksjoner verken av antall ulykker eller tilbakefall. Opplæringstiltak retter seg i hovedsak mot førere som har begått gjentatte eller alvorlige trafikklovbrudd (uten alkohol- eller avhengighetsproblemer). For slike tiltak er det i de fleste studiene heller ikke funnet noen effekt. Noen nyere studier av tiltak som fokuserer på føreratferd har imidlertid funnet relativt store reduksjoner av antall tilbakefall og ulykker. Dersom opplæringstiltak tilbys som alternativ til førerkortinndragelse, medfører opplæringen som regel økt antall nye lovbrudd og ulykker (i forhold til førerkortinndragelse). For såkalte Victim Impact Panels (diskusjoner mellom førere dømt for ruspåvirket kjøring og personer som ble skadd i rusrelaterte ulykker, som regel et supplerende i forbindelse med mer omfattende programmer) spriker resultatene og det er ikke mulig å dra noen konklusjoner om hvorvidt slike tiltak kan være effektive.

Prikkbelastningsordninger

Prikkbelastningsordninger har som formål å redusere antall trafikklovbrudd som har sammenheng med innblanding i ulykker, men som ikke i seg selv er tilstrekkelige for strenge sanksjoner. Etter innføring av prikkbelastningsordninger ble det i flere land funnet relativt store ulykkesreduksjoner (sammenlagt -15%). Effekten er imidlertid som regel kortvarig. Den avtar over tid og det er ikke kjent hvorvidt antall ulykker forblir lavere etter flere år enn det ellers hadde vært. De typer føreratferd som er omfattet av prikkordninger har i flere studier vist seg å bli forbedret, men bl.a. i Norge ble det ikke funnet noen effekt i den generelle førerpopulasjonen. For individuelle førere kan det å ha prikker ha en avskrekkende effekt (førere begår færre nye lovbrudd). Det å ha prikker har imidlertid også sammenheng med en generelt risikabel kjørestil, noe som kan medføre økt fare for flere prikker.

Bøter og fengselsstraff

Bøter og fengselsstraffer er sanksjoner for de mest alvorlige trafikklovbrudd. Fengselsstraffer benyttes i Norge i hovedsak for promillekjøring og de mest alvorlige fartsgrenseovertredelser. Empiriske studier har for det meste ikke funnet noen effekt på det totale antall ulykker, verken av å innføre minstesatser for bøter og fengselsstraffer eller av å øke slike satser. Dette betyr imidlertid ikke at man kunne forvente at antall ulykker forblir uendret dersom man avskaffer bøter og fengselsstraffer for trafikkforseelser. Studier som har sammenlignet virkningen av fengselsstraffer med andre sanksjoner blant førere som ble dømt (de fleste for promillekjøring), har ikke funnet systematiske forskjeller. Det betyr at fengselsstraff ikke nødvendigvis er mer effektiv for å forhindre nye lovbrudd enn andre sanksjoner (bøter, førerkortinndragelse og ev. promilleprogrammer).

1 Introduction

This report summarizes findings from literature reviews that have been conducted as a part of the revision of the Handbook of Road Safety Measures. The Handbook of Road Safety Measures is a compendium of 145 different types of road safety measures that has been under continuous development since 1980. It is supported by the Norwegian Public Roads Administration and the Ministry of Transport. It has been published in English by Elvik et al. (2009) and it is continuously updated in Norwegian on www.tshandbok.no.

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Tables in the appendix: For many sections in this report, tables in the appendix provide short summaries of relevant empirical studies. The summaries in these sections are based on these studies, even if not all studies are explicitly referred to in the text, and the text may contain more references than those included in the tables.

Driving under the influence (DUI) refers in this report to the operation of a motor vehicle while being under the influence of psychoactive substances, including alcohol, legal and illegal drugs.

1.1 Driving under the influence of alcohol

The degree of alcohol intoxication is normally described in terms of blood alcohol concentration (BAC). A BAC of 0.1 (or "one promille") means that there are 0.10 g of alcohol for every dL of blood (or one gram per kg blood). The ratio of breath alcohol to blood alcohol is 2100:1, meaning that 2100 mL of air will contain same amount of alcohol in 1 mL of blood.

A BAC of 0.01 is commonly regarded as the lowest limit of detection. The legal BAC limit in most countries is 0.02 (e.g. in Norway), 0.05 (e.g. in Germany), or 0.08 (e.g. in the UK).

Common effects of different BAC levels include (in more detail summarized for specific BAC levels in Table 1):

- **Low BAC (ca. .01-.05):** Feeling slightly affected, slight euphoria, loss of shyness
- **Medium BAC (ca. .05-.10):** Increased risk taking, impaired judgement increasing impairment of reaction time, speech, reasoning
- **High BAC (above .10):** Significant impairment of motor coordination, judgement, reaction times; euphoria increasingly replaced by dysphoria
- **Very high BAC:** Nausea, vomiting, mental confusion. BAC levels above 0.3 or 0.4 are usually associated with unconsciousness and potentially lethal.

The amount of alcohol a person has to drink for obtaining a certain BAC level depends on body weight, age, and sex, amongst other things. When a person can function quite normally (without evidence of intoxication) with a BAC of 0.15 or higher this person can usually be diagnosed as an alcoholic (Wallach, 2007).

Table 1: Common effects of different BAC levels.

Medscape.com[1]		**Norwegian Institute of Public Health**[2]	
0.01-0.05	No loss of coordination, slight euphoria, loss of shyness.	0.01-0.05	Feeling slightly affected.
0.04-0.06	Well-being feeling, relaxation, lower inhibitions, minor impairment of reasoning and memory, euphoria.	0.05-0.10	Increased risk taking, impaired judgement.
0.07-0.09	Slight impairment of balance, speech, vision, reaction time, and hearing, euphoria; judgment and self-control reduced. Caution, reasoning, and memory are impaired.		
0.10-0.125	Significant impairment of motor coordination and loss of good judgment; speech may be slurred; balance, vision, reaction time and hearing will be impaired. Euphoria.	0.10-0.15	Impaired balance, blurred speech, motor impairment, tiredness, possibly nausea.
0.13-0.15	Gross motor impairment and lack of physical control; blurred vision and major loss of balance; euphoria is reduced and dysphoria is beginning to appear.		
0.16-0.20	Dysphoria (anxiety, restlessness) predominates, nausea may appear; the drinker has the appearance of a "sloppy drunk".	0.15+	Loss of memory.
0.25	Needs assistance in walking; total mental confusion; dysphoria with nausea and some vomiting.		
0.30	Loss of consciousness.	Very high	Reduced / possible loss of consciousness, vomiting, possible death from ca. 0.30, increased risk of death if also under the influence of tranquilizers, barbiturates, analgesics, anticonvulsants or other drugs with a subduing effect on the brain.
0.40 or more	Onset of coma, possible death due to respiratory depression/arrest.		

[1] https://emedicine.medscape.com/article/2090019-overview#showall

[2] http://www.fhi.no/tema/alkohol/virkninger-av-alkohol

In the following, we summarize some findings about the effects of alcohol that are relevant for the interpretation of findings from empirical studies that are described in the following chapters.

Impairment by alcohol: Alcohol impairs driving skills at low levels (from 0.02 BAC) and alcohol consumption may even impair driving skills at zero BAC, such as after having been drunk (hangover) and among drivers with alcohol abuse disorders.

- Alcohol has acute disinhibiting effects on behavior (Fillmore et al., 2009), impairs judgments about the dangers of risky behaviors (Amlung et al., 2014), and impairs inhibitory control (the ability to inhibit a response that has already been instigated) at relatively low blood alcohol concentrations (BAC) that fail to slow response times (Miller & Fillmore, 2014).
- Alcohol impairs driving skills even at low BAC levels. According to reviews of studies of the effect of alcohol, the majority of experimental studies found significant impairments of driving skills at a BAC of 0.05, and most drivers are impaired in at least some relevant driving skills at a BAC of 0.02 (Moskowitz & Fiorentino, 2000; Fell & Voas, 2013).

- Driving performance is impaired at lower BAC levels than those at which general impairment becomes measurable, probably because of the complexity of the driving task and because driving skills are among those that are most sensitive alcohol (Schnabel et al., 2010).
- Impaired driving behavior was found even after the BAC-level had returned to zero after having been drunk (Liu & Ho, 2010).
- Chronic alcohol use is associated with sustained states of impulsive (under-controlled) behavior (Bates et al., 2002; Fillmore, 2007).
- Alcohol abuse disorders are considered by many investigators to represent a disinhibitory psychopathology (Fillmore et al., 2009).

Acute alcohol tolerance: Drivers may develop tolerance to some aspects of acute impairment, while they remain impaired with regard to other aspects.

- Acute alcohol tolerance means that “alcohol-induced impairment is greater when measured soon after beginning alcohol consumption than when measured later in the drinking session, even if the BAC is the same at both times” (NIAAA, 1995). It does not develop for all effects of alcohol but does develop to the feeling of intoxication experienced after alcohol consumption (NIAAA, 1995).
- In an experimental study, both error rate and response times on a task that required quick and correct responses increased with increasing BAC. With decreasing BAC, response time returned to the baseline level, but the error rate continued to increase Schweizer et al., 2004).
- Acute alcohol tolerance was observed for measures of response time, motor coordination, and ratings of intoxication in an experimental study by Miller & Fillmore (2014). These measures returned to sober levels by the time BAC fell to near zero. By contrast, impairment of inhibitory control showed no acute tolerance and remained impaired even when drinkers' BAC returned to near zero.

Functional alcohol tolerance: The brain adapts and compensates for some effects of alcohol over time, but not for all. Such adaptation may be specific for specific driving functions and driving environments. It may lead to serious overestimation of ones fitness to drive

- Functional alcohol tolerance develops when the brain adapts and compensates for the effects of alcohol over time. Functional tolerance develops at different rates for different functions. For example, more tolerance was developed for tasks requiring mental functions than for tasks requiring eye-hand coordination, such as driving a car. For lower BAC levels the development of functional tolerance depends on the environment (environment-dependent tolerance). If alcohol always is consumed in a specific environment, functional tolerance may develop in this environment, without being transferred to other environments (NIAAA, 1995).
- The development of functional tolerance can be accelerated by practicing a task while under the influence of alcohol (learned tolerance); rewarding successful task performance can also accelerate the development of functional tolerance (NIAAA, 1995).
- Functional tolerance may develop for parts for the driving task in specific environments or situations. However, tolerance does not develop for all functions that are relevant for the driving task, and drivers may be equally impaired as other drivers (with the same ABC and no tolerance) in unexpected situations. Thus, a driver who has developed functional tolerance for alcohol, may seriously overestimate his fitness to drive.

Self-estimated alcohol impairment: Drivers are generally poor in judging their own level of impairment.

- In an experimental study Starkey and Charlton (2014) found that self-estimated level of intoxication was only poorly related to actual BAC levels (up to 0.08), and degree of actual impairment.

- Participants in an experimental study judged driving to be significantly less dangerous and were more willing to drive on the descending limb (decreasing BAC) compared to the ascending limb (increasing BAC) (Amlung et al., 2014).

1.2 Impairment and crash risk

1.2.1 The effect of BAC-level on crash and injury risk

A meta-analysis has been conducted of studies that have empirically investigated the relationship between BAC-level and crash or injury risk. The meta-analysis is based on a total of 440 effect estimates from 75 studies. A list of all studies can be found in Appendix V.1.

Figure 1 shows the summary effects of relative risk estimates for different BAC-levels. Risk estimates that refer to "KSI" include all results for fatalities and serious injuries, while those for "Crash" include all results that refer to being injured in a crash, crash involvement or culpability in a crash. BAC-levels were grouped into five closed intervals and four open-ended intervals. Individual study results were included in the group where they fit best (for example a result for BAC .02-.05 would be put into the category .01-.05). Detailed results from meta-analysis with confidence intervals are shown in Table 2.

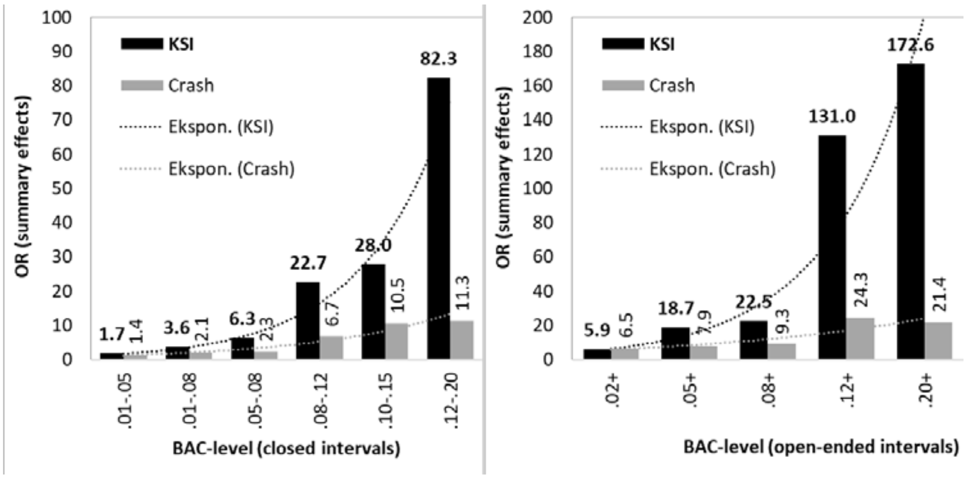

Figure 1: Summary effects of relative risk estimates by BAC-level (left: closed intervals; right: open-ended intervals), results from meta-analysis.

Table 2: Summary effects of relative risk estimates by BAC-level (left: closed intervals; right: open-ended intervals), results from meta-analysis; statistically relative risk estimates in bold letters.

	KSI			Crash		
BAC	N	Rel. risk	95% Confidence interval	N	Rel. risk	95% Confidence interval
.01-.05	16	**1.75**	(1.36; 2.24)	17	**1.39**	(1.27; 1.52)
.01-.08	8	**3.64**	(1.53; 8.65)	6	**2.10**	(1.71; 2.58)
.05-.08	12	**6.31**	(4.71; 8.44)	23	**2.26**	(2.06; 2.49)
.08-.12	10	**22.65**	(13.92; 36.87)	9	**6.70**	(5.54; 8.1)
.10-.15	5	**27.97**	(14.21; 55.04)	6	**10.50**	(9.03; 12.2)
.12-.20	3	**82.32**	(1.04; 6499.4)	7	**11.28**	(7.86; 16.18)
.02+	51	**5.88**	(4.82; 7.17)	39	**6.46**	(4.65; 8.98)
.05+	12	**18.69**	(11.82; 29.54)	21	**7.86**	(5.7; 10.84)
.08+	23	**22.53**	(12.66; 40.08)	24	**9.26**	(7.32; 11.71)
.12+	9	**130.96**	(53.78; 318.89)	11	**24.34**	(16.62; 35.63)
.20+	3	172.63	(0.57; 52701)	8	**21.44**	(13.37; 34.38)

The results in Figure 2 and Table 2 show that risk increases about exponentially with increasing BAC and that the increase is far more pronounced for more serious crashes.

With one exception, all results are statistically significant. However, some confidence intervals are extremely large and there is large heterogeneity in the results. Some potential moderator variables that may affect the size of the effects are discussed in the following.

Crash severity

The results from meta-analysis only distinguish between KSI crashes and crash involvement (unspecified severity). Increasing BAC has on average far greater effect on KSI than on crashes in general.

The results for KSI include are based on individual study results that refer to fatalities, serious injuries, and all fatal or serious injuries. Systematic differences between the different types of results were not found.

The results for crash involvement are based on individual study results that refer to either crash involvement, injury, or being the triggering / responsible unit in the crash. Systematic differences between the different types of results were not found.

Consistent with the finding that alcohol has greater effects on more serious crashes, several studies also show that crashes involving drunk drivers on average are more serious than other crashes (Mayhew & Simpson, 1986; Warren, 1976). Norwegian crash data from 1983-1999 show that there are more killed or severely injured in crashes involving a drunk car driver (20% of all killed or injured) than in crashes with no drunk car drivers involved (17% of all killed or injured). Savolainen and Gosh (2008) investigated factors influencing the severity of motor vehicle deer collisions. Alcohol involvement rates were 0.18% in motor vehicle deer collision with property damage only while it was 15.3% (85 times the rate in PDO collision) in motor vehicle deer collisions with fatal or incapacitating injury.

Crash type

The results from meta-analysis are for the most part based on studies that include all crashes. Some of the studies have investigated specific crash types: Motorcycle crashes, single vehicle crashes, or young driver crashes. Systematic difference between specific crash types were not found and results are therefore only presented for all studies combined. However, there are relatively few and highly heterogeneous results for specific crash types and it is therefore not possible to conclude that alcohol impairment has the same effect in all types of crashes.

For example, one may assume that alcohol has a greater effect on crash risk among motorcyclists than among car or truck drivers because of the effects of alcohol on balance and motor coordination (Lin & Kraus, 2009). Moreover, alcohol impaired motorcycle riders are far more often than others riding unhelmeted which strongly increases fatality risk (Lin & Kraus, 2009).

Crash risk at very high BAC levels

In meta-analysis, crash and injury risk were found to increase strongly and about exponentially with increasing BAC. Schnabel et al. (2010) suggests that most drivers are able to compensate for the impairing effects of alcohol up to a certain level, but that compensating mechanisms may fail at higher levels. Such a mechanism might explain why crash risk increases about exponentially, although impairment increases mostly linearly.

At the highest BAC levels, the curves for crash risk flatten out at BAC above about .12. Several studies also show that BAC-risk curves flatten from BAC-levels of around 0.25 (Blomberg et al., 2005, 2009; Phillips et al., 2015).

The curves for KSI do not flatten and some studies found extremely large increases of crash risk at high BAC-levels (for example ca. 1500 times the risk of sober drivers at BAC in the study be Keall et al., 2013).

However, there is large heterogeneity especially in the results for the highest BAC-levels and the risk curves cannot be expected to increase indefinitely. From some point, increasing BAC will prevent all drivers from driving and it may in itself be fatal.

Besides methodological aspects that may contribute to the large heterogeneity at high BAC-levels, results are also likely to be sensitive to the distribution of BAC-levels.

One may also expect large differences between individual drivers. For being able (in any sense) to drive at high BAC levels, a driver needs some tolerance for alcohol. Drivers with high BAC levels are more likely than others to have developed a tolerance for alcohol (and to be alcoholics), and they are likely to differ from other drivers in other respects than BAC level (Keall et al., 2004).

Methodological considerations: Control for potential confounding variables

DUI is related to numerous other factors that also are related to crash and injury risk, e.g. the drivers age and gender, time of day and speed limit. One might therefore assume that controlling for such factors may affect the results from studies of the relationship between BAC and crash or injury risk.

However, although studies with control for potential confounding variables on average found somewhat greater effects than studies without such control, the effect is not statistically significant. In the further analysis, results from studies with and without control are combined; from studies that have reported results with and without control, the results with control for potential confounding factors were included.

Adjustment for confounding factors: Many studies have statistically controlled for other factors and / or matched the sites from which data from crash-involved and non-crash involved drivers were collected.

General differences between sober drivers and drivers with different BAC-levels that often are controlled for, include:

- Time of day and week (more drivers are drunk at night and on weekends)
- Location (more drivers are drunk near pubs and restaurants)
- Driver characteristics (male and young drivers are more often drunk than others).

Methodological considerations: Treatment of drugs other than alcohol

Studies differ with respect to the treatment of other psychoactive substances. There are three groups of studies:

(1) **Other substances unspecified:** Drivers under the influence of other psychoactive substances among both BAC-positive and BAC-negative drivers (most studies)
(2) **Alcohol only:** All drivers not under the influence of other psychoactive substances
(3) **Alcohol and other:** Drivers under the influence of alcohol and one or more other psychoactive substances, compared to completely sober drivers.

Methodological considerations: Hit-and-run drivers

Another common methodological problem is related to missing data. Hit-and-run drivers have higher BAC-levels on average than other crash involved drivers (Blomberg et al., 2005; based on BAC tests of hit-and-run drivers who were caught by the police within two hours after the crash). It is therefore likely that drivers with high BAC levels are underrepresented among crash involved drivers. Crash risk at high BAC levels is therefore likely to be underestimated if this type of missing data bias is not controlled for. In the study by Blomberg et al. (2005), relative risk estimates with adjustment for hit-and-run crashes are about 30% higher at BAC .10, twice as high at BAC .18, and 1.7 times as high at BAC .24, compared to risk estimated without adjustment for hit-and-run.

Geography and the relationship between the amount of drunk driving and risk among drunk drivers

The relationship between BAC and crash/injury risk may differ between different countries. For example, BAC has been found to have a stronger influence on crash risk in Norway and Finland than in southern Europe and North America (Gjerde et al., 2014). Also in the present meta-analysis, greater effects of BAC were found in Nordic countries than in other geographic regions, while other geographic regions do not differ significantly. Other geographic regions investigated are USA, Canada, Oceania, Asia, France, and other European countries.

A likely explanation is that drunk driving is less common in the Nordic countries than in other countries. It is therefore likely that drunk driving is more strongly related to other types of high-risk behavior that will contribute to high crash risk and severity.

Elvik (2015) has investigated the relationship between the proportion of BAC-positive drivers in the general driver population and the relative fatality risk of BAC-positive drivers. The results are shown in Figure 2. The results are based on studies from different countries.

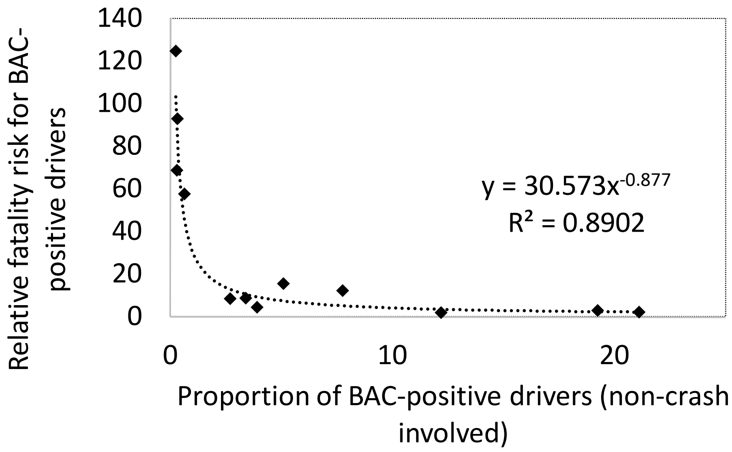

Figure 2: Relationship between the proportion of BAC-positive drivers in the general driver population and the relative fatality risk of BAC-positive drivers (Elvik, 2015).

Lower percentages of drunk drivers are associated with higher estimated risks for drunk drivers. According to Elvik (2015), there are several possible explanations. When the incidence of drunk driving is very low (such as in Norway and Finland, the four data points with the lowest incidence and highest risk in the figure) the estimated relative risk is highly sensitive for the estimated proportion of drunk drivers among non-crash involved drivers. Another possible explanation is that drunk drivers in countries with little drunk driving are a more extreme risk group of drivers who show more other high-risk behavior than drunk drivers in countries where drunk driving is more common.

Drivers: Age

Young people who drive drunk have a greater risk of crash involvement than older drinking drivers at the same BAC (Blomberg et al., 2005; Mayhew et al., 1986; Romano et al., 2018; Peck et al., 2008; Zador et al., 2000).

In the studies by Krüger et al. (1996) and Zador et al. (2000), crash risk increases far more with increasing BAC-levels among young drivers than among older drivers.

Likely explanations for the high crash risk among young drivers who are under the influence of alcohol are that their driving skills are more adversely affected by alcohol than among older drivers and that young drivers who drink and drive have more "pre-existing characteristics that predispose them to risk taking and crash involvement" (Peck et al., 2008).

More information in the Appendix: Table 7: Impairment and crash risk – Driver age

Drivers: Gender

Some studies found stronger associations between BAC and crash risk among male drivers than among female drivers (Blomberg et al., 2005; Zador et al., 2000).

However, Peck et al. (2008) found no differences between males and females, based on the same data as the study by Blomberg et al. (2005). Also in the studies by Keall et al. (2004) and Peck et al. (2008), no differences were found between males and females.

1.2.2 Pedestrian accidents

The effects of alcohol impairment among pedestrians on road injuries have been investigated in the following studies:

Jehle & Cottington, 1988 (USA)
Kim et al., 2008B (USA)
Miles-Doan, 1998 (USA)
Zajac & Ivan, 2003 (USA)
Jang et al., 2010 (USA)
Dultz et al., 2011 (USA)
Lasota et al., 2020 (Poland)
Harmon et al., 2021 (USA)

These studies show that drunk pedestrians have far higher risk of injury from falls and motor vehicle collisions, that they are more likely to sustain fatal or serious injury, and that they are more often at-fault in collisions. Estimated odds ratios for fatal or serious injury when being drunk are up to 7.5. Summary effects were not calculated.

However, drunk pedestrians are likely to be injured at times and in places where other road users are more likely to be drunk or otherwise impaired as well. The isolated effect of pedestrian impairment may therefore be smaller.

Only one of the studies found no relationship between pedestrians BAC level and injury severity, except among female pedestrians (Lasota et al., 2020, based on injured pedestrians hit by passenger cars).

More information in the Appendix: Table 8: Impairment and crash risk – pedestrian accidents

1.2.3 Bicycle accidents

The effects of alcohol impairment on road injuries among cyclists have been investigated in the following studies:

Airaksinen et al., 2018 (Finland)
Andersson & Bunketorp, 2002 (Sweden)
Asbridge et al., 2014 (Canada)
Bíl et al., 2010 (Czech Republic)
Helak et al., 2017 (USA)
Kim et al., 2007 (USA)
Li et al., 2001 (USA)
Martínez-Ruiz et al., 2013 (Spain)
Olkkonen & Honkanen, 1990 (Finland)
Sethi et al., 2016 (USA)

These studies show that drunk cyclists (compared to non-drunk cyclists):

- Have four to ten times as many crashes (Asbridge et al., 2014; Olkkonen & Honkanen, 1990)
- Have two to six times as many fatal or serious crashes (Sethi et al., 2016; Li et al., 2013); at BAC .08+, they have about 20 times as many fatal or serious crashes
- Are more often fatally or seriously injured when involved in a motor vehicle collision (Bíl et al., 2010; Kim et al., 2007), also when controlling for helmet use and other potential confounding factors (Helak et al., 2017)
- Have more serious head injuries (Airaksinen et al., 2018; Andersson & Bunketorp, 2002)
- Are about five times as often culpable in a crash (Martínez-Ruiz et al., 2013).

Other factors that are overrepresented among drunk cyclists include (Andersson & Bunketorp, 2002; Twisk & Reurings, 2013):

- Night time and weekends
- Single bicycle crashes
- Small amounts of cycling per year, little experience with their bicycle
- Bicycles without a hand-brake or gears
- Being unhelmeted.

More information in the Appendix: Table 9: Impairment and crash risk – bicycle accidents

1.2.4 Drug driving and crash risk

Norway has defined legal limits for 28 common illegal and prescription drugs (Samferdselsdepartementet, 2016). Limits were introduced for the first time in 2012, and the list of substances was expanded in 2016. These limits are meant to correspond roughly to a BAC of 0.02. Regulated substances include: Benzodiazepines (15 substances), cannabis, opioids, hallucinogens, amphetamine, methamphetamine, and ecstasy.

Table 3 shows average relative crash risk estimates for a numbers of substances, based on a series of meta-analyses described by Elvik (2021). A relative crash risk of two, for example, implies that the driver has twice as high crash risk as a sober driver. The relative risk estimates are *average* values (with sober drivers as a reference group). For an individual driver, the relative risk can be far higher than shown in the table, especially at high concentrations and short time after intake. There are far more studies that have investigated effects of illicit drugs than studies of medicinal drugs.

Table 3: Average relative crash risk while driving under the influence of several illicit and prescription drugs (the actual risk can be substantially higher), based on Elvik (2021), 95% confidence intervals in () parentheses, number of studies in [ ] parentheses.

Substance	Fatal crashes	Injury crashes	Property damage only crashes
Illegal drugs			
Amphetamine	5.70 (3.27; 9.95) [13]	8.98 (3.44; 23.40) [4]	8.67 (3.23; 23.33) [1]
Cannabis	1.39 (1.26; 1.54) [32]	1.62 (1.22; 2.16) [22]	1.43 (1.26; 1.63) [19]
Cocaine	2.91 (1.81; 4.67) [7]	1.59 (1.06; 2.38) [5]	1.52 (1.02; 2.26) [5]
Opiates	2.03 (1.34; 3.09) [10]	1.98 (1.55; 2.54) [20]	4.76 (2.10; 10.80) [5]
Prescription drugs			
Antiasthmatics		1.33 (1.09; 1.62) [6]	
Antidepressants		1.28 (1.07; 1.52) [25]	1.28 (0.90; 1.80) [5]
Antihistamines	0.69 (0.18; 2.63) [2]	1.12 (1.02; 1.22) [7]	
Sedatives [a]	3.26 (2.30; 4.62) [10]	1.65 (1.49; 1.82) [51]	1.36 (1.04; 1.76) [4]
Anti-inflammatory		1.38 (1.22; 1.56) [5]	1.53 (1.17; 2.01) [4]
Insulin		1.14 (0.84; 1.54) [4]	1.01 (0.59; 1.74) [2]
Methadone		2.08 (1.47; 2.95) [3]	
Penicillin		1.12 (0.91; 1.39) [5]	
Analgesics	2.35 (1.42; 3.89) [8]	1.78 (1.35; 2.36) [17]	
Sleeping medicine	2.31 (1.13; 4.70) [2]	1.42 (0.87; 2.31) [4]	4.00 (1.31; 12.21) [1]

[a] Large variation between substances; for example flunitrazepam has far greater effect.

On average, the relative risk estimates are higher for illicit drugs than for prescription drugs. Only for Methadone, a relative risk above two was found. However, there are several substances with far higher risks than those shown in Table 3, for example flunitrazepam (Gustavsen et al., 2008: relative risk about four). Neutel (1995) has shown that the relative risk while driving under the influence of sedatives and Anxiolytics can be about ten times the risk of a sober driver.

The relative risk estimates do not seem to vary systematically with crash severity. This is also confirmed by a study that compared the effects on crash severity between alcohol and other drugs. Waller et al. (1997) showed that while alcohol had a strong influence on crash severity, other drugs, in the absence of alcohol, did not.

Uncertainty

There are several factors that may have contributed to high uncertainty in the results (Elvik, 2021). These are described in the following.

Degree of impairment: Most studies have not investigated effects at different concentrations of substances in the blood of the drivers or taken into account the actual degree of impairment. Drivers may be completely sober, although they still may have traces of a substance in their blood.

For example, Ramaeker et al. (2004) showed that cannabis is not related to at-fault crash involvement when the presence of metabolites is investigated (i.e. the drivers has been under the influence of cannabis in the past). Only when recent use is investigated (actual impairment), cannabis is related to crash involvement. The effect of cannabis is generally stronger for higher degrees of impairment, but there is large variation between individuals in how much cannabis impairs their driving abilities (Sewell et al., 2009).

Control for confounding variables: Many studies have controlled for easily accessible variables like the drivers age and gender, but only few studies have controlled for other relevant factors, such as impairment by other substances than those under investigation or underlying illnesses. For example, Baldock and Lindsay (2014) found that more than one third of all drivers who tested positive for cannabis, also were under the influence of alcohol, mostly at high BAC-levels (above .15). Without controlling for alcohol, the effect of cannabis on crash risk is therefore likely to be overestimated. Also other studies found large proportions of cannabis-impaired drivers to be under the influence of alcohol or other substances as well (Dubois et al., 2015; Ramaeker et al., 2004). Moreover, combinations of substances may imply larger increases of crash risk than one would expect if the effects were additive (Ramaeker et al., 2004).

Publication bias: Several of the results in Table 3, are likely to be affected by publication bias, i.e. a trend that "unexpected" results (such as small or no risk increases) are less likely to be published than "expected" results.

Relationship between the amount of drug driving and relative risk

The relative crash risk while driving under the influence of illicit drugs has been found to be related to the percentage of drug drivers in general traffic (Elvik, 2018). For example, Elvik (2018) has estimated relative fatal crash risks for cannabis at different shares of drivers who are under the influence of cannabis. The average relative risk is 1,39. However, when only one percent of drivers is driving under the influence of cannabis, the relative risk increases to two or even higher. In other words, the more common it is to drive under the influence of a substance, the less dangerous. This does not mean that being under the influence of the substance in itself is less risky. Rather, the less common a substance is, the more other risk factors are likely to be present among drivers who are using the substance. When only one percent of all drivers are using cannabis, these are probably high-risk drivers also without cannabis. When cannabis use is very common, also average drivers with average crash risk are using it.

1.2.5 Combining substances

Studies that have investigated the effects on crash risk of combinations of substances show consistently that combinations of alcohol and other substances increase crash risk far more than any substance alone. Studies are also consistent in showing that the contribution of alcohol to crash risk is far greater than that of other substances.

Bogstrand et al. (2012) and Gjerde et al. (2011) found large relative injury and fatality risks of above 200 for alcohol combined with other substances, compared to 36 (Bogstrand, injuries) and 69 (Gjerde, fatalities) for alcohol alone.

For cannabis and alcohol, several studies show substantial increases of crash risk even at small doses which, each taken alone, not would have had any large effects (Dubois et al., 2015; Dussault et al., 2002; Ramaeker et al., 2004; Sewell et al., 2009).

The effects on driving performance are also far greater when cannabis and alcohol are combined than when only one of them is present. This was found in a systematic review of 57 studies (Simmons et al., 2022).

The effects of cannabis and alcohol on driving abilities are different: Cannabis impairs mostly highly automated driving functions, while alcohol also impairs more complex tasks (Sewell et al., 2009). Cannabis is associated with decreased speed and increased headways, i.e. behavior that otherwise would be considered as safer, while alcohol is associated with increased speed (Lenné et al., 2010). Without alcohol, drivers can often compensate for the effects of cannabis. However, with alcohol, such compensating strategies are less successful or impossible (Sewell et al., 2009).

More information in the Appendix: Table 10: Impairment and crash risk – Combining substances

1.3 Incidence of impaired driving

1.3.1 Non-crash involved drivers

Drunk driving in Norway

The incidence of drunk driving in Norway has been investigated by:

Bø,1972
Christensen et al., 1978
Glad, 1985 (Norway)
Gjerde et al., 2011 (Norway)
Bogstrand et al., 2012 (Norway)
Gjerde et al., 2013 (Norway)
Furuhaugen et al., 2018 (Norway)

In Norway, the proportion of BAC-positive drivers has remained about unchanged over time since about 1985. According to the most recent study, about 0.2% of all drivers in Norway are above the legal limit of 0.02 (Furuhaugen et al., 2018). This is a minimum-estimate because some drivers refused testing. Before 1985, considerably larger proportions were found (Elvik, 2016: 0.95% in 1978 and 1.97% in 1972).

More information in the Appendix: Table 11: Incidence of impaired driving - Non-crash involved drivers – Drunk driving in Norway.

Drug driving

Studies that have investigated the incidence of drug driving in the general driver population (non-crash involved drivers), include:

Drummer et al., 2004 (Australia)
Gjerde et al., 2008, 2013; Furuhaugen et al. 2018 (Norway)
Bogstrand et al., 2012 (Norway)
Voas et al, 2013 (USA)
Christophersen & Gjerde, 2015 (Norway)
Dubois et al., 2015 (USA)
Jamt et al., 2017 (Norway)
Starkey et al., 2017 (New Zealand)
Valen et al., 2017A (Norway)
Alcañiz et al., 2018 (Spain)

The incidence of drug driving and the most common types of substances differ a lot between countries. The most common illicit drugs in Norway are stimulant drugs (such as amphetamine), followed by cannabis. However, the use of cannabis has increased over time, while the use of benzodiazepines has decreased. In other countries, cannabis is more common.

Several studies show that drugs, especially illicit drugs, are far more often found in drunk drivers than in drivers who were not under the influence of alcohol.

More information in the Appendix: Table 12: Incidence of impaired driving – Non-crash involved drivers – Drug driving.

1.3.2 Crash involved drivers in Norway

The incidence of DUI in crashes is far higher than among non-crash involved drivers, especially in fatal crashes. Norwegian studies that have investigated the incidence of DUI among crash-involved drivers, include:

Assum, 2005 (Norway)
Bogstrand et al., 2012 (Norway)
Statens vegvesen (UAG), 2005-2014 (Norway)
Ponce et al., 2019 (Norway, Brazil)
Statens vegvesen, 2019 (Norway)
Hesjevoll et al., 2022 (Norway)

Over time, drunk driving among crash involved drivers has decreased, both in Norway and in other countries (Hedlund & McCartt, 2002; NHTSA, 2000; Ponce et al., 2019; Schwartz & Beltz, 2018).

The distribution of substances varies considerably between studies and between countries. However, studies from different countries have in common that considerable proportions of DUI drivers are under the influence of a mix of substances.

In Norway, alcohol is most common among pedestrians and car drivers, while illicit drugs are most common among heavy vehicle drivers and motorcycle riders, and a mix of different types of substances (alcohol and drugs) is most common motorcyclists and cyclists. Fatal crash involved drivers with illegal BAC levels had more often also been under the influence of other drugs than drivers who had not been under the influence of alcohol.

Among crash involved heavy vehicle drivers, alcohol is far less prevalent than among crash involved light vehicle drivers. This is consistent with the finding that drunk driving is far less common among heavy vehicle drivers. On the other hand, illicit drugs, especially stimulants (amphetamine, methamphetamine) are relatively more common among crash involved heavy vehicle drivers than among drivers of light vehicles.

More information in the Appendix: Table 13: Incidence of impaired driving – Crash involved drivers in Norway

1.4 Factors related to DUI

Driver age and gender

Relationships between driver age and gender and DUI has been investigated in a large number of studies from different countries:

Fabbri et al., 2002 (Italia)
NHTSA, 2002 (USA)
Maxwell & Freeman, 2007 (USA)
Peck et al., 2008 (USA)
Vehmas et al., 2012 (Finland)
Jamt et al., 2017 (Norway)
Valen et al., 2017A (Norway)
Schwartz & Beltz, 2018 (USA)
Statens vegvesen (UAG), 2005-2014 (Norway)
Davey et al., 2014 (Australia)
Dubois et al., 2015 (USA)
Jamt et al., 2017 (Norway)

Yao et al., 2018 (USA)
Alcañiz et al., 2018 (Spain)

Young drivers and male drivers are generally overrepresented both among drunk and drugged drivers. Young male drivers are most overrepresented.

More information in the Appendix: Table 14: Factors related to DUI – Driver age and gender

Road user groups

There are differences in the incidence of DUI between road user groups, and these differ between countries. In Norway, alcohol is most common among car drivers and pedestrians, and less common among motorcycle riders. In the USA, alcohol is more common among pedestrians and motorcycle riders than among car drivers. These results are based on the following studies:

NHTSA, 2002 (USA)
Drummer et al., 2007 (Australia)
Lin & Kraus, 2009 (USA)
Statens vegvesen, 2005-2014 (Norway)
Christophersen & Gjerde, 2015 (Norway)
Høye et al., 2016 (Norway)

More information in the Appendix: Table 15: Factors related to DUI – Road users

Heavy vehicle drivers

Studies from many different countries show that stimulants (such as amphetamine and methamphetamine) are the most “popular” substances used by heavy vehicle drivers, while only very few heavy vehicle drivers are under the influence of alcohol:

Lund et al., 1988 (USA)
Lemire et al., 2002 (Canada)
NHTSA, 2002 (USA)
Drummer et al., 2007 (Australia)
Assum & Erke, 2009 (Norway)
TISPOL, 2009 (21 European countries)
Rowden et al., 2011 (Australia)
Vehmas et al., 2012 (Finland)
Alcañiz et al., 2018 (Spain)

The most likely explanation is that heavy vehicle drivers often drive long distances and that they often suffer from sleep deficit, monotony, and fatigue. While stimulants can be used to amend such states, alcohol is rather counterproductive. Car drivers more often than truck drivers use other types of drugs, although amphetamine and methamphetamine also are relatively common.

More information in the Appendix: Table 16: Factors related to DUI – Heavy vehicle drivers

Socioeconomic status

Drunk drivers have on average lower socioeconomic status than sober drivers :

Campos et al., 2013 (Brazil)
Ferguson et al., 1999 (Australia)
Yao et al., 2018 (USA)

More information in the Appendix: Table 17: Factors related to DUI – Other factors

Other traffic violations

Drunk drivers have more often previous convictions for other traffic violations than drunk driving. This is a consistent finding in several studies:

Ferguson et al., 1999 (Australia)
Høye et al., 2016 (Norway)
Kasantikul et al., 2005 (Thailand)
Romano & Voas, 2011 (USA)
Soderstrom et al., 1993 (USA)

More information in the Appendix: Table 17: Factors related to DUI – Other factors

Seat belt use

Non-use of seat belts is more common among drunk drivers than among other drivers. The higher the BAC-level, the fewer drivers are using the seat belt. This is based on the following studies:

NHTSA, 2002 (USA)
Kweon & Kockelmann, 2010 (USA)
Romano & Voas, 2011 (USA)

More information in the Appendix: Table 17: Factors related to DUI – Other factors

Criminal history

The relationship between criminal history and drunk driving has been investigated by:

LaBrie et al., 2007 (USA)
Hubicka et al., 2008 (Sweden)
Høye et al., 2016 (Norway)

Drunk drivers have more often a criminal history than sober drivers. Especially previous criminal charges for offences related to illicit drugs (such as possession, sales, and DUI, amongst other things) are a strong predictor for DUI (based on analyses of fatal motorcycle crashes in Norway).

More information in the Appendix: Table 17: Factors related to DUI – Other factors

Alcohol problems and addiction

The relationship between alcohol problems and addiction and drunk driving has been investigated by:

Dunn et al., 1997 (USA)
Ferguson et al., 1999 (Australia)
Baker et al., 2002 (USA)
Hedlund & McCartt, 2002 (USA)
Vaa, 2003 (review)
Flowers et al., 2008 (USA)
Valencia-Martín et al., 2008 (Spain)
Charlton et al, 2010 (review)
Fell, Tippetts & Voas, 2010 (USA)
Ferguson, 2012 (USA)
Campos et al., 2013 (Brazil)
Dow et al., 2013 (review)
Yao et al., 2018 (USA)

In addition to acute impairment, unhealthy drinking patters have also been found to be related to increased crash risk.

Among drunk drivers and DUI convicted drivers, regular alcohol consumption and alcohol problems are overrepresented. Alcohol dependence is according to two large reviews on average related to an increase of crash risk by 2.0-5.1 (Vaa, 2003; Charlton et al., 2013). Drug abuse is on average related to an increase of crash risk by 32% (Dow et al., 2013).

"Deviant attitudes" to drunk driving and a social context that is supportive of drunk driving are also overrepresented. Higher BAC-levels are associated with more alcohol problems.

However, even among "hard core" drinking drivers, far from all have alcohol problems or are otherwise socially deviant.

More information in the Appendix: Table 17: Factors related to DUI – Other factors

Crash types

Single vehicle (SV) crashes are clearly overrepresented in DUI-related crashes:

Soderstrom et al., 1993 (USA)
Kasantikul et al., 2005 (Thailand)
Ahlm et al., 2009 (Sweden)
Christophersen & Gjerde, 2015 (Norway)
Statens vegvesen, 2005-2015 (Norway)
Høye et al., 2016 (Norway)

More information in the Appendix: Table 17: Factors related to DUI – Other factors

Time of day and week

The rate of alcohol involvement is far higher in night-time and weekend crashes than in daytime crashes:

NHTSA, 2000 (USA)
Fabbri et al., 2002 (Italia)
Kasantikul et al., 2005 (Thailand)

More information in the Appendix: Table 17: Factors related to DUI – Other factors

Vehicle age

Drunk drivers involved in fatal crashes on average are driving older cars (13.0 years on average) than other drivers involved in fatal crashes (10.3 years on average; Statens vegvesen, 2005-2013; Norway).

1.5 Factors related to repeat offending

Repeat offenders account for large proportions of DUI and DUI-related crashes. A large number of studies has identified factors that are overrepresented among reoffending drivers:

Ferguson et al., 1999 (literature review)
Baca et al., 2001 (USA)
Christophersen et al., 2002 (Norway)
Hedlund & McCartt, 2002 (USA)
Lapham et al., 2006 (USA)
Nochajski and Stasiewicz, 2006 (USA)
Shaffer et al., 2007 (USA)
Fu, 2008 (USA)
Hubicka et al., 2008 (Sweden)

Holmgren et al., 2008 (Sweden)
Robertson et al., 2009 (USA)
Purssell et al., 2010 (Canada)
Rauch et al., 2010 (USA)
Bishop, 2011 (USA)
Statens vegvesen (UAG), 2005-2013 (Norway)
Møller et al., 2015 (Denmark)
Keating et al., 2019 (USA)

Factors that are overrepresented among reoffending drivers are similar to those that are overrepresented among drunk and drug drivers:

- Young age
- Male
- Low education / socioeconomic status,
- Alcohol problems, regular or heavy drinking patterns
- Other traffic violations
- Unlicensed driving
- Conviction for non-traffic related crime
- Use of illicit drugs
- Psychiatric problems.

However, repeat offenders are a very heterogeneous group consisting of with various subgroups with different profiles of risk factors (Nochajski & Stasiewicz, 2006).

Table 18: Factors related to repeat offending

2 DUI Legislation

DUI laws described in this chapter include laws that provide a legal background for police enforcement and sanctions, and laws that restrict the availability or consumption of alcohol. More detailed descriptions of these laws are given in the respective sections.

This chapter includes the following laws:

- BAC limits
- Random breath testing laws
- Minimum legal drinking age
- Availability of alcohol (several laws and other measures)
- Drug driving laws
- Other laws: Implied consent, anti-plea bargaining, dram shop, social host liability, and child endangerment laws

Relevant laws treated in other chapters are laws about:

- License suspension and revocation
- Alcohol ignition interlock
- Vehicle impoundment or confiscation.

2.1 BAC limits

2.1.1 Per se laws (0.10 and 0.08) in USA

Most states in the USA have per se BAC laws according to which it is illegal to drive with BAC over 0.08 or 0.10, independent of driving behavior or accident involvement. Before the introduction of per se laws, driving under the influence of alcohol was only persecuted if drivers had been involved in an accident or otherwise raised the attention of the police. Per se BAC laws also imply that primary enforcement of DUI is legal (which it had not been before the introduction of the per se laws).

In 2001 per se laws had been introduced in 19 states, in 2003 all states except Massachusetts had per se laws (Bernat et al., 2004).

The introduction of per se BAC laws with BAC limits of .10 or .08, has been investigated in a large number of empirical studies, including several meta-analyses and reviews. The presentation of results in this chapter is based on reviews and meta-analyses:

Tippetts et al., 2005
Elvik et al., 2009
Grant, 2010B

The results of the reviews differ widely. Per se BAC laws reduce alcohol involved fatal crashes by 15% according to Tippetts et al. (2005), by 6% according to Elvik et al. (2009) and they do not have any effect according to Grant (2010B).

Also a more recent US-study that is based on panel data from 50 states (1985 to 2019) shows that the introduction of 0.08 g/dl per se law is significantly associated with reductions in alcohol-related crash fatalities (Hosseinichimeh et al., 2022).

The results from Tippetts et al. (2005) indicate that per se BAC laws are most effective in states that have administrative license suspension/revocation laws and where sobriety checkpoints are frequently conducted.

A possible adverse effect of per se laws may be an increase of hit-and-run crashes (French & Gumus, 2015) when sanctions for drunk driving are more severe than those expected for non-DUI hit-and-run.

More information in the Appendix: Table 19: BAC limits

2.1.2 Reduced BAC limit: .08 to .05

The effects of reducing the legal BAC limit from .08 to .05 has been investigated in the following studies:

Smith, 1988 (Queensland, Australia)
Homel, 1994 (New South Wales, Australia)
Henstridge et al., 1995 (New South Wales and Queensland, Australia)
Bernhoft & Behrensdorff, 2000 (Denmark)
Bartl & Esberger, 2000 (Austria)
Albalate, 2006 (eight European countries)

Based on these studies, the BAC limit reduction has been accompanied by a crash reduction of 10% (-13; -8). There are no clear differences between crash types (all crashes vs. DUI related crashes) or degrees of severity (fatal, injury, unspecified severity). It is therefore not possible to attribute the crash reductions directly to the reduced BAC limits.

Two studies that are not included in the calculation of summary effects (Blais et al., 2015, Canada; McLean et al., 1995, Australia) have not found any effects on fatally injured drivers, with BAC .08+, late night drivers with BAC .08+ and DUI-related offences.

More information in the Appendix: Table 19: BAC limits

2.1.3 BAC limits below .05

BAC limits have been reduced to .02 or .03 in several countries from different initial BAC-levels (between .05 and .15). Crash evaluations are available from the following studies:

Norström & Laurell, 1997 (Sweden)
Borschos, 2000 (Sweden)
Desapriya et al., 2007 (Japan)
Nagata et al., 2008 (Japan)
Assum, 2010 (Norway)
Andreuccetti et al., 2011 (Brazil)
Otero & Rau, 2017 (Chile)

Results show crash reductions up to 32%. However, in most studies, additional measures have been implemented at the same time, such as increased enforcement or increased sanctions. Without controlling for such changes (or other potential confounding factors), the crash reductions cannot be attributed to the reduced BAC-limit alone.

In Norway, a non-significant increase of the number of DUI-proxy crashes was found (fatal single-vehicle nighttime crashes; +9% [-9; +30]; Assum, 2010).

Results from several studies indicate that enforcement may be a necessary condition for the effectiveness of a low BAC-limit and for maintaining the effect over time. They indicate further that low BAC-limits mainly affect drivers in the lower BAC-ranges, but not heavy drinkers or those driving at high BAC-levels. Among young drivers, somewhat larger effects were found than among adult drivers in Japan.

More information in the Appendix: Table 19: BAC limits

2.1.4 Zero tolerance laws (reduced BAC limit for young drivers)

Young drivers have a higher accident risk than other drivers and alcohol increases accident rate more for young drivers than for other drivers (Peck et al., 2008). Under a zero tolerance law, it is illegal for young drivers (under age 21, which also is the minimum legal drinking age) to drive at any measurable BAC (above 0.01 or 0.02). In the USA, all states had passed zero tolerance laws by 1998 (Grant, 2010A).

The following studies are available that have investigated crash effects of zero tolerance laws:

Maisey, 1984 (Australia)
Haque et al., 1986 (Australia)
Haque & Cameron, 1989 (Australia)
Hingson et al., 1994 (USA)
Bartl & Esberger, 2000 (Austria)
Whetten-Goldstein et al., 2000 (USA)
Eisenberg, 2001 (USA)
Voas, Tippetts & Fell, 2003 (USA)
Villaveces et al., 2003 (USA)
Chang et al., 2012 (USA)

Summary effects are shown in Table 4.

Table 4: Effects of zero tolerance laws on crashes (fatal/injury).

			Percentage change in the number of crashes	
Drivers	**Severity**	**Crash types**	**Best estimate**	**95% CI**
Young drivers	Injury/fatal	DUI-related crashes	**-12**	(-19; -5)
	Injury/fatal	All crashes	**-3**	(-8; +3)
All drivers	Fatal	DUI-related crashes	**-8**	(-16; +0)
	Fatal	All crashes	**-3**	(-5; -1)

The results indicate that zero tolerance laws reduce the involvement of young drivers in DUI-related crashes, but not in other crashes. However, although the reduction of DUI-related crashes among adult drivers is not statistically significant, it is not close to zero as would have been expected (zero tolerance laws target specifically young drivers). Romano et al. (2015; not included in the analysis) found a similar effect (-7% fatal DUI-related crashes among underage drivers).

In the study by Grant (2010A), almost identical effects as those shown in Table 4 were found for young and adult drivers in DUI-proxy crashes. This is interpreted by Grant (2010A) as an indication of zero tolerance laws not having any effect on alcohol related crashes among young drivers. Instead, the reductions that were found of alcohol related crashes, are likely to be due to other changes, such as other alcohol policies, or drinking habits and culture in general.

In summary, one may conclude that zero tolerance law may have reduce alcohol related crashes among young drivers. However, the effect is most likely smaller than shown in Table 4.

2.1.5 Reduced BAC limit for DUI convicted drivers

In Maine (USA) a law was introduced in 1988 which defined the illegal BAC limit for DUI convicted drivers at 0.05. In 1995 this limit was reduced to BAC 0.00. No effects have been found of these changes on accidents or recidivism (Jones & Rodriguez-Iglesias, 2004).

2.2 Random breath testing laws

Random breath testing laws allow the police to breath test drivers without suspicion. Effects on accidents have been studied by:

Saffer & Chaloupka, 1989 (USA)
Evans et al., 1991 (USA)
Ruhm, 1996 (USA)
Whetten-Goldstein et al., 2000 (USA)
Eisenberg, 2001 (USA)
Villaveces et al., 2003 (USA)
Albalate et al., 2006 (eight European countries)

Based on these studies, the summary effect on fatal accidents is a non-significant reduction by 1% (-3; +1). The results are about the same for fatal accidents involving and alcohol and for total numbers of fatal accidents. The result does not change if the European study is omitted. In other words, Random breath testing laws do not seem to have any direct effect on crashes.

In the European study by Albalate et al. (2005), random breath testing alone was not found to have any statistically significant effect on the total number of fatal crashes. However, a statistically significant effect was found for reduced BAC limits in combination with a random breath testing law (-6% [-10; -2]), but not for reduced BAC limits in total (with or without random breath testing law: -4% [-10; +2]).

2.3 Minimum legal drinking age (MLDA)

Minimum legal drinking age (MLDA) laws specify an age below which the purchase or public consumption of alcoholic beverages is illegal.

In the USA, sanctions were imposed on all states which have a minimum legal drinking age below 21 since 1984. By 1987 all states had introduced a minimum legal drinking age of 21 (Shults et al., 2001).

Empirical studies of the effects of increased MLDA include:

US General Accounting Office (1987; cited from Hedlund et al., 2001)
O'Malley & Wagenaar, 1991 (USA)
Voas, Tippetts, & Fell, 1999 (USA)
Shults et al., 2001 (review)
Wagenaar & Toomey, 2002 (review)
Elvik et al., 2009 (meta-analysis)
Grant, 2010B (review and meta-analysis)
Chang et al., 2012 (USA)

The effects of reduced MLDA have been investigated by:

Shults et al., 2001 (review)
Elvik et al., 2009 (meta-analysis)

These studies show consistently that a higher MLDA is associated with fewer alcohol-related crashes among young drivers and that lowering the MLDA is associated with increasing alcohol-related crashes. Estimated crash reductions following increases in MLDA are around 15%. However, some of the results indicate that the crash reductions may (at least partly) be due to other factors than changed MLDA.

More information in the Appendix: Table 20: DUI Legislation – Minimum legal drinking age (MLDA)

2.4 Availability of alcohol

2.4.1 Alcohol consumption and drunk-driving crashes

The following studies have investigated the relationship between per capita alcohol consumption and the number of alcohol-related crashes:

Walsh, 1987 (Ireland)
NHTSA, 2001 (USA)
Skog, 2003 (Canada)
Noland & Quddus, 2004 (USA)
Young & Bielinska-Kwapisz, 2006 (USA)
Kaplan & Prato, 2007 (USA)
Dang, 2008 (USA)
Arranz & Gil, 2009 (Spain)
French & Gumus 2015 (USA)
Romano et al., 2015 (USA)
Kalsi et al., 2018 (Finland)
Stringer, 2018 (USA)
Hosseinichimeh et al., 2022 (USA)

All studies found positive relationships between per capita alcohol consumption and motor vehicle fatality rates (both overall and alcohol-related fatalities). Not all results refer specifically to alcohol related fatalities or crashes, but none of the studies found a negative or no relationship. Fatalities and serious injuries among pedestrians and cyclists were also found to be associated with alcohol consumption (Noland & Quddus, 2004).

The relationship between alcohol consumption and fatalities is stronger among male than among female drivers and it is stronger among elderly and young drivers than among other adult drivers (Kaplan & Prato, 2007). In the Canadian study (Skog, 2003) a statistically significant relationship between alcohol consumption and motor vehicle fatalities was only found among males, not among females.

The proportion of the population who are regularly visiting bars or taverns has not been found to be related to alcohol-related fatalities (Stringer et al., 2018).

More information in the Appendix: Table 21: Availability of alcohol - Alcohol consumption and drunk-driving crashes

2.4.2 Prohibition

During prohibition, the production, importation, transportation, and sale of alcoholic beverages prohibited in the USA in 1920 to 1933. During the nationwide prohibition, both liver cirrhosis and the number of drivers arrested for drunk driving were strongly reduced. After the end of the prohibition in 1933, liver cirrhosis and the number of drivers arrested for drunk driving increased strongly (Dills et al., 2005).

Today there are still jurisdictions in the US (counties, cities, towns) where alcohol sales are prohibited. The prohibition may include on-premise sales, off-premise sales, or both. Crash effects of local alcohol prohibition has been investigated in a number of studies:

Dills et al., 2005 (USA)
Eger, 2006 (USA, Kentucky)
Adams & Cotti, 2008 (USA)
Webster et al., 2008 (USA)

Elvik et al., 2009 (review)
Stringer, 2018 (USA)

The results are inconclusive. In a systematic review by Elvik et al. (2009), most studies found more crashes or fatalities in counties with local alcohol prohibition ("dry counties") than in counties without local alcohol prohibition ("wet counties"). However, studies that have controlled for the number of alcohol-related fatal crashes *before* the introduction of local alcohol prohibition, found that dry counties have fewer – not more – crashes than wet counties. The most recent study (Stringer et al., 2018) found varying results (all of which nonsignificant), depending on model specifications.

Possible explanations for the inconsistent results include general geographical and social differences. Local alcohol prohibition, may be more likely to be introduced in counties with many (alcohol related) accidents (Elvik et al., 2009) or in counties with a strong anti-alcohol culture (Stringer et al., 2018). Moreover, people in dry counties, drive more on average in order to buy or consume alcohol than people in wet counties, and they may drive home while being intoxicated (Stinger et al., 2018).

More information in the Appendix: Table 22: Availability of alcohol - Prohibition

2.4.3 Alcohol taxes and prices

Alcohol policies often aim at reducing alcohol consumption by increasing taxes on alcohol. Increasing taxes are usually related to increasing prices. Studies that have investigated crash effects of alcohol policies have for the most part investigated effects of alcohol taxes, not prices, because information about taxes is more readily available, more stable over time, and because they can more directly be affected by policy makers.

Alcohol taxes and prices may affect crash numbers in several ways. Increasing alcohol prices may reduce alcohol consumption and thus reduce alcohol related crashes. On the other hand, when alcohol prices increase only in certain geographical areas but not in others, people may drive longer distance for purchasing cheaper alcohol. This may lead to more crashes.

In a systematic review of the relationship between alcohol taxes and crashes, Elvik et al. (2009) found inconsistent results. The main impression is that alcohol prices do not directly affect the number of accidents. Amongst other things, several studies found relationships between alcohol prices and total road fatalities, but no specific effects on alcohol related fatalities. The results are based on 15 US-studies from 1987-2007.

In a meta-analysis of 112 primary studies, Wagenaar et al. (2009) found statistically significant negative relationships between alcohol prices or taxes and alcohol sales or consumption. The strongest relationship was found for spirits, followed by wine and beer. The results show further that alcohol consumption among heavy drinkers is less affected by alcohol prices or taxes than alcohol consumption in total.

Studies not included in the review by Elvik et al. (2009) include:

Walsh, 1987 (Ireland)
Young & Bielinska-Kwapisz, 2006 (USA)
Ponicki et al., 2007 (USA)
Arranz & Gil, 2009 (Spain)
Elvik et al., 2009 (review)
Mäkelä & Österberg, 2009 (Finland)
Sen & Campbell, 2010 (USA)
Cotti & Tefft, 2011 (USA)
Morrisey & Grabowski (2011)
Chang et al., 2012 (USA)

Romano et al., 2015 (USA)
Saar, 2015 (Estonia)
Kalsi et al., 2018 (Finland)
McClelland & Iselin, 2019 (USA)

Most of these studies found negative relationships between alcohol taxes or prices and total crash or fatality numbers. Three studies found negative relationships between alcohol taxes and alcohol related fatalities (Chang et al., 2012; Cotti & Tefft, 2011; Saar, 2015). Two other studies found no relationship (McClelland & Iselin, 2019; Romano et al., 2015).

In summary, there is some evidence that increasing alcohol taxes and prices are negatively related to alcohol-related crashes and fatalities. However, the effects may not always be interpreted as causal effects but they may be due to other factors.

An analysis of societal costs of alcohol consumption in the UK, Sweden, and Finland (Herrnstad et al., 2015) concludes that current alcohol taxes in the three European countries are hard to justify on externality grounds.

More information in the Appendix: Table 23: Availability of alcohol - Alcohol taxes and prices

2.4.4 Limiting the availability of alcohol

Alcohol outlet density

Increasing alcohol outlet density can affect crash numbers by increasing alcohol consumption (which would be expected to increase crash numbers) and by reducing driving distances (which would be excepted to reduce crash numbers).

In a systematic review, Elvik et al. (2009) found nine studies of the relationship between alcohol outlet density and alcohol related crashes (from 1983-2007). The studies are too heterogeneous for calculating a summary effect. The results resemble the results from studies of local alcohol prohibition: Some studies found more accidents in areas with a high outlet density, while others found no relationship. The most likely explanation for the inconsistent results is that low outlet density may be associated with less drinking, but also with more driving. According to a study from the USA, the "point of diminishing returns" is at about one outlet per million of the drinking age population. At lower outlet densities, additional driving will outweigh any positive effects of decreasing outlet density (Colon, 1982).

Moreover, a relationship between outlet density and crashes does not necessarily imply causality from outlet density to crashes. Areas with a high outlet density are generally more densely inhabited areas, which also may affect the number of alcohol-related accidents (McCarthy, 2003) and outlet density is likely to be higher in areas with a high demand for alcohol (Pulito & Davies, 2012).

Studies of the relationships between alcohol outlet density and crashes that are not included in the review by Elvik et al. (2009) include:

Chen et al., 2009 (USA)
Nordlund, 2010 (Norway)
Gruenewald & Johnson, 2010 (USA)
Ponicki et al., 2013 (USA)
Rickard et al., 2013 (USA)
Rowland et al., 2014 (Australia)
Romano et al., 2015 (USA)
Morrison et al., 2016 (Australia)
Hobday & Meuleners, 2018 (Australia)

The results from these studies are somewhat inconsistent. Most studies found that increasing outlet density is related to increasing or unchanged crash numbers. Romano et al. (2015) found an indirect effect via beer consumption: Greater outlet density was associated with more beer consumption among underage drivers and thus with alcohol related fatal crashes (beer consumption was one of the strongest predictors for alcohol related fatal crashes). Effects of outlet density may differ for different types of outlets (Morrison et al., 2016; Rowland et al., 2014).

In the Norwegian study (Nordlund, 2010), alcohol consumption was found to decrease in municipalities that got new monopoly shops following an increase of the number of alcohol outlets in Norway around the year 2000. The decrease was due to a decrease of the consumption of illegal alcohol; consumption of spirits from the monopoly shops increased. In municipalities that had monopolies since before 2000, alcohol consumption increased, which reflects an overall increase of alcohol consumption (no effect of the change was expected in these municipalities).

An analysis of societal costs of alcohol consumption in the UK, Sweden, and Finland (Herrnstad et al., 2015) concludes that alcohol sales restrictions are hard to justify because of their large transaction costs. The authors conclude that targeting alcohol-related crashes directly will be more efficient economically.

More information in the Appendix: Table 24: Availability of alcohol – Limiting the availability of alcohol – Alcohol outlet density

State monopoly

The effects of state monopolies on crashes were investigated in the following studies:

Colon, 1982 (USA)
He et al., 1999 (review)
Pulito & Davies, 2012 (USA)
Rossow et al., 2008 (Norway and Finland)
Stockwell et al., 2009 (Canada)
Trolldal, 2005 (Canada)
Zullo et al., 2013 (USA)

Theoretically, a state monopoly for alcohol sales may decrease alcohol consumption due to reduced outlet density, restricted days and hours of sale, and increasing prices (He et al., 1999). A Canadian study (Stockwell et al., 2009) found that an increasing percentage of private (vs. government owned) liquor stores is associated with increased alcohol sales when controlling for the total numbers of liquor stores.

However, none of the empirical studies listed above found convincing evidence that a state monopoly for alcohol sales reduces alcohol related crashes or fatalities. Two studies found a trend towards lower fatality rates, but without reaching statistical significance (Trolldal, 2005; Zullo et al., 2013). The remaining studies did not find any effects. In the study by Pulito and Davies (2012), low levels of state control of alcohol sales were associated with increased alcohol-related fatalities (for higher levels of control no effect was found).

A potential positive effect of state monopoly was found by Rossow et al. (2008) who found that young people more often were refused to buy alcohol in state monopoly shops than in other shops.

More information in the Appendix: Table 25: Availability of alcohol – Limiting the availability of alcohol – State monopoly

Regulating days and hours of sales

Two US-studies found that repealing a ban on Sunday sales of packaged alcohol increased both alcohol sales and alcohol-related fatalities in New Mexico (McMillan & Lapham, 2006; Stehr, 2010). However, in other states, Stehr (2010) did not find any effects on alcohol-related fatalities. The most likely explanation for different effects in different states is that alcohol sales on Sundays increased by about 10% in New Mexico, while the increase was smaller in other states (Stehr, 2010).

In a systematic review, Popova et al. (2009) concluded that restricting the availability of alcohol is effective in reducing alcohol related harm. However, most of the studies included in the review refer to other than motor vehicle crashes.

More information in the Appendix: Table 26: Availability of alcohol – Limiting the availability of alcohol –Other

Fake identification laws

There are different types of law regulating the production and use of fake identifications (ID) in the context of alcohol purchase and consumption. Such laws may address:

- The use of fake identifications by minors
- The production and transfer of fake identifications
- Support and sanctions for retailers to avoid alcohol sales to persons presenting fake identifications (Romano et al., 2015).

Effects on alcohol-related fatal crashes were investigated by

Fell, Scherer, Thomas, & Voas, 2014 (USA)
Romano et al., 2015 (USA)

The results are inconsistent. Romano et al. (2015) found relatively large reductions of underage alcohol-related fatal crashes (-14% for laws against the use of fake ID; -9% for laws targeting retailers). Fell et al. (2014) found only small and for the most part not statistically significant effects (a statistically significant 1% reduction for fake-ID supplier laws, no effects of other types of fake-ID laws).

More information in the Appendix: Table 26: Availability of alcohol – Limiting the availability of alcohol –Other

2.4.5 Limiting alcohol consumption while driving: Anti-consumption and open container laws

Open container laws

Open container laws prohibit to have open alcohol contained in a car while driving. Effects on accidents have been investigated in the following US studies:

Evans et al., 1991 (USA)
Eisenberg, 2001 (USA)
Whetten-Goldstein et al., 2000 (USA)
Chang et al., 2012 (USA)

In summary, these studies show that open container laws are associated with a reduction of both total fatalities (-7% [-13; -1]) and alcohol-related fatalities (-5% [-13; +4]). Since both effects are of about equal size (with the effect for alcohol-related fatalities being slightly smaller and non-significant), the most reasonable conclusion is that open container laws have no effect on alcohol-related fatalities.

Other studies showed that the enforcement of open container laws is related to less drunk driving (Lenk et al., 2016; Sanem et al., 2015). Lenk et al. (2015) found no effect of open container laws per se on the amount of drunk driving.

In summary, open container laws by themselves were not found to affect drunk driving or drunk driving crashes. However, enforcement of such laws may. The results are based on relatively few studies.

Anti-consumption laws

Anti-consumption laws prohibit the consumption of alcohol for all car occupants. Only one study has been found that has investigated the effects of such laws on crashes. Whetten-Goldstein et al. (2000; USA) found no statistically significant effect on alcohol-related fatal crashes (-7 [-21; +9]). The total number of fatal crashes was reduced by -11% [-19; +3], indicating that the (non-significant) reduction of alcohol-related fatal crashes is unlikely to be related to the law.

2.4.6 Laws regulating alcohol advertisements

Alcohol advertisements can influence young people to drink more alcohol and to develop alcohol-related health problems (Collins et al., 2007; Grenard et al., 2013). However, results from empirical studies of the effects of alcohol advertisements are inconsistent and difficult to generalize (Collins et al., 2007).

Only one study has been found that has investigated effects of laws prohibiting alcohol advertisements targeting minors on road fatalities (Smith & Geller, 2009). The results show that counties with such laws have 33% fewer fatalities among young drivers (15-20 years) in SV crashes than states without such legislation. However, other differences between counties with and without such legislation are not controlled for. The result can therefore not be interpreted as a causal effect of the alcohol advertisement legislation.

More information in the Appendix: Table 26: Availability of alcohol – Limiting the availability of alcohol –Other

2.5 Drug driving laws

Under per se drug driving laws it is illegal to drive with specified substances (other than alcohol) in the blood. Such laws can have a general deterrent effect, and they can make prosecution of drug driving easier, but they do not necessarily have any positive effects on enforcement (Lacey et al., 2010).

2.5.1 Legal limits for drug driving

In Norway, it is illegal to drive "under the influence of alcohol or other intoxication or anaesthetics" (road traffic law, § 22). Norway has defined legal limits for 28 common illegal and prescription drugs (Samferdselsdepartementet, 2016). Limits were introduced for the first time in 2012, and the list of substances was expanded in 2016. These limits are meant to correspond roughly to a BAC of 0.02. Regulated substances include: Benzodiazepines and other sedatives (15 substances), cannabis, opioids, hallucinogens, and stimulants (including cocaine, amphetamine, methamphetamine, and ecstasy).

In Sweden, zero tolerance for drug driving was introduced in 1999. Other European countries with similar laws are France, Finland, Germany, Belgium, Poland, and Switzerland (Holmgren et al., 2008). According to the Swedish zero tolerance law for drug driving, the presence of a banned substance in the blood of a driver is sufficient to charge the driver for DUI, i.e. even if there is no evidence of impairment.

The study by Holmgren et al. (2008) found high re-arrest rates among drivers charged for driving under the influence of illicit drugs (mostly amphetamine) after the introduction of the law. 68% of all drivers under the influence of illicit drugs were rearrested up to 23 times (compared to 14% of drunk drivers who were rearrested up to ten times). The authors conclude that the law does not deter from drug driving. However, re-arrest rates from before the introduction of the law are not available.

The incidence of medicinal and illicit drugs in traffic in Norway has been investigated in road side studies in 2005-2006, 2008-2009, and 2016-2017 (Gjerde et al., 2008, 2013, Furuhaugen et al. 2018). The results show that 2.3 % of all vehicle kilometers travelled in Norway are driven under the influence of medicinal drugs and 1,7% under the influence of illicit drugs, the most common ones being cannabis (1.3%), cocaine (0.3%), and amphetamine (0.2%). Among those drivers who were suspected of drug driving, only very few (1.3%) had used medicinal drugs as prescribed by a doctor (Christophersen et al., 2002).

These reults do not allow conclusions about the effectiveness of legal limits for drug driving on crash numbers.

2.5.2 Legalization of cannabis

Cannabis use has been legalized in some states in the USA, either in general or only for medical purposes (when prescribed by a doctor). Legalization may affect crashes in different ways (Dills et al., 2016):

- Crashes may increase as a consequence of increased rug use.
- Crashes may decrease because drivers substitute alcohol with marijuana (alcohol impairs driving far more than marijuana).

The effects on crashes have been investigated in the following studies:

Anderson et al., 2013 (USA)
Salomonsen-Sautel et al., 2014 (USA)
Dills et al., 2016 (USA)
Aydelotte et al., 2017 (USA)
Santaella-Tenorio et al., 2017 (USA)
Hansen et al., 2018 (USA)
Keric et al., 2018 (USA)
Lee et al., 2018 (USA)
Monfort, 2018 (USA)
Lane & Hall, 2019 (USA)
Woo, 2019 (USA)
Young, 2019 (USA)
Nazif-Munoz et al., 2020 (Uruguay)

The studies vary with respect to the type of legalization studied and the type of outcome variable. Most studies refer to the legalization of cannabis for recreational use (i.e. not specifically for medical use).

General legalization: The results for general legalization are as follows:

- Total fatalities and crashes:
  - Increases: Two studies (Monfort, 2018; car drivers in the study by Nazif-Munoz et al., 2020)
  - Unchanged: Six studies (Aydelotte et al., 2017; Dills et al., 2016; Hansen et al., 2018; Lane & Hall, 2019; Young, 2019; motorcyclists in the study by Nazif-Munoz et al., 2020)
- Cannabis-related fatalities:
  - Increase: Two studies (Lee et al., 2018; Woo, 2019)
  - Unchanged: One study (Keric et al., 2018).

Medical use: For legalization of cannabis for medical use the following results were found:

- Total fatalities and crashes:
  - Decrease: Two studies (Anderson et al., 2013; Santaella-Tenorio et al., 2017).
- Marijuana-related fatal crashes
  - Increased: One study (Salomonsen-Sautel et al., 2014)
  - Unchanged: One study (Lee et al., 2018).

In summary, the results are highly inconsistent. A general legalization of cannabis may be associated with increasing cannabis-related fatalities. However, total fatalities and crashes were found to be unchanged in most studies.

A legalization of cannabis for medical use may, or may not be associated with increasing cannabis-related crashes. Two studies found decreases of cannabis-related crashes. Anderson et al. (2013) explain the decrease with reduced drunk driving and the greater risk associated with drunk driving compared driving under the influence of cannabis. Sevigny (2018) did not find any effect of medical marihuana laws on cannabis-positive driving.

More information in the Appendix: Table 27: Drug driving laws – Legalization of cannabis

2.6 Other laws

2.6.1 Implied consent laws

Under implied-consent laws, sanctions can be imposed on drivers who refuse the BAC test. A US study showed that states with higher BAC test refusal rates also have slightly higher DUI-crash rates on average (Voas, Kelley-Baker, Romano, & Vishnuvajjala, 2009).

Common sanctions for refusing BAC-tests are administrative license suspension and vehicle impoundment (see sections **4.2** and **4.3**). However, sanctions for DUI convictions (such as penalties, jail, and treatment requirements) are often more severe, reducing the incentive for drunk drivers to accept the BAC test (Voas et al., 2009).

Empirical studies have not found any effects on alcohol-related or total crashes (Benson et al, 1999; Ruhm, 1996; Whetten-Goldstein et al., 2000).

More information in the Appendix: Table 28: Other laws

2.6.2 Anti-plea bargaining legislation

Under an anti-plea bargaining law, prosecutors and defense attorneys cannot agree on reducing a DUI charge to a less serious charge in exchange for the driver pleading guilty to the lesser charge. In 2014, 13 states of the US had such legislation (Goodwin et al., 2015).

Empirical studies have not found evidence for the effectiveness of anti-plea bargaining legislation (Benson et al., 1999; Evans et al., 1991). However, a recidivism study (Surla & Koons, 1988) indicates that anti-plea bargaining laws reduce the proportion of drivers with multiple DUI convictions.

2.6.3 Dram shop laws

Dram shop laws impose civil liability on liquor stores and other commercial establishments that sell alcoholic beverages to minors or obviously intoxicated persons who subsequently cause death or injury to third-parties, for example in a car crash.

In a meta-analysis from 2009 (Elvik et al., 2009) that is based on five US-studies from 1996-2001, a statistically significant reduction of alcohol-related fatal crashes was found (-17% [-24; -9]). However, since an almost equally large reduction was found for all fatal crashes (-14% [-21; -5]) it is likely that other factors than dram shop laws have contributed to the results.

A large multi-state study that covers 51 US-jurisdictions during the years 1982-2010 (Romano et al., 2015) did not find any effect of dram shop laws on fatal alcohol-related crashes.

In summary, there is no evidence for dram shop laws to be associated with reductions of alcohol-related fatal crashes.

More information in the Appendix: Table 28: Other laws

2.6.4 Social host liability

Social host liability laws impose civil liability on private persons who serve alcohol to minors or obviously intoxicated persons who subsequently cause death or injury to third-parties, e.g. in an accident.

Several studies that are based on large amounts of data did not find evidence for effects of social host liability laws on alcohol-related crashes (Fell, Scherer, Thomas & Voas, 2014; Romano et al., 2015; Whetten-Goldstein et al., 2000).

More information in the Appendix: Table 28: Other laws

2.6.5 Child endangerment laws

In the USA, the majority of children (65%) killed in alcohol-related crashes had been a passenger in a car with an intoxicated driver. About two thirds of these children (61%) had not been restrained and one third had been riding with an unlicensed driver (Quinlan et al., 2014). Under child endangerment laws, impaired driving while carrying children is a separate offence with enhanced DUI-penalties. In 2015, 46 states of the US had separate or higher penalties for impaired drivers who have children in their vehicles (Goodwin et al., 2015).

A study that has investigated the effect on fatal crashes found no effects on the number of impaired drivers among those driving with children (Kelley-Baker & Romano, 2016). Among possible explanations are a lack of publicity and enforcement.

More information in the Appendix: Table 28: Other laws

2.7 Economic conditions

Economic conditions may affect drunk driving crashes in several ways. They may affect both drinking habits, the total amount of driving, driving patterns, and drunk driving.

Economic conditions and crashes

Studies that have investigated relationship between economic conditions (for the most part unemployment) and alcohol-related crashes include:

Chi et al., 2011 (USA)
Cotti & Tefft, 2011 (USA)
Krüger, 2013 (Sweden)
He, 2016 (USA)

The results are inconsistent with regard to total and non-alcohol related crashes. Alcohol related crashes were consistently found to *decrease* as unemployment increases. These results may partly be due to relationships between unemployment and total amount of driving (more unemployment – less driving). However, both Cotti & Tefft (2011) and Krüger (2013) have controlled for VMT. Cotti & Tefft (2011) found reduced alcohol-related fatalities, but no effect on other fatalities. Krüger (2013) found reduced total fatalities and reduced drunk driving. Thus, both studies indicate that reduced drunk driving is likely to have contributed to reduced fatalities.

Economic conditions and drinking

Relationships between economic conditions and drinking has been investigated in the following studies:

Dee, 2001B (USA)
Ruhm & Black, 2002 (USA)
Gili et al., 2012 (Spain)
Ólafsdóttir, 2015 (Iceland)
Ásgeirsdóttir et al., 2016 (Iceland)

Most studies found that poor economic conditions are associated with reduced alcohol consumption. However, regarding heavy / binge drinking the results are inconsistent, one of the studies found increased binge drinking (Dee, 2001B). Alcohol related disorders (and other mental health problems) were found to increase in Spain (Gili et al., 2012).

In contrast to these results, unemployment and other variables representing low socioeconomic status on the individual level are associated with *increased* drunk driving, and drunk driving recidivism (se section 1.4).

In summary, most studies indicate that increasing unemployment is associated with reduced drinking and reduced drunk driving crashes, although unemployed drivers are overrepresented among drunk drivers and drunk driving recidivists.

More information in the Appendix: Table 29: Economic conditions

2.8 Gasoline prices

Increasing gasoline prices have frequently been found to be related to decreasing total crashes and fatalities (Chi et al., 2012).

The relationship between gasoline prices and DUI crashes may be affected by two mechanisms with contrary effect (Chi et al., 2011). Increasing gasoline prices:

- May cause drivers to choose other modes of transport, to increase fuel economy or to drive shorter distances (e.g. to a nearer pub) in order to save gasoline, all of which would be related to less drunk driving and fewer DUI crashes

- Are related to poor economic conditions, and these have been found to be related to less drunk driving and fewer DUI crashes. On the other hand, some people drink more in poor economic conditions, and increasing gasoline prices may contribute to increased economic stress of such individuals.

Studies that have investigated the relationship between gasoline prices and DUI crashes include:

Chi et al., 2011 (USA)
Cotti & Tefft, 2011 (USA)
Romano et al., 2015 (USA)

The result from the study by Chi et al. (2011) indicate that increasing gasoline prices are associated with decreasing DUI crashes and that gasoline prices have a stronger relationship with DUI crashes than with total crashes. The other two studies did not find any statistically significant relationships between gasoline prices and alcohol-related crashes.

More information in the Appendix: Table 30: Gasoline prices

3 DUI enforcement

This chapter includes the following types of measures:

- DUI checkpoints
- DUI patrolling
- The general amount of DUI enforcement and DUI arrest rates
- Random roadside drug testing.

3.1 DUI checkpoints

DUI checkpoints are a type of stationary police enforcement, where drivers are stopped and tested for BAC and/or other substances. DUI checkpoints vary, amongst other things, with respect to:

- Whether all drivers are stopped, drivers are stopped at random, or only when they arouse suspicion, and whether all drivers who are stopped are tested or only those drivers whose behavior indicates alcohol
- How DUI is tested, e.g. by behavioral indicators, breath tests or passive detectors (blood tests are normally taken only after a positive result from another type of test)
- How large and visible the checkpoints are; checkpoints may be conducted by unmarked or marked police cars; in Australia and New Zealand special «booze buses» are used that are highly visible and equipped for testing large numbers of drivers
- Whether checkpoints are conducted at random times and places or more targeted at times and places where a high proportion of drivers with illegal BAC is suspected.
- Accompanying publicity campaigns
- Length of duration; some checkpoint programs are conducted as «Blitzes» with short periods of high-intensity enforcement, followed by periods with no or little enforcement.

To conduct DUI checkpoints, random stopping of drivers has to be permitted, i.e. stopping drivers without suspicion and, preferably, also to randomly breath test drivers independent of behavior or accident involvement. Such laws have been implemented in most motorized countries. Checkpoints can potentially be more effective when breath test results (instead of blood samples) are permitted as evidence in court.

The effects of DUI checkpoints on crashes have been investigated in a meta-analysis by Erke et al. (2009) that includes 40 studies from 1980 to 2005. More recent studies that might have been included in an updated meta-analysis, have not been found in a literature review conducted in 2020. The summary of the results that is presented in the following is therefore based on the study by Erke et al. (2009). The estimated effects on crashes, based on meta-analysis, are shown in Table 5. The most important results can be summarized as follows:

Overall, alcohol-related crashes were found to be reduced by -17% on average. This includes results from studies that have used some proxy measure of DUI crashes, such as nighttime single vehicle crashes. Other results from meta-analysis indicate that this effect may be somewhat overestimated. Amongst other things, methodological aspects of the studies, may have contributed to bias. Moreover, there are substantial differences between the effects of different types of checkpoint programs, which are discussed in the following.

Methodological aspects: Studies with a comparison group have consistently found larger effects than studies without a comparison group. The results are likely to be affected by publication bias and Table 5 shows therefore as far as possible results that are controlled for publication bias.

Duration of enforcement: The largest effect was found during the first three months (-22%) after implementation of a checkpoint program, and smaller effects for programs of longer duration.

There may be a confounding effect with intensity of enforcement. Those studies that have investigated effects during the first three or three to six months are for the most part studies of high-intensity enforcement "blitzes". Studies that have investigated changes of one program over time have not found decreasing effects over time.

A more recent US study (Morrison et al., 2019) found a statistically significant effect on alcohol-related crashes during the first week after a checkpoint, but no more long-lasting effects. This study is based on daily crash and enforcement data.

Country: The results indicate that Australian checkpoints were the most effective ones. Factors that may have contributed to the large effects of Australian DUI checkpoints include:

- The amount of drunk driving and the proportion of crashes involving alcohol has initially been greater in Australia than in most other countries
- The total number of BAC-tests taken per driver is high in Australia compared to other countries. In Victoria and New South Wales the proportion of license holders who were BAC-tested per year was 51% in 1994 and 37% in 1998. In Sweden, this proportion is ca. 17%, which is the second highest in Europe (the proportion is higher in Finland, but Finland is not represented among the studies included in the meta-analysis).
- DUI checkpoints in Australia are often conducted with booze buses, the checkpoints are highly visible and easily recognizable as DUI enforcement.

Accompanying publicity: The results indicate that DUI checkpoints that are accompanied by publicity campaigns are more effective than other checkpoints (for example, the Australian checkpoints were accompanied by large amounts of publicity). However, the effects of publicity are not statistically significant when other factors (such as country) are controlled for.

Testing all drivers who are stopped at a checkpoint (instead of testing only drivers suspected of drunk driving) is likely to improve the effectiveness of DUI-checkpoints. However, the results are somewhat uncertain, mainly because many studies provided insufficient information about whether or not all drivers were tested. It was not possible to investigate the effects of stopping all drivers vs. stopping drivers randomly or selectively.

Frequency of checkpoints: A study from the USA (Lacey et al., 2008) shows that that states with more frequent checkpoints (per 100,000 population) had larger reductions of fatal alcohol involved crashes than states with less frequent checkpoints. Lenk et al. (2016) found that states that conduct sobriety checkpoints at least monthly have about 40% less drunk driving than states without sobriety checkpoints. States with a sobriety checkpoint law had 18% less drunk driving.

Combination with other types of enforcement: The combination of static DUI checkpoints with other types of DUI enforcement (mobile and covert enforcement) has proven to be effective in several Australian studies (Wundersitz & Woolley, 2008).

Table 5: Effects on accidents of DUI checkpoints.

Studies included		Percentage change in the number of accidents: Best estimate	95% confidence interval
All studies	All crashes[1]	**-14**	(-18; -11)
Studies with vs. without comparison group			
Without comparison group	All crashes[1]	**-13**	(-20; -5)
With a comparison group	All crashes[1]	**-9**	(-12; -7)
Crash type			
All studies	Alcohol crashes (proxy) [1]	**-17**	(-21; -12)
All studies	All crashes[1]	**-10**	(-16; -4)
All studies	Daytime crashes	**-7**	(-18; +4)
Duration of enforcement			
< 3 months	All crashes[1]	**-22**	(-34; -7)
3-6 months	All crashes	**-21**	(-36; -3)
6+ months	All crashes	**-14**	(-16; -11)
Country			
Australia (studies with a comparison group)	All crashes[1]	**-13**	(-14; -12)
New Zealand (all studies)	All crashes[1]	**-7**	(-13; -1)
USA (all studies)	All crashes[1]	**-8**	(-12; -4)
Other countries (all studies)	All crashes	**-4**	(-13; +5)
Accompanying publicity			
With paid media	All crashes[1]	**-14**	(-19; -10)
Publicity without paid media	All crashes[1]	**-11**	(-16; -6)
No publicity	All crashes	**-6**	(-12; 0)

[1] With control for publication bias.

3.2 DUI patrolling

The effects of increased police patrolling targeting alcohol-impaired driving has been investigated in two reviews.

Goss et al. (2008) found 32 studies from 1976-2003 in a Cochrane review. Patrolling was in 69% of these studies directed towards DUI alone and towards DUI and other offences in the remaining studies. In most studies (91%) increased patrolling was accompanied by other measures such as media campaigns. Summary effects were not calculated. The results are as follows:

- Fatalities or fatal crashes (ten studies): Almost all studies found reductions (but only one of these was statistically significant).
- Injury or total crashes (18 and 20 studies, respectively): Inconsistent results, but still over half of these studies found reductions.
- Drunk driving (nine studies): Less than half of the studies found reductions; no associations were found between the effects on drunk driving and alcohol-related crashes.

Because of the mostly inconsistent results and methodological weaknesses of most primary studies, the authors conclude that there is not sufficient evidence for concluding that increased patrolling reduces alcohol-related crashes.

Elvik et al. (2009) conducted a review and meta-analysis of studies of the effects of increased DUI patrolling on alcohol-related crashes. Ten studies from 1974-2003 were included (two of these were also included in the review by Goss et al., 2008, and three studies may have investigated the same measure as studies included in the review by Goss et al., 2008). In most studies, increased patrolling was accompanied by media campaigns and in some studies additional measures were introduced at the same time, such as administrative improvements or training for police officers. Results from meta-analysis do not show any large or statistically significant effects (fatal crashes: -3% [-9; +4]); injury crashes: -2% [-6; +1]).

In summary, increased patrolling targeting DUI may reduce alcohol-related crashes, but empirical evidence is weak at best and many studies did not find any effects, especially for non-fatal crashes.

3.3 Intensity of enforcement and DUI arrest rates

Relationships between different indicators of the intensity of DUI-enforcement and crashes have been investigated in the following studies:

Arranz & Gil, 2009 (Spain)
Dula et al., 2007 (USA)
Elvik, 2010; Elvik & Amundsen, 2014 (Norway)
Fell et al., 2014 (USA)
Fell et al., 2015 (USA)
Rezapour et al., 2018 (USA)
Sevigny, 2018 (USA)
Stringer, 2019 (USA)
Welki & Zlatoper, 2009 (USA)
Wiliszowski & Jones, 2003 (USA)
Yao et al., 2016 (USA)

The studies are far too heterogeneous for calculating summary effects. They have applied widely different measures of the amount of police enforcement (arrest rates, number of sanctions, budgets, numbers of police officers, active hours in the field, number of traffic stops) and different outcome variables. Despite these differences, almost all studies show that increasing enforcement is related to fewer (all, alcohol- or drug-related) crashes. Only one of the studies found no relationship (Dula et al., 2007).

More information in the Appendix: Table 31: Intensity of enforcement and DUI arrest rates

3.4 Random roadside drug testing

Empirical studies that have investigated the effects of random roadside drug testing on crashes have not been found. However, several Australian studies have reported other kinds of evaluations. Two studies showed that random roadside drug testing increased the detection of drug drivers (Baldock & Wooley, 2013; Rowden et al., 2011). However, among the general driver population there was a low level of awareness of the method (Freeman & Davey, 2008). Horyniak et al. (2017) have investigated effects of random roadside drug testing on individual drivers. The results show that the experience of road-side drug testing had increased over time. However, there was no association between experiencing a road side drug test and drug driving, indicating that such testing does not have any specific deterrent effect.

More information in the Appendix: Table 32: Random roadside drug testing

The relationship between the risk of detection for drug driving and the incidence of drug driving has been investigated in Norway by Elvik (2010) and Elvik & Amundsen (2014). The results show the following relationship between the relative risk of detection and incidence of drug driving (one at unchanged risk of detection):

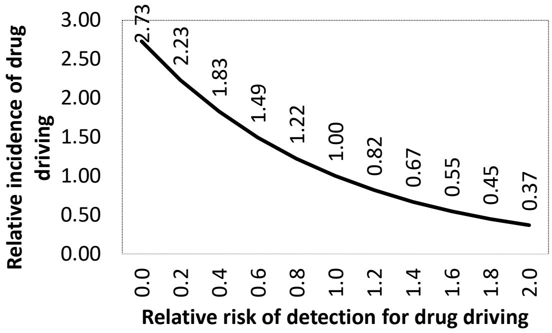

Figure 3: Relationship between the relative risk of detection and incidence of drug driving (one at unchanged risk of detection) (Elvik, 2010; Elvik & Amundsen, 2014).

According to these results, an increase of the risk of detection by 60% is on average accompanied by a decrease of the incidence of drug driving by 45%.

3.5 Other / combined measuress

The following table gives an overview of evaluations of DUI enforcement programs that could not be summarized with any of the measures described in the sections above.

More information in the Appendix: Table 33: Other/combined measures

4 DUI-specific sanctions

The general aim of sanctions for road traffic violations is to deter drivers from committing violations. Sanctions may also aim at removing drivers from traffic to prevent them from posing a risk to other road users.

According to classical deterrence theory, sanctions are more effective in deterring from committing violations, the more certain, swift, and severe they are (Davey & Freeman, 2011). In other words, the more certain a driver is of being punished immediately and severely for a violation, the less likely will he or she be to commit the violation, at least in theory. The certainty of punishment has been found to have a greater effect on behavior than the severity, while there is relatively little evidence of the effect of the swiftness of punishment (Macdonald et al., 2013).

Two general types of deterrence can be distinguished (Bjørgo, 2014):

- **Specific deterrence** refers to the effect of a sanction among those who have been punished. For example a driver who has been apprehended, convicted, and sanctioned for drunk driving, for example with license suspension and a penalty, may abstain from drunk driving in the future in order to avoid being punished again.
- **General deterrence** refers to the effect of a sanction on the general driver population. For example, drivers in general may be less likely to drive drunk when there are severe sanctions for drunk driving than when there are not.

For many of the measures described in this chapter, effects on crashes and violations are reported separately for specific and general deterrence effects.

A limitation of deterrence theory is that it focuses on the intended effects on sanctions, while actual behavior can be affected by many other factors as well. For example, speeding or hooning behavior is often affected by the social context where illegal behavior may be «rewarded» (by encouragement and admiration of peers) and where the presence of peers may produce a sense of anonymity and invulnerability (Leal et al., 2009). Drunk driving may be affected by social factors as well, and additionally by habit and addiction. Such factors may in many cases explain why not all sanctions have the intended or expected effects. On the other hand, sanctions may have social and other consequences that are at least as deterrent as the sanction itself. For example, being convicted for drunk driving or getting a license or vehicle impounded may in itself not be regarded as sufficiently severe for abstaining from drunk driving, but the reactions in the social network may (Bjørgo, 2014). Moreover, avoiding sanctions can in some situations produce behavior that is more risky than the violations it intends to deter from, such as fleeing from the police or leaving a crash scene (hit and run crashes; French & Gomus, 2015).

4.1 Relationships between violations, convictions, and crashes

Traffic violations, or convictions for traffic violations, and crash involvement have in a large number of studies been found to be correlated. There are two contrary effects of previous violations and crashes that can affect future violations and crashes:

- **Habit:** Drivers who commit violations or are involved in crashes, have on average a more risky driving style and are therefore more likely to commit more violations or to be involved in more crashes.

- **Deterrence:** Drivers who have been convicted for traffic offences or involved in a crash, may want to avoid further convictions or crashes, and therefore improve their behavior and reduce their future involvement in traffic violations and crashes.

Most studies support the first type of effect. Only few studies support a deterrence effect, which seems to be only short-lived.

4.1.1 Previous convictions and future crashes

The number of previous convictions has often been found to be among the best predictors for future violations (Bates et al., 2015; Piquero & Pogarsky, 2002). The following studies have investigated relationships between violations and future crashes on an individual level:

Gebers & Peck, 2003 (USA)
Redelmeier et al., 2003 (Canada)
Fabbri et al., 2005 (Italy)
Strathman et al., 2007 (USA)
Carnegie & Eger, 2009 (USA)
Goldenbeld et al., 2013 (Netherlands)
Jørgenrud et al., 2018 (Norway)
Walter & Studdert, 2015 (Australia)
Barraclough et al., 2016 (meta-analysis)
Høye et al., 2016 (Norway)
Kim et al., 2016 (Korea)

The majority of studies found positive relationships, i.e. drivers with previous violations are more likely to be involved in crashes than other drivers. Fabbri et al. (2005) found that alcohol involvement in a crash was a strong predictor for future crashes.

The most likely explanation is that previously convicted drivers on average have a generally more risky driving style (Walter & Studdert, 2015). If being detected and sanctioned for violations has any deterrence effect, this effect does not outweigh the generally higher baseline risk.

However, one of the studies found no relationship between previous violations and future crashes (Strathman et al., 2007) and one study found a negative relationship (Reelmeier et al., 2003). The latter is explained by the authors with a short-lived deterrent effect. The negative relationship was only found during the first 1-2 months and disappeared from the third month after the conviction.

Høye et al. (2016) found positive relationships between previous criminal charges during ten years prior to involvement in a fatal crash and violations committed in the crash among motorcycle riders involved in fatal crashes in Norway. These relationships were specific for the type of offence. For example, drivers with a previous criminal charge related to illegal drugs were far more likely to be under the influence of illegal drugs in the crash. Relationships were also found for DUI, speeding and unlicensed driving/riding.

More information in the Appendix: Table 34: Previous convictions and future crashes

4.1.2 Previous crashes and future crashes or violations

The following studies have investigated relationships between previous crashes and future crashes or violations:

Carnegie et al., 2009 (USA)
Chandraratna et al., 2005 (USA)
Chen et al., 1995 (Canada)
Stradling, 2005 (Scotland)

Strathman et al., 2007 (USA)
Watson et al., 2017 (Australia)

Most studies found positive relationships between past and future crash involvement. That is, drivers who had been involved in crashes previously, were more likely to be involved in crashes or to commit violations in the future than drivers without previous crash involvement.

Only one study found a negative relationship: In the study by Watson et al. (2017), DUI-convicted crash involved drivers were less likely to commit future violations than DUI-convicted non-crash involved drivers. The authors explain the results with a short-lived deterrent effect of crash involvement.

More information in the Appendix: Table 35: Previous crashes and future crashes or violations

4.2 License suspension and revocation

License suspension and revocation aim at deterring drivers from committing violations and at preventing convicted drivers from committing further violations. The underlying assumption is that (most) drivers want to avoid losing their license and will stop driving when their license is suspended.

License suspension is one of the most common sanctions for DUI, but it can also be used as a sanction for other violations such as speeding, reckless driving, refusal to perform a BAC-test, and for drivers who have accumulated a certain amount of penalty points. License suspension may also be used as a sanction for non-driving related offences (Carnegie & Eger, 2009).

Licenses can be suspended by court order or on the spot by the police (administrative license suspension). Suspended licenses can be reinstated, either after a certain amount of time or when the driver satisfies certain conditions imposed by a judge.

License revocation implies that a person's driving license is permanently cancelled and cannot be reinstated. License revocation normally is ordered by court. Common reasons for license revocation are multiple DUI offences and convictions for serious offences. To obtain a valid license, drivers with a revoked license have to apply for a new license and complete the ordinary licensing process.

Specific rules and practices regarding license suspension and revocation differ between countries and between states within countries. Amongst other things, drivers with a suspended or revoked license can be denied vehicle insurance, or insurance fees can be increased.

Several measures may contribute to prevent drivers with a suspended or revoked license from driving, amongst others:

- Electronic driving license which prevents drivers without a valid license from starting the vehicle engine (Sagberg, 2016)
- Vehicle impoundment and confiscation.

A License Sanction Enforcement System is described by Voas (2010), consisting of devices attached to both legs that register leg movements and that can identify movement patterns typical for car driving.

Exposure and risk of apprehension among drivers with a suspended or revoked license

Drivers with a suspended or revoked license should in theory not be driving at all and therefore not be involved in crashes. However, the risk of apprehension for these drivers is small as long as they are not involved in crashes. Large proportions of suspended drivers were found to continue driving, though less than licensed drivers (DeYoung et al., 1997; Lenton et al., 2010; Parrish & Masten, 2015; Peck & Voas, 2002).

Reduced exposure can be expected to reduce crash involvement. However, drivers with suspended licenses have on average far higher crash risk than other drivers which may partly or wholly offset the effects of reduced exposure. Moreover, those drivers with most alcohol problems and the highest crash risk («hardcore drunken drivers») are least likely to be deterred by license suspension (and most other anti-DUI measures; Darnell, 2015).

More information in the Appendix: Table 36: Exposure and risk of apprehension among drivers with a suspended or revoked license

Crash risk among drivers with suspended or revoked licenses vs. licensed drivers

The relationship between unlicensed driving and crash involvement or crash severity has been investigated in the following studies:

Watson, 1997 (Australia)
DeYoung et al., 1997 (USA)
Watson, 2004 (Australia)
Blows et al., 2005 (Australia)
Watson & Steinhardt, 2006 (Australia)
Brar, 2012 (USA)

All studies have directly or indirectly controlled for driving exposure which means that crash risk can be interpreted as crashes per driven kilometers. Crash risk, or crash severity, is in all studies far higher among drivers without a valid license than among license drivers. The relative crash risk of drivers without a valid license is between 1.5 and 5.4.

Whether S/R drivers have higher or lower relative risk than never licensed drivers is inconsistent between studies, but the differences are for the most part relatively small. Thus, both lack of experience and other risk factors may contribute to the high risk of different groups of unlicensed drivers.

Among drivers with suspended license, those who are suspended for non-driving reasons have in several studies been found to have lower crash risk than those with a license suspended for driving reasons or those with a valid license (DeYoung & Gebers, 2004; Carnegie & Eger, 2009). Non-driving reasons for license suspension that apply in some states of the USA, include failure to pay a motor vehicle fine, court fine, or child support, ficticious license plates, and failure to appear in court for certain reasons (Carnegie & Eger, 2009).

The assumption that unlicensed drivers are (or at least should be) motivated to avoid detection and thus adopt a safer driving style (Watson, 2004), is not supported.

In-depth analyses of fatal crashes in Norway 2005-2014 show that 7% of fatal crash involved drivers and 10% of all drivers who were responsible for crash occurrence, had no valid license (Sagberg, 2016). In the USA, over 10% of all drivers in fatal crashes do not have a valid license (Griffin & DeLaZerda, 2000).

A possible bias in studies that have estimated the relative crash risk of unlicensed drivers is that the involvement of unlicensed drivers may be underreported, compared to that of licensed drivers, especially in single vehicle crashes (Watson & Steinhardt, 2006). Another possible bias in studies that have estimated exposure by the quasi induced exposure method (non-at fault drivers as a comparison for at-fault drivers) is that drivers without a valid license may be more likely to be held responsible for a crash than licensed drivers (Watson, 2004).

More information in the Appendix: Table 37: Crash risk of drivers with suspended or revoked licenses vs. licensed drivers

Typical risk factors among drivers with suspended or revoked license

Factors that typically are overrepresented among crash involved drivers with a suspended or revoked license and among unlicensed drivers, include alcohol and drugs, speeding, inattention, being young and / or male, non-use of seat belts, driving stolen vehicles, single vehicle crashes, weekend and nighttime crashes. This has been found in the following studies:

Bernhoft & Behrensdorff, 2000 (Danmark)
Blows et al., 2005 (Australia)
Brown et al. (2008)
MacLeod et al. (2012)
Sagberg, 2016 (Norway)
Statens vegvesen (UAG), 2005-2015 (Norway)
Watson & Steinhardt, 2006 (Australia)

Drivers without a valid license are also strongly overrepresented in hit-and-run crashes (MacLeod et al., 2012).

More information in the Appendix: Table 38: Typical risk factors among drivers with suspended or revoked license

Specific deterrence: Effects of license suspension on crashes among suspended drivers

Effects of license suspension on crashes among suspended drivers has been investigated in the following studies:

Siskind, 1996 (USA)
Masten & Peck, 2004 (review and meta-analysis)
Stephen, 2004 (USA)
Strathman et al., 2007 (USA)
Carnegie et al., 2009 (USA)
Fell & Scherer, 2017 (USA)
Watson et al., 2017 (Australia)

The studies show consistently that drivers with suspended license have fewer crashes on average than drivers with a valid license, most likely because of reduced exposure. After the suspension period, there is no evidence of reduced crash involvement.

In a large state level study, Fell & Scherer (2017) show that longer suspension periods are associated with reductions of fatal alcohol-related crashes which is interpreted as a general deterrence effect. However, among drivers with previous convictions for drunk driving, no effects of administrative license suspension were found, neither an overall effect nor an effect of suspension length. The latter results indicates that administrative license suspension does not have any specific deterrence effect.

More information in the Appendix: Table 39: Specific deterrence: Effects of license suspension on crashes among suspended drivers

Administrative license suspension laws

Administrative license suspension laws imply that the police, a department of motor vehicles, or a licensing department may suspend the license of drivers for certain offences (e.g. drunk driving or refusing to take a BAC test), without involving a court.

Under administrative license suspension laws, the police has to spend less resources on collecting evidence for court trials, and has thus more available resources for enforcement activities (Brubacher et al., 2017; Macdonald et al., 2013). Moreover, the punishment comes far swifter than when a court is involved (Fell & Scherer, 2017). The swiftness of punishment is one of the factors that, according to deterrence theory, affects the effectiveness of sanctions (Darnell, 2015).

The effects of administrative license suspension laws on crashes has been investigated in the following studies:

Evans et al., 1991 (USA)
Rodgers, 1995 (USA)
Ruhm, 1996 (USA)
Voas, Tippetts and Fell, 2000 (USA)
Whetten-Goldstein et al., 2000 (USA)
Young & Likens, 2000 (USA)
Dee, 2001A (USA)
Eisenberg, 2001 (USA)
Sen, 2001 (Canada)
Mann et al., 2002 (Canada)
Villaveces et al., 2003 (USA)
Voas, Tippetts and Fell, 2003 (USA)
Bernat et al., 2004 (USA)
Noland & Karlaftis, 2005 (USA)
Kaplan & Prato, 2007 (USA)
Wagenaar et al., 2007 (USA)
Asbridge et al., 2009 (Canada)
Chang et al., 2012 (USA)
Macdonald et al., 2013 (Canada)
Brubacher et al., 2017 (Canada)
Fell & Scherer, 2017 (USA)

Most of these studies are multivariate multi-state studies that have compared fatal crash rates between states with and without administrative license suspension laws while controlling for a number of other relevant factors.

Based on these studies, the number of fatal DUI crashes is reduced by 7% (-9; -5). The results may be affected by publication bias. With statistical control for publication bias the effect is slightly reduced to -6% (-8; -4). A large US study that could not be included in meta-analysis (Romano et al., 2015) found a similar effect on alcohol related fatal crashes (-7%). Another study that could not be included in meta-analysis found no or even detrimental effects of administrative license suspension laws (Darnell, 2015). This is a before-after study in eight states with a matched control group.

For the total number of crashes, a reduction by 4% (-5; -2) has been found. This might indicate that a part of the effect on DUI crashes may be due to other factors. However, since a large part of all fatal crashes involve DUI, one should expect a reduction of the total number of crashes, though smaller than the reduction of DUI crashes.

These results refer to the general effects of the laws, i.e. to the effects on the whole driver population.

Several studies show that the effects of administrative license suspension laws are greater:

- In areas with many alcohol serving establishments (Brubacher et al., 2017), possibly because there is more drunken driving in such areas, or because of increased media coverage.
- Among drivers without previous DUI convictions; among drivers with previous DUI convictions, no effect was found (Fell & Scherer, 2017)
- For longer lengths of the license suspension period (Darnell, 2015; Fell & Scherer, 2017).

In summary, administrative license suspension laws may reduce alcohol related crashes. However, the effect is likely to be small and restricted to laws prescribing long suspension periods.

More information in the Appendix:

Table 40: Administrative license suspension laws

4.3 Vehicle impoundment and confiscation

Drivers with suspended licenses drive on average less than drivers with a valid license, but many continue to drive. For those drivers who continue to drive with a suspended license, the deterrence effect of license suspension is probably small or completely absent (Bernhoft & Behrensdorff, 2000). Moreover, those who continue to drive have far higher crash risk than licensed drivers (see section 4.2).

To increase the deterrence effect, both specific and general, of license suspension, vehicles can be impounded, immobilized, or confiscated. The main objectives of vehicle impoundment and similar measures are:

- To deter drivers from committing violations that may result in vehicle impoundment
- To prevent drivers from committing violations with the impounded or confiscated vehicle
- To provide a stronger barrier for drivers with suspended licenses to abstain from driving.

Vehicle impoundment can be expected to have a stronger deterrent effect than license suspension because it prevents drivers from driving their own car during the suspension period, while a suspended license is not regarded as an obstacle by many. In the case of vehicle confiscation, the loss of the car can additionally be regarded as a supplement to penalties and it will permanently prevent the driver from using it for committing violations. It can also have a more pedagogical aspect, especially in cases when a vehicle is impounded or confiscated that has been «misused» such as for speed trials or hooning, and when the Police has few other possibilities of preventing such behavior (Synvis, 2016).

Additionally, getting a vehicle impounded is far less easy to hide for others, for example for family members, colleagues or the employer, and it probably provides a much stronger signal than license suspension or penalties alone that the sanctioned behavior is not tolerated (Synvis, 2016). It may also make it less likely that other are willing to borrow a car to someone who got his or her own car impounded.

Laws: Several states in the USA, New Zealand, and Canada have introduced laws that allow the impoundment or confiscation of the vehicles of drivers with a suspended license or with illegal BAC levels (Voas & DeYoung, 2002).

A review among European countries (Belgium, Canada, Denmark, Norway, Spain, Sweden, and the United Kingdom) by McKnight et al. (2008) showed that vehicle impoundment and forfeiture are only rarely used, mostly because they are regarded as too harsh. However, this argument is questionable if the concern for the offenders mobility needs are weighed against other peoples' safety, especially as regards repeat offenders (Olstad, 2015; Synvis, 2016).

Vehicle impoundment means that the vehicle is towed in as long as the license is suspended, and can be returned to the owner against payment of a fee. The impoundment period is usually as long as the license suspension period (sometimes it is shorter). It is usually longer for more severe violations (mostly higher BAC levels) and longer for repeat offenders than for first-time offenders. Vehicle impoundment laws are often administrative, i.e. the vehicle can be impounded immediately by the police whenever a driver is caught with an illegal BAC level or without a valid license. Impounded vehicles can be returned to the owner after the impoundment period against the payment of a fee. Vehicles can also be impounded if the driver is not the owner of the vehicle. In such cases the reinstatement of the vehicle to the owner is possible under certain conditions.

In the US, 45 states had a law providing for vehicle sanctions other than alcolock in 2008 (McKnight et al., 2008). In other countries that were reviewed by McKnight et al. (2008), vehicle sanctions were only rarely used in 2008 (Australia, Belgium, Denmark, Norway, Spain, Sweden, and the United Kingdom). The reported reasons were for the most part that vehicle impoundment and forfeiture were considered too severe. Only Canada and New Zealand have a comprehensive vehicle impoundment and confiscation program (Voas et al., 2004; McKnight et al., 2008).

In Australia and New Zealand, vehicle impoundment has been introduced as a sanction for hoon driving[1] (Leal et al., 2009). For example, in Queensland vehicles are impounded for 48 hours at the first offence, for three months at the second offence, and permanently (forfeited) at the third offence (Leal et al., 2009).

In Norway, the police can prohibit the use of vehicles for a period of up to one year. The road traffic act (§36) describes the conditions under which the use of vehicles can be prohibited, as well as means of enforcing prohibitions. Conditions under which the use of a vehicle may be prohibited, include for the most part the technical condition of the vehicle, but also negligent driving by the owner or a person who regularly uses the vehicle with the owners' consent (§36-1.d). A general restriction is that the prohibition must be necessary with regard to road safety. When the use of a vehicle is prohibited, the police may, amongst other things, impound the registration plates, immobilize the vehicle with a mechanic or electronic device, or impound the vehicle.

Vehicle confiscation (or forfeiture) means that the vehicle is not returned to the owner but sold. Vehicle confiscation is mostly limited to repeat offenders (Voas et al., 2004) and rarely used, mainly because of expensive administrative procedures and the normally low value of confiscated vehicles.

In Norway it is possible, in principle, to use vehicle confiscation as a sanction for traffic violations. Vehicle confiscation is usually practiced in combination with penalties and/or jail sentences, and not an administrative sanction, i.e. it has to be administered by a court, not by the police. Legally, the confiscation of vehicles is founded on §69(c) of the criminal code, according to which: «Objects that … c) have been used … during a criminal act, can be confiscated ». Vehicle confiscation is not a standard sanction. It is recommended only for sanctioning repeated or particularly severe violations that endanger other peoples' health or life, and when it is regarded as necessary for preventing future criminal acts (Riksadvokaten, 2014). Additionally, the proportionality has to be considered, i.e. the consequences of the confiscation for the owner of the car (Synvis, 2016). With these restrictions, vehicle confiscation is used more seldom than it probably could (or should). Olstad (2015) has summarized the use of vehicle confiscation in DUI cases. The results show that vehicle confiscation is used very restrictively and only for habitual offenders with a (large) number of previous convictions for serious offences (e.g. driving with high BAC levels) who are expected to continue to use the car for drunk driving unless it is confiscated. Another obvious example of a type of violations where vehicle confiscation might be used more often is hooning where mostly young drivers use their cars for «playing» on public roads: The police has few other possibilities of preventing such behavior (drivers are frequently fleeing from the police and chasing them, especially when they are using motorcycles, is usually regarded as too risky), the vehicles that are used for hooning (especially motorcycles) are often mostly used as «toys» and sometimes not even suitable for legal use on public roads, and confiscation of such vehicles may have a more pedagogical effect than any other sanction (Synvis, 2016).

[1] Hooning describes activities such as illegal street racing, speed trials, and driving in a way that produces unnecessary noise and smoke, such as burnouts (spinning the rear wheels until they produce smoke), donuts (driving in a way that leaves a donut-formed pattern of burn marks on the asphalt), and drifting (sliding sidewise through a curve at high speed) (Leal et al., 2009).

Possible alternatives to vehicle impoundment or confiscation that are used in other countries, are license plate impoundment, attaching a sticker to the license plate, withdrawal of the vehicle registration, or confiscation of the ignition keys.

Drivers whose vehicles are impounded have fewer opportunities to drive illegally than drivers from whom only the license is suspended. Most of them do no longer have an own car to drive and many may also have reduced opportunities to borrow a vehicle, especially those who got a vehicle impounded that was not their own (Voas & DeYoung, 2002).

4.3.1 Specific deterrence effects of vehicle impoundment and similar measures

The effects of vehicle impoundment and similar measures on crash involvement among individual drivers have been investigated in the following studies:

Rodgers, 1994 (USA, Minnesota)
Crosby, 1995 (USA)
Beirness et al., 1997 (Canada, Maintoba)
Voas et al., 1997 (USA, Oregon)
Deyoung, 1999 (USA, California)
Voas et al., 1998 (USA, Ohio, Hamilton County)
Leaf & Preusser, 2011 (USA, Minnesota)
Rosenbloom & Eldror, 2013 (Israel)

The comparison group consists in most studies of drivers who were convicted for the same (type of) violations as those with impounded vehicles, but without getting their vehicles impounded. Comparison group drivers had in many cases not committed equally severe offences, as those with impounded vehicles, which makes a direct comparison difficult. This problem is avoided in studies that have applied comparison groups of drivers whose offences were similar to those in the study group, but who were convicted before the implementation of a vehicle impoundment (or similar) law.

During the impoundment period, violations and rearrest rates were generally found to be reduced by up to 50%, although the size of the reductions vary considerably between studies. Crash involvement was found to be reduced by 13% (non-significant) in one study that has investigated the effects of license plate stickering (Voas et al., 1997).

After the impoundment period, effects on violations and rearrest rates persisted in most, but not all studies, and they were considerably smaller than during impoundment. Crash effects are available from two studies. One of them found crash reductions of 25% and 37% among first and repeat offenders, respectively, during the first year after vehicle impoundment for driving with a suspended or revoked license (Deyoung, 1999). The other did not find any effect (Rosenbloom & Eldror, 2013). In both studies, drivers with impounded vehicles and comparison group drivers are comparable in terms of their violations.

In summary, despite somewhat inconsistent results, vehicle impoundment seems to have larger and more long-lasting effects than license suspension.

The reductions of crashes and violations, both during and after the impoundment period, can be explained by both deterrence and reduced exposure. Not all drivers retrieve their cars and it may be more difficult to borrow a car, especially if the impounded car had been borrowed.

A potential adverse effect of vehicle impoundment was found in the study by Leal et al. (2009) who conducted interviews with young drivers who were frequently engaging in hooning. Results from the interviews show that the sanctions for the second and third hooning offence (vehicle impoundment for three months and vehicle forfeiture, respectively) are regarded as so severe that the drivers are willing to take high risks for avoiding to be caught by the police. This includes fleeing from the police and thus engaging in high-risk pursuits. The 48-hour period of vehicle impoundment for the first offence is not regarded as sufficiently severe for having any deterrent effect (besides the increasing threat of losing the vehicle for future offences).

More information in the Appendix: Table 41: Specific deterrence effects of vehicle impoundment and similar measures

4.3.2 General deterrence effects: Vehicle impoundment laws

Studies that have investigated the general deterrence effects of vehicle impoundment laws, found mixed results.

The effects of vehicle impoundment laws are for the most part:

- Larger for more serious crashes/injuries than for less serious crashes/injuries
- Larger for crashes, fatalities, and injuries than for violations
- Larger when vehicle impoundment was a part of a larger «package» of measures that were introduced at the same time than when it was the only new measure.

Vehicle impoundment law as a single measure

Crash effects of vehicle impoundment law as the only new measure have only been investigated in four studies:

DeYoung, 1998 (USA, California)
Cooper et al., 2000 (USA, California)
McKnight et al., 2013 (USA, Washington state)
Byrne et al., 2016A (Canada, Ontario)
Byrne et al., 2016B (Canada, Ontario)

Vehicle impoundment was in all studies a sanction for unlicensed driving or driving with a suspended license and in some studies additionally for DUI.

Two of these studies found crash reductions (Cooper et al., 2000; McKnight et al., 2013). In the study by Cooper et al. (2000), the number of injury crashes decreased by 3.4% for every 10% increase of the cumulative number of vehicle impoundments. In the study by McKnight et al. (2013), motorcycle crashes involving unlicensed riders decreased by 22% (statistically significant), while the total number of motorcycle crashes only decreased by 1.6% (non-significant). Byrne et al. (2016A) found a reduction of driving with a suspended license by 19%.

The results from the other studies no not indicate that vehicle impoundment laws have any crash reducing effects.

In summary, although some studies found crash reductions, there is no consistent evidence that vehicle impoundment laws reduce crashes. Possible explanations include methodological aspects, the implementation of the laws (for example media coverage and accompanying enforcement), and small numbers of drivers who were sanctioned under the law. Moreover, the laws included in the studies addressed mainly driving while suspended or unlicensed. Studies that found reductions of crashes and violations (on the individual level or in the whole driver population) have for the most part investigated vehicle impoundment as sanctions for DUI or speeding.

More information in the Appendix: Table 42: General deterrence - Vehicle impoundment law as a single measure

Vehicle impoundment law as one of several measures

The effects of vehicle impoundment as a part of a larger «package» of measures was investigated in the following studies:

Macdonald et al., 2013 (Canada, British Columbia)
Beirness & Beasley, 2014 (Canada)
Brubacher et al., 2014 (Canada, British Columbia)
Meirambayeva et al., 2014A,B (Canada, Ontario)
Byrne et al., 2016A (Canada, Ontario)
Brubacher et al., 2017 (Canada, British Columbia)
Gargoum & El-Basyouni, 2017 (Canada, 3 provinces)

Most studies found crash reductions in the target group of the laws by around 20%. Studies that have investigated the effects of vehicle impoundment on the targeted offences (DUI, speeding or unlicensed driving), found large reductions by around 20-50%.

Vehicle impoundment was in most studies introduced as a sanction for speeding and/or DUI and accompanied by other measures, such as increased license suspension periods and increased penalties.

More information in the Appendix: Table 43: General deterrence - Vehicle impoundment law as one of several measures

License plate stickers

License plate stickers while the drivers' license is suspended as a sanction for DUI yielded contradicting results in two states in the study by Voas et al. (1997). Crashes and violations were statistically significantly reduced in one state, while no statistically significant changes were found in the other state. In summary, the results are inconclusive regarding the effects of license plate stickers.

More information in the Appendix: Table 44: General deterrence – License plate stickers

Confiscation of ignition keys

Confiscation of ignition keys as an administrative sanction for drivers apprehended for DUI has been introduced in several Australian jurisdictions (Watson & Nielson, 2006). Empirical evaluations of this measure were not found.

4.4 Alcohol ignition interlock

Alcolock is an in-vehicle device that requires the driver to provide a breath test in order to start the engine. When the breath sample contains alcohol above a defined limit (normally the legal limit), the engine will not start (Assum & Hagman, 2006).

Alcolock can be programmed to require a new breath test every time the engine is started or only after the engine has been turned off for a certain amount of time. Alcolock can also be programmed to require new breath tests at random intervals while driving. In primary prevention programs it is more common not to require retests unless the engine has been turned off for more than for example 30 or 45 minutes. The devices may log information about results from breath tests and these may be used for example to monitor the compliance of DUI convicted drivers in an alcolock program or of employees in companies with an alcolock program.

Some technical issues and potential problems with alcolock are (Bjerre & Kostela, 2008):

- The device has a warming-up phase of about 10 seconds
- Alcolock often functions poorly in cold weather and may require a warm up phase of several minutes or does not function at all
- Alcolock has to be calibrated regularly (once or twice per year)
- False positive results may occur in some cases (for example persons on specific types of diets may test positively despite being sober; Jones & Rössner, 2006)
- In order to prevent problems in case of false positive test results, alcolocks may be equipped with a bypass switch.

Alcolock may be used as a means of secondary or primary prevention.

Secondary prevention means that DUI-convicted drivers are required to install alcolock in their vehicles in order to drive legally, usually as a part of a treatment program or probation conditions. Three different types of interlock laws are distinguished in the USA (McGinty et al., 2017):

- Mandatory interlock laws: All DUI convicted drivers are required to use an alcolock in order to drive legally
- Partial interlock laws: Specific groups of DUI convicted drivers (such as repeat offenders) are required to use an alcolock in order to drive legally
- Permissive interlock laws: Judges may require DUI convicted drivers to use alcolock.

Alcolock is often offered (under certain conditions) as an alternative to license suspension or other more restrictive sanctions, but may also be ordered without optional other sanctions. Finland introduced alcolock as an alternative to license suspension for alcoholics (Vehmas et al. 2012, 2014). Installation rates are often low (e.g. 22% in the study by Vezina, 2002).

Primary prevention means that alcolock is installed in all vehicles of a specific type, for example company vehicles, buses, taxis, vehicles in school transport, or snow scooters.

In Norway several counties require alcolock in buses in public transport and school buses. The Norwegian Public Roads Administration has the aim to install alcolock in all vehicles owned by public administration, in all driving school vehicles and in all vehicles driving on behalf of public administration (Statens vegvesen, 2014). Since 2019, all buses and minibuses used for commercial passenger transport and registered in Norway after January 1st, have to be equipped with alcolock.

Similar to Norway, alcolock is used on a voluntary basis in commercial vehicles in Sweden and Finland. In France, alcohol interlocks are mandatory for school transport vehicles since 2009 (Vehmas et al., 2012).

Alcolock is not normally available on new cars but can be retrofitted. Volvo offers alcolock as optional equipment. The system offered by Volvo requires 10 sec. warming-up (starts to warm up when the central locking system is unlocked). It has a bypass function which, when activated, allows starting the engine without a breath test either once or an unlimited number of times.

4.4.1 Secondary prevention

Drivers who have been convicted for driving under the influence of alcohol have a high risk of recidivism (Baca et al., 2001). Alcohol problems are probably the most important risk factor for recidivism (Yu, 2000) and repeat DUI offenders are often quite immune to legal sanctions (Freeman, 2004).

Effects of alcolock on crashes with convicted DUI offenders: Specific deterrence

Specific deterrence effects of alcolock among convicted DUI offenders have been investigated in the following studies:

Vezina, 2002 (Canada, Quebec)
Bjerre, 2005 (Sweden)
DeYoung et al., 2005 (USA, California)
Bjerre & Thorsson, 2008 (Sweden)
Watson et al., 2015 (Australia, Victoria)
Kerns, 2017 (USA, Maryland)
Vanlaar et al., 2017 (Canada, Nova Scotia)

For the most part, the results show that alcolock has no effect or even may increase crash involvement when compared to drivers with a suspended license. The most likely explanation is that alcolock participants drive more than those with a suspended license. However, alcohol related crashes may decrease.

After the removal of alcolock, most, but not all, studies found large increases of crash involvement, and higher crash rates than among drivers without alcolock.

Among multiple offenders, more favorable effects (or less unfavorable effects) were found on crash involvement than among first-time offenders while alcolock was installed. However, after the removal of alcolock, crash involvement increased more among multiple offenders than among first-time offenders.

However, the results cannot necessarily be generalized. None of the studies has reported results that refer to crash risk (numbers of crashes per vehicle kilometer), and there may be large differences in exposure, not only between alcolock groups, but also between the comparison groups in the different studies. Moreover, there may be selection effects, i.e. drivers with and without alcolock may not be directly comparable.

A limitation of mandatory alcolock programs is that many convicted drivers do not have alcolock installed in their vehicles and continue to drive with a suspended or revoked license (Raub et al., 2003). In order to make installing alcolocks more attractive, it has been discussed to offer more restrictive sanctions as alternatives to alcolock, such as electronically monitored home confinement (Voas, Marques & Roth, 2007).

More information in the Appendix: Table 45: Alcolock

Effects of alcolock on recidivism while installed: Specific deterrence

Recidivism rates were in a large number of studies found to be reduced among participants in alcolock programs, on average by 75% according to reviews and meta-analysis (Elder et al., 2011; Willis et al., 2004). However, participation is voluntary in most programs, mostly in exchange for reduced sanctions. Thus, general differences between participant and non-participants are likely to have contributed to the large effects. Treatment and requirements of abstinence from alcohol in some of the programs are also likely to have contributed to the effects.

Close monitoring was found to improve the effectiveness of alcolock programs. Including first-time DUI offenders, including those with low BAC (> .08) can also improve the effectiveness.

After removal of alcolock, effects on recidivism dissipate in most studies. In one study (with random assignment of eligible offenders to alcolock and alternative sanctions; Rauch et al., 2011) effects on recidivism persisted over four years after removal of alcolock.

More information in the Appendix: Table 45: Alcolock

Effects of alcolock on recidivism after removal of the devices

Most studies did not find any effects of alcolock programs on recidivism after the removal of the alcolock devices (Bax et al., 2001; Beck et al., 1999; DeYoung, 2002; Elder et al., 2011; Nochajski and Stasiewicz, 2006; Voas et al., 1999; Roth et al., 2007). The results indicate that most drivers only reduce driving after drinking, or drinking before driving, but not drinking overall.

A possible explanation for the failure of many studies to find an effect of alcolock programs after removal of the devices, especially among multiple DUI offenders, is that alcolocks reduce driving after drinking or drinking before driving, but not drinking overall (Marques et al., 2010; Vezina, 2002).

Drivers who perform better during the alcolock program (i.e. who have no or few failed interlock tests) have on average lower recidivism rates. Some studies found reduced post-treatment recidivism rates for alcolock programs with a strong treatment component (Bjerre & Thorsson, 2008; Vanlaar et al., 2017; Voas et al., 2016).

In summary, the results indicate that long-term effects of alcolock programs are most likely if the programs aim at producing lasting effects on drinking behavior, not only on driving after drinking. Alcolock programs with a treatment component that aims at those offenders with the best chances for succeeding with the treatment, may be effective in reducing DUI even after the removal of the alcolocks.

More information in the Appendix: Table 45: Alcolock

Effects of alcolock programs on total crash numbers: General deterrence

The effects of alcolock programs on jurisdiction-wide numbers of alcohol-related crashes have been investigated in the following studies:

McCartt et al., 2013A (USA, Washington)
McCartt et al., 2013B (USA)
Kaufman & Wiebe, 2016 (USA)
Ullman, 2016 (USA)
McGinty et al., 2017 (USA)
Vanlaar et al., 2017 (Canada, Nova Scotia)
Soper, 2020 (USA)

For the most part small but statistically significant crash reductions and decreases of DUI conviction rates were found. Most studies found reductions of alcohol-related crashes by between -7% and -15%, while some studies only found small and non-significant effects.

The results indicate that the effectiveness of alcolock programs can be increased by including first-time and low-BAC offenders in the programs, instead of limiting their use to high-BAC and multiple offenders, as most of the earlier programs did.

More information in the Appendix: Table 45: Alcolock

4.4.2 Primary prevention

The use of alcolock as a primary prevention measure implies that alcolock is installed in all motor vehicles (of a specific type), regardless of whether or not the drivers has any previous DUI convictions or belongs to a high-risk group.

No studies have been found on the effects on accidents of alcolock that are based on a sufficient number of accidents to allow meaningful conclusions. Theoretically, installing alcolock in all passenger cars in Norway may reduce the number of the total number of killed or seriously injured in motor vehicle crashes by up to 11% (Høye, 2019).

Several trials have been made with installing alcolock in commercial vehicles, i.e. all vehicles owned by a specific company:

Bjerre & Kostela, 2008 (Sweden)
Bjerre, 2005 (Sweden)
Assum & Hagman, 2006 (Norway)
Silverans et al., 2007 (Norway, Spain, and Germany)
Vehmas et al., 2012 (Finland)

The experiences can be summarized as follows:

- Reported reasons for installing alcolocks were mainly improving quality (drivers fitness to drive) and the company`s image, as well as demand from customers.
- Improving road safety was for the most part *not* among the primary reasons and very few reported known alcohol problems as one of the reasons. However, a few cases of alcohol problems could be uncovered and subsequently treated.
- Attitudes towards alcolock were mainly positive, and became more positive as the employees gained experience. Acceptance depends on how alcolock is implemented and incorporated in the companies' alcohol policy.
- From the drivers' perspective alcolock should be installed in all vehicles in a company.
- The most negative thing about alcolock was considered to be time and trouble spent using the device (warm-up time, trouble in cold temperatures). Some drivers felt embarrassed by having to use the device in public places.
- There were few reported technical problems, but in cold temperatures, alcolock can cause delays.

More information in the Appendix: Table 45: Alcolock

4.4.3 Cost-benefit studies of alcolock

Lahausse & Fildes (2009) have conducted a cost-benefit analysis of installing alcolock in all new vehicles in Australia. The results indicate that benefits would be about three times the costs (at a discount rate of 4% and an expected vehicle life time of 15 or 25 years and if alcolock is not circumvented in 95% of cases). The proportion of alcohol related fatalities in Australia at the time of the study was about 25%.

Anderson et al. (2011) have estimated cost-benefit ratios for installing alcolock in all passenger cars, trucks, and motorcycles. They assume for all vehicle types a reduction of relevant (alcohol involved) crashes by 80% (based on the results of the study by Bjerre, 2005). Other assumptions in the analysis are:

- Unit cost: 1500 AUS-$
- Benefit period: 16 years (passenger cars), 13 years (trucks), 11 years (motorcycles)
- Discount rate: 5.5%
- Crash costs: Based on crashes in New South Wales (1999-2008)

Table 6: Cost-benefit analysis of alcohol ignition interlock (Anderson et al., 2011).

	Relevant crashes, % of all crashes		Estimated effect on all crashes		Benefit-cost ratio	Break-even costs
	Fatal	Injury	Fatal	Injury		
Passenger cars	13 %	4 %	11 %	3 %	**0.5**	$ 770
Trucks	3 %	1 %	2 %	1 %	**2.5**	$ 3700
Motorcycles	3 %	1 %	2 %	1 %	**2.0**	$ 3000

The study by Anderson et al. (2011) is based on more detailed assumptions about crash effects in different types of vehicles than the study by Lahausse and Fildes (2009). The latter study is based on lower costs for alcolock. At the costs assumed by Lahausse and Fildes (2009), alcolocks would have a cost-benefit ratio above one in the study by Anderson et al. (2011). However, alcolocks at that price are also likely to be less effective (Anderson et al., 2011).

An American study estimated the installation of alcolock in all new vehicles to be cost-effective after three years (Carter et al., 2015).

4.5 DUI-courts and intensive supervision programs

DUI offenders are often highly resistant to classical measures such as license suspension, penalties or jail. Many offenders do not comply with restrictions, or return to the same behavioral patterns (involving both drinking / substance abuse and driving) as before their latest conviction. Therefore, more comprehensive measures have been developed that address the underlying problems of (repeat) DUI offenders, aiming at lasting behavioral changes.

In many states of the USA courts have been established which are specialized on severe DUI offences. These courts follow the model of drug courts, addressing the alcohol addiction problems of repeat drug driving offenders (Fell et al., 2010). They combine classical sanctions (penalties, jail) with comprehensive and restrictive programs, including demands on alcohol abstinence, treatment, and monitoring, amongst other things. Non-compliance with restrictions or requirements is met with immediate sanctions, such as short jail terms or exclusion from the program.

Only one study was found that has investigated the effects of DUI courts on crashes. Bouffard and Bouffard (2011) found no effects on the number of country-wide alcohol-related crashes after the implementation of DUI courts. They compared the development of crash numbers over time, before and after the introduction of the DUI court. The swiftness of the sanctions improved, which might have been expected to reduce drunk driving. However, certainty of sanctioning remained unchanged and the severity of the sanctions decreased.

Studies that have investigated effects on drunk driving and/or recidivism include:

Jones et al., 1996 (USA)
Jones and Lacey, 1999
Eibner et al., 2006 (USA)
Lapham et al., 2006
MacDonald et al., 2007 (USA)
Carey et al., 2008 (USA)
Ronan et al., 2009 (USA)
Bouffard et al., 2010 (USA)
Fell et al., 2010 (USA)
Bouffard & Bouffard, 2011 (USA)

The results are inconsistent. Five studies found reduced recidivism among DUI court participants (Carey et al., 2008; Eibner et al., 2006; Fell et al., 2010; Lapham, 2006; Ronan et al., 2009) while the remaining studies found no effects. These results cannot easily be generalized because the measures applied can be very different (Miller et al., 2015). Generally, greater effects have been found of more restrictive programs, and among drivers with less criminal background. For intensive supervision programs (which are similar to most DUI court programs), Miller et al. (2015) found for the most part favorable results.

In a review and meta-analysis of **drug courts**, Mitchell et al. (2012) found inconsistent results. Consistently favorable effects were only found in methodologically weaker studies (not in experimental studies). In general, effects were smaller for courts including violent offenders and for juvenile drug courts.

In a literature review of DUI **rehabilitation programs**, Ferguson et al. (1999) conclude that such programs can reduce recidivism by about 7.9%. Programs that include several types of interventions (e.g. counselling, education, probation) and that are combined with sanctions were found to be more effective than programs with only a single component and programs that are not combined with sanctions.

More information in the Appendix: Table 46: DUI-courts and intensive supervision programs

4.6 Sobriety requirements

The rationale of sobriety requirements for DUI offenders is that as long as DUI-offenders continue drinking there will be a risk that they also will be driving after drinking. Alcohol problems were found to be the strongest predictor of DUI recidivism, while sanctions have no significant effect on recidivism when alcohol problems are statistically controlled for (Yu, 2000). Several devices and programs for monitoring sobriety are described by Voas (2010).

A «24/7 Sobriety» program has been evaluated by

Caulkins & DuPont, 2010 (USA)
Kubas et al., 2015 (USA)
Stevens, 2016 (USA)

The program requires DUI offenders to submit two alcohol- and drug-tests every day as a condition of bail. Failed tests are sanctioned with short jail terms.

Compliance rates were generally high (Caulkins & DuPont, 2010). Recidivism and alcohol-related crashes were reduced among drivers enrolling in the program, but not crashes and violations not related to alcohol (Kubas et al., 2015). However, no general deterrent effect was found (Stevens, 2016), i.e. DUI arrest rates were unchanged after the implementation of the program.

More information in the Appendix: Table 47: Sobriety requirements

5 Treatment and educational programs for DUI-convicted drivers

Treatment and educational programs for DUI-convicted drivers aim at changing either substance abuse or drunk/drug driving behavior. Such programs may include educational or therapeutic measures.

Most treatment programs target drivers with addiction problems. Many DUI offenders, especially multiple offenders and drivers convicted of driving at high BAC levels, have addiction problems. Other sanctions (such as license suspension, fines, or imprisonment), have in many studies been found to be less effective among addicted drivers than among other drivers (Fowler & Alcorn, 2002). To increase the effectiveness of such sanctions, they may be combined with treatment.

Most educational programs have drivers without addiction problems as a target group. They aim mostly at reducing several types of risky behavior in traffic, such as DUI or speeding. They may also focus on more general behavior patterns, such as choosing means of transport other than the own car for drinking occasions.

This chapter focuses only on treatment and educational programs for which empirical evaluations on crashes and/or recidivism have been found. It is not a comprehensive review of treatment or educational programs. More comprehensive programs, such as DUI-courts, that often also include treatment and educational components, are described in section 4.5.

5.1 Treatment

Treatment programs are often used in combination with sanctions. Participation in such programs can be more or less voluntary. For example, incentives for participation may be reduced sanctions, or treatment may be a precondition for reinstatement of the driving license. However, treatment is most effective if participation is voluntary and motivated by the desire to get rid of addiction problems. The effects of non-voluntary programs may therefore be limited (Ferguson et al., 1999). Drivers with a criminal background are often excluded from treatment offers.

Studying the effects of treatment programs for DUI offenders is generally challenging and there are few methodologically strong studies. The most serious threats to validity are:

Selection bias: Offenders participating and completing treatment programs are highly unlikely to be comparable to those not participating or not completing such programs, unless they are randomly assigned or closely matched and for some reason without option of participating. Several studies found far higher re-arrest rates among non-completers than among those that completed a treatment program (Green et al., 1991; Moore et al., 2008; Nochajski et al., 1993). Selection bias makes it impossible to determine to what degree, if at all, the treatment program has contributed to differences between treatment and comparison groups.

Publication bias: Results are likely to be affected by publication bias (Wells-Parker et al., 1995).

Short term effects: Most studies have evaluated effects only during the treatment period. However, behavior changes during treatment can often be explained in terms of a desire to avoid sanctions if probation conditions are violated.

Because of these limitations, the present review is mainly based on systematic reviews and meta-analyses of DUI treatment interventions:

Miller et al., 2015 (meta-analysis)
Wells-Parker et al., 1995 (meta-analysis)

Both meta-analyses conclude that there is no evidence for the effectiveness of treatment programs for DUI offenders, neither for recidivism nor for crash involvement.

However, a methodologically relatively strong evaluation of a chemical dependency treatment in prison (Duwe, 2010; USA), which is not included in any of the meta-analyses, found statistically significant reductions of rearrest rates (-17% [-29; -5]), reconviction rates (-21% [-36; -6]), and reincarceration rates (-25% [-43; -8]) among released prisoners. The participants had been sentenced for different types of violations, including DUI (also person offences, drug offences, and other offences).

For brief alcohol interventions for adolescents and young adults (including but not specifically focusing on DUI) reductions in alcohol consumption and alcohol related problems were found in a meta-analysis by Tanner-Smith and Lipsey (2015). The greatest reductions were found for interventions including motivational interviews, decisional balance, and goal-setting exercises. Effects on crash involvement have not been investigated.

Results from studies included in the review by Miller et al. (2015) and other studies (Adinoff et al., 2005; Brown et al., 2009; Deyoung, 1999; Nochajski et al.; 1993; Peck et al., 1994; Watson, 1998) indicate that effects of treatment programs depend on a number of factors:

- **Addiction problems:** Among drivers with addiction problems, educational programs are not effective, while pharmacological treatments may be effective for treating certain types of addiction.
- **Criminal records:** Treatment is less effective among drivers with criminal records than among other drivers. Criminal records are generally related to a high risk of reoffending.
- **Cognitive impairments:** The effects of psychotherapy may be limited among DUI offenders with cognitive impairments
- **Follow-up period:** Most studies that have reported effects over different time periods, show that the effects decrease over time.

Studies that have investigated treatment programs that could be chosen as an alternative to license suspension of revocation found reduced recidivism. However, this may be due to a selection bias, i.e. systematic differences between participants and non-participants.

Changes in recidivism rates over time since 1996 were investigated by LaBrie et al. (2007). The results do not indicate that there were any general changes or that DUI treatment has improved over time.

In summary, treatment programs for DUI offenders cannot generally be expected to have any effects on recidivism or crashes, although some programs may be effective, especially for drivers without addiction problems, criminal records, or cognitive impairments.

The following table gives on overview of studies, including some methodologically weak studies not included in the review above.

More information in the Appendix: Table 48: Treatment of DUI-convicted drivers

5.2 Education

The specific target groups for driver improvement interventions and other educational programs differ between interventions. They may include drivers who have collected a certain amount of penalty points or drivers convicted for certain violations such as DUI or speeding.

Educational interventions target mostly drivers without addiction problems. These drivers have on average lower crash risk than drivers with addiction problems, but there are by far more of them («prevention paradox», Woodall et al., 2004). Drivers with addiction problems have higher crash risk but are less susceptible to educational interventions (McKnight, 1995).

Participation in educational programs may be more or less voluntary. In some countries, such courses may under certain circumstances be taken in exchange for sanctions. For example in Germany, demerit points may be deleted or licenses reinstated if a driver participates in a driver improvement course.

Meta-analyses of driver improvement courses: Effects on recidivism or crashes have been investigated in a large numbers of empirical studies. The present summary is mainly based on two large meta-analyses:

Masten & Peck, 2004 (meta-analysis)
Ker et al., 2005 (meta-analysis)

These meta-analyses found small but statistically significant reductions of recidivism and crash rates for warning letters, group meetings, and individual meetings (Masten & Peck, 2004) and for remedial driver education in general (Ker et al., 2005). Effects on crashes are for the most part far smaller than effects on violations (an exception is the study by Villaveces et al., 2011 which is not included in any of the meta-analyses). The effects are relatively stable during the first two years post-intervention. However, no effects were found over two years after the intervention. The results are likely to be affected by publication bias, selection bias, and other biases. Thus, the reductions of crashes and violations may be overestimated.

On the other hand, estimated crash effects might have been more favorable if only at-fault crashes been included in the studies (af Wåhlberg, 2011).

Short behavioral interventions for convicted DUI-drivers: After the publication of the two meta-analyses, many more studies were published. Studies that are methodologically relatively solid, include:

Rider et al., 2007 (USA)
Mills et al., 2008 (Australia)
Schermer et al., 2008 (USA)
Ouimet et al., 2013 (Canada)

These studies have investigated relatively short interventions that focus mostly on driving behavior (not on alcohol problems or drinking behavior). All interventions investigated in these studies target convicted or crash involved drunk drivers. The studies found on average a large and statistically significant reduction of recidivism (-43% [-51; -33]). Ouimet et al. (2013) found a reduction of the number of crashes by 27% (-80; +169).

It is unclear whether specific characteristics of the interventions can explain the large effects. All studies have employed strategies for minimizing selection bias. However, other biases may be present, including publication bias.

Prison-based educational intervention: Barta et al. (2016) have investigated effects of a program for imprisoned DUI-offenders. For participants in the program, the last period of imprisonment was replaced by home confinement. Additionally, participants received pre-release psycho-education and close post-release supervision. Recidivism was markedly reduced among participants in comparison to a historical comparison group.

Driver improvement course for deleting demerit points in Germany: For drivers with accumulated demerit points, a new curriculum was introduced in 2014 which under certain conditions can lead to the deletion of demerit points. The curriculum consists of four lessons of 75-90 min. (individual or group based) in addition to obligatory homework. An empirical evaluation found no effects on the driving records of drivers who completed the curriculum (Klipp et al., 2019).

Overview: Table 49 gives an overview of the results from empirical studies that have investigated effects of driver improvement courses and similar measures that were published after the meta-analysis by Masten & Peck (2004). Studies with possible selection bias or other major methodological flaws are not included in the summary above.

More information in the Appendix: Table 49: Education of DUI-convicted drivers

5.3 Victim Impact Panels (VIPs)

DUI offenders may be court ordered to attend at so-called Victim impact panels (VIPs). Victim impact panels imply that DUI (or other) offenders are confronted with people who have been victims to the same type of crime as the one committed by the offenders. Victim impact panels are generally regarded as a very expensive measure (Miller et al., 2015)

Effects of VIPs on drink driving recidivism has been investigated in the following studies:

Shinar & Compton, 1995 (USA)
Sprang, 1997 (USA)
Fors & Rojek, 1999 (USA)
C'de Baca et al., 2001 (USA)
Polacsek et al., 2001 (USA)
Rojek et al., 2003 (USA)
Wheeler et al., 2004 (USA)
Landenberger & Lipsey, 2005 (meta-analysis)
Crew & Johnsen, 2011 (USA)
Goodwin et al., 2015 (literature review)
Miller et al., 2015 (systematic review)
Joyce & Thompson, 2017 (USA)

The studies by Joyce and Thompson (2017) and Polacsek et al. (2001) are not included in any of the reviews.

Among the individual studies (not including reviews):

- Three studies found **no effects** on recidivism (Crew & Johnsen, 2011; Polacsek et al., 2001; Wheeler et al., 2004)
- One study found generally **reduced recidivism**: Joyce & Thompson (2017), a methodologically relatively strong study, found reduced recidivism among VIP participants (-40% after two years)
- Two studies found **reduced recidivism only in specific groups**: White men, ages 26-35 years with and one prior DUI arrest (Fors & Rojek, 1999); Offenders above 35 years of age (Shinar & Compton, 1995).
- One study found **reduced recidivism during the first two years**, but not in later years (up to five years; Rojek et al., 2003).
- One study found a **possible increase among female drivers**, and **no effect** among male drivers (C'de Baca et al., 2001).

Additionally, Landenberger & Lipsey (2005) concluded that the inclusion of VIPs reduces the effectiveness of treatment programs; however, this study did not specifically focus on DUI offenders.

In summary, the evidence for the effectiveness of VIPs is mixed and it is not possible to draw general conclusions.

More information in the Appendix: Table 50: Victim impact panels

6 Demerit point systems

Drivers who commit certain types of traffic violations are more likely to commit more violations in the future (Bates et al., 2015) and to be involved in crashes. This has consistently been found in a large number of studies (Barraclough et al., 2016).

The aim of demerit point systems is to deter drivers from repeatedly committing traffic violations that are known to be related to crash involvement, but that are not in themselves sufficiently severe for license suspension.

In a demerit point system certain types of traffic violations are registered. Types of violations that are registered are normally those that are regarded as being related to crash risk, but not in itself sufficient for license suspension or more serious sanctions (for example, DUI is not covered by the Norwegian demerit point system because it is in itself sufficient for both license suspension and more serious sanctions).

For each detected violation, a certain number of demerit points is registered. When a driver has collected a certain number of points, different types of sanctions can be applied. Normally, drivers first get a warning letter with information about consequences of further violations (in Norway after the sixth demerit point). When more demerit points are registered, the drivers' license is suspended for a certain amount of time (in Norway after eight points). In some countries, drivers can participate at specific educational measures (such as driver improvement courses) in order to delete demerit points or to avoid license suspension.

The number of demerit points that is registered for a violation may vary, amongst other things:

- Between different types of violations, with the more serious violations resulting in more demerit points (for example in Norway where most violations are registered with three points and some with only two)
- Between novice drivers and other drivers, with novice drivers getting more points for the same violations as experienced drivers (for example in Norway, novice drivers get twice the number of points as experienced drivers)
- Between times of the year, such that more demerit points are registered during times with a generally increased crash risk (for example in New South Wales in Australia; Castillo-Manzano & Castro-Nuño, 2012).

In some countries, for example in Germany and Ireland, insurance companies get information from the demerit point systems and can use these as a basis in the offers they make to individual drivers (Castillo-Manzano & Castro-Nuño, 2012).

In Norway, a demerit point system was introduced in 2004 and revised in 2011. The relationship between violations and number of demerit points are is based on the relationships between violations and crash risk (Stene et al., 2008). Violations that generate demerit points are:

- Speeding (more than 10 km/h above the speed limit at speed limits of 60 km/t or below; more than 15 km/t at speed limits of 70 km/h and above)
- Red-light running
- Illegal passing
- Failure to yield
- Close following
- Driving a tuned-up moped or motorcycle
- Non-use of seat belt or securing of passengers below 15 years.

For most violations three demerit points are registered. Two points are registered for minor speed limit violations and non-use of seat-belts or securing of young passengers. When a driver has accumulated four points, a warning letter is issued. When a driver has accumulated eight points within three years, the license is suspended for six months. If a driver is caught for a violation that in itself is sufficient for license suspension (such as DUI or excessive speed), accumulated demerit points are taken into account in determining the length of the suspension period. Novice drivers in the probation period get twice as many points as other drivers, and thus get their license suspended at the second violation for which points are registered.

6.1 Effects of demerit point systems on crashes

The effects of demerit point systems on fatalities, injuries, or crashes have been investigated in the following studies (studies marked with an * are included in the calculation of summary effects):

Chatenet, 1993 (France)
Lenehan et al., 2005* (Ireland)
Farchi et al., 2007* (Italy)
Zambon et al., 2007* (Italy)
Stene et al., 2008 (Norway)
Montag, 2010* (Czech Republic)
Novoa et al., 2010* (Spain)
Pulido et al., 2010* (Spain)
Akhtar & Ziyab, 2012* (Kuwait)
DePaola et al., 2013 (Italy)
Sagberg, 2016* (Norway)

The summary effect (based on the results from studies marked with an asterisk) is a statistically significant reduction of the number of crashes and injuries by 15% (-20; -10). There are no systematic differences between the results for different degrees of severity. Results for fatalities, injuries, and total crashes are therefore combined.

Most studies are based on relatively short time periods. Several studies showed that the effects of a newly introduced demerit point system tend to decrease rapidly during the first one or two years (Butler et al., 2006; Castillo-Manzano & Castro-Nuño, 2012; Farchi et al., 2007; Montag, 2010). The results can therefore only be interpreted as short term effects. In the long run, the effects are likely to be smaller or non-existent.

More information in the Appendix: Table 51: Demerit point systems – effects on crashes

In two studies, demerit point systems were found to have larger effects among men than among women (Novoa et al., 2010; Sagberg, 2016). In the Norwegian study (Sagberg, 2016) an effect was only found among young men, and none among young women. Among those studies that have investigated effects on driver behavior, a larger effect was found among men, compared to women, in one study (Zambon et al., 2008), while a larger effect was found among women, compared to men, in another study (Gras et al., 2014).

Masten & Peck (2004) show in a meta-analysis that interventions (warning letters, driver improvement courses, license suspension) that are triggered by demerit points, have greater effects on both crashes and violations than interventions that are triggered by single violations. A possible explanation is that drivers who have received points are more motivated to avoid more points.

6.2 Effects of demerit point systems on driver behavior

Effects in the general driver population

Effects of demerit point systems on several types of driver behavior (speed, violations, seat belt use, DUI) in the general driver population has been investigated in the following studies:

Mehmood, 2010 (Arab emirates)
Dionne et al., 2011 (Canada)
DePaola et al., 2013 (Italy)
Zambon et al., 2007 (Italy)
Zambon et al., 2008 (Italy)
Stene et al., 2008 (Norway)
Gras et al., 2014 (Spain)
Izquierdo et al., 2010 (Spain)

Most studies found improvements of those types of driver behavior that are addressed by the demerit point systems. However, in Canada, the demerit point system was part of an insurance scheme and the effects cannot be interpreted as effects of the demerit point system alone. In Spain, media coverage and a generally improved focus on road safety may have contributed to the improvements. I Norway and in the Arab Emirates, no effects were found.

Effects among individual drivers

Effects on behavior among drivers with demerit points have been investigated in the following studies:

Schade, 2005 (Germany) Montoro & Roca, 2008 (Spain)
Roca & Tortosa, 2008 (Spain)
Stene et al., 2008 (Norway)
Abay, 2015 (Denmark)
Sagberg & Ingebrigtsen, 2018 (Norway)
Sagberg & Sundfør, 2019 (Norway)

Sagberg and Ingebrigtsen (2018) found a U-shaped relationship between the current number of demerit points and the chance of getting new points among individual drivers. The authors explain the relationship in terms of a combination of two effects:

- Habit (more previous violations are related to more future violations)
- Deterrence (more previous violations are related to more future violations).

Most other studies found reductions of the drivers propensity to get new demerit points among those who already had one or more points which is in support of the deterrence hypothesis.

However, according to the German study, drivers with penalty points are more often involved in crashes and violations than drivers without penalty points and larger numbers of penalty points are associated with more crashes and violations. These results support the hypothesis of habitual behavior.

Results from studies that have investigated the relationship between previous and future violations provide most support to the hypothesis of habitual behavior.

More information in the Appendix: Table 52: Demerit point systems – effects on driver behavior

7 Fines and imprisonment

Fines and jail sentences are among the most common sanctions for road traffic law violations, besides license suspension or revocation, both in the USA[2] and in other countries.

In contrast to fixed penalties, administrative license suspension, fines and imprisonment cannot be administered by the police, but only by courts. Fines and imprisonment as standard sentences are often differentiated according to the severity of the offence and previous offences. Imprisonment may be unconditional or on probation. Fines and imprisonment often come in addition to substantial other costs, depending on the type and severity of violation (such as legal fees, license reinstatement, alcohol treatment, increased insurance rates; Goodwin et al., 2015).

There may be large differences between countries regarding penalties and the length of prison sentences. In the USA, jail sentences for DUI are often very short (a few days) while jail sentences for example in Norway are far longer. Moreover, the actual time served in jail is often much shorter than what the offender was sentences to.

In Norway, standard sanctions for driving under the influence of alcohol is 1.5 monthly salaries, for BAC levels between .05 and .12 additionally jail (usually conditional), and for BAC levels above 0.12 additional unconditional jail (at least 21 days). Jail sentences can under certain circumstances be served under home confinement or with an electronic ankle bracelet.

Methodological problems: There are several methodological problems with evaluation studies of fines and imprisonment:

- It is usually difficult or impossible to control for systematic differences between offenders receiving different types of sanction.
- Different types of sanctions are often combined, making it difficult to investigate effects of one specific type of sanction.
- Offence or re-offence rates are only rough measures of actual law violations.
- Jail sentences are on average far longer than the actual time served in jail (Guenzburger & Atkinson, 2014). Most empirical studies are based on sentence length, while not all offenders even serve any time in jail.

7.1 Mandatory minimum fines and imprisonment – general effects

The effects of minimum fines and jail sentences have been investigated in a number of studies that have been summarized in several reviews and meta-analyses:

Elvik et al., 2009
Wagenaar et al., 1995
Wagenaar et al., 2000
Wagenaar et al., 2007

[2] https://dui.drivinglaws.org/resources/state-dui-laws.htm

The general conclusion is that neither mandatory minimum fines nor jail sentences can be expected to have large or long-lasting effects on crashes or drunk driving. In a meta-analysis, Elvik et al. (2009) found no effects, neither on total nor on alcohol-related crashes (based on eight studies from 1991-2007). Wagenaar et al. (2007) conclude that both mandatory minimum sanctions and jail may have some deterrence effect, possibly mainly among young drivers and most likely not among heavy drinkers.

More information in the Appendix: Table 53: Mandatory minimum fines and jail sentences – general effects

7.2 Increasing penalties/fines – general effects

The following studies have investigated effects of increasing penalties for drunk driving on crash numbers:

Hingson et al., 1987 (USA)
Neustrom & Norton, 1993 (USA)
Young & Likens, 2000 (USA)
Briscoe, 2004 (Australia, NSW)
Castillo-Manzano et al., 2011 (Spain)
Novoa et al., 2011 (Spain)
Chang et al., 2012 (USA)

The studies are too heterogeneous for calculating meaningful summary effects.

Most studies found no effects on crashes, regardless of crash severity and alcohol involvement.

Some studies found crash reductions (Hingson et al., 1987; Neustrom & Norton, 1993; Castillo-Manzano et al., 2011). However, these are based on methodologically weak studies and may be due to other factors that are not controlled for. McCartt & Northrup (2003; USA) have investigated effects on drunk driving and found no long-lasting effects.

More information in the Appendix: Table 54: Increasing penalties / fines– general effects

7.3 Penalties vs. jail (general effects)

A study from Norway and Sweden (Ross & Klette, 1995) has investigated the effects of an introduction of differentiated sanctions for DUI. The new sanctions implied that DUI offenders could be punished with fines only, instead of prison, depending on the BAC level. They found a reduction of the number of fatal crashes (-18% [-25; -10]) but no effect on injury crashes (-3% [-8; +2]). The results may be affected by other changes that were not controlled for (for example an increase of police enforcement and the reduction of the illegal BAC limit from 0.05 to 0.02 in Sweden). However, one may conclude that mandatory jail sentences are not always more effective than monetary penalties.

More information in the Appendix: Table 55: Penalties vs. jail – general effects

7.4 Jail vs. other sanctions (specific effects)

The following studies have investigated the specific effects of fines and imprisonment as a DUI sanction:

Caudy et al., 2018 (USA)
de Figueiredo, 2016 (USA)
DeYoung, 1995 (USA)

Green & Winik, 2010 (USA)
Martin, 1993 (USA)
Trevena & Weatherburn, 2015 (Australia)
Villettaz et al., 2006 (review)
Weatherburn & Moffatt, 2011 (Australia)
Weinrath & Gartrell, 2001 (Canada)

All studies have compared effects of different sanctions between otherwise (more or less) comparable offenders.

Most studies found no differences in re-arrest rates, recidivism or reoffending rates among drivers sentenced to jail instead of other sanctions for DUI or drug offences. This includes two studies that have used an experimental design (random assignment of offenders to judges who differ in their use of jail sentences).

Some studies show that jail may be associated with higher re-arrest rates, especially among high risk offenders (Caudy et al., 2018), but also among first-time offenders (DeYoung, 1995).

However, one study found reduced recidivism for longer jail terms (Weinrath & Gartrell, 2001) and Villettaz et al. (2006) conclude, based on a literature review, that methodologically better studies are generally more favorable to jail. However, the review is not limited to road traffic related offences.

There are several possible explanations of a lack of effects of jail sanctions. For drinking drivers, incapacitation is generally more effective than attempts to deter (de Figueiredo, 2016). Jail incapacitates only temporarily and may additionally contribute to "negative peer learning" (de Figueiredo, 2016). Moreover, far from all offenders sentenced to jail, actually serve any jail time and served jail times are often shorter than the sentence. Thus, results from empirical studies do not necessarily say anything about the effects of serving jail time, but rather on the effects of being sentenced to jail (Guenzburger & Atkinson, 2014).

More information in the Appendix: Table 56: Jail vs. other sanctions (specific effects) (overview of results)

More information in the Appendix:

Table 57: Jail vs. other sanctions (specific effects) (detailed results)

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Appendix

V 1. Meta-analysis BAC-level and crash risk: Included studies

Studies included in meta-analysis: Overview

Studies	N of effect estimates	Sum of weights
All crashes	**392**	176 035.9
Ahlm et al., 2009 (Sweden)	1	8.5
Assum et al., 2005 (Norway)	7	49.3
Bogstrand et al., 2012 (Norway)	4	10.6
Borgialli et al., 2000 (USA)	1	81.7
Borkenstein et al., 1964 (USA)	9	2 558.5
Brault et al., 2004 (Canada)	4	76.4
Brubacher et al., 2016 (Canada)	2	64.9
Brubacher et al., 2019 (Canada)	6	117.0
Carvalho et al., 2016 (Brazil)	1	4.7
Chang et al., 2020 (Taiwan)	10	172.9
Chihuri et al., 2017 (USA)	15	1 298.4
Connor et al., 2004 (New Zealand)	9	36.6
Desapriya et al., 2006 (Canada)	2	381.4
Drummer et al., 2004 (Australia)	1	23.4
Drummer et al., 2020 (Australia)	14	90.7
Dubois et al., 2015 (USA)	7	128 111.1
Dussault et al., 2002 (Canada)	11	116.1
Fujita & Shibata, 2006 (Japan)	2	107.3
Gadegbeku et al., 2011 (France)	14	687.4
Gjerde et al., 2013 (Norway)	6	57.9
Harland et al., 2018 (USA)	3	27.2
Hels et al., 2011 (Six European countries)	16	769.0
Holubowycz et al., 1994 (Australia)	1	164.4
Hou et al., 2012 (Taiwan)	2	12.2
Hsieh et al., 2013 (China)	5	230.5
Keall et al., 2004 (New Zealand)	7	2 574.9
Keall et al., 2013 (New Zealand)	8	73.3
Koval et al., 2008 (USA)	2	1 079.8
Krüger & Vollrath, 2004 (Germany)	7	353.4
Kufera et al., 2006 (USA)	5	112.4
Kuypers et al., 2012 (Belgium)	18	217.9
Laumon et al., 2005 (France)	19	960.6
Legrand et al., 2013 (Belgium)	1	46.0
Lenguerrand et al., 2008 (France)	18	884.8
Li & Chihuri, 2019 (USA)	8	1 512.5
Li et al., 2017 (USA)	12	2 285.8
Lillsunde et al., 2012 (Finland)	14	280.1
Longo et al., 2000 (USA)	8	67.2
Lowenstein & Koziol-McLain, 2001 (USA)	2	6.7
Mao et al., 1997 (Canada)	9	1 145.0
Mathijssen, 2005 (Netherlands)	6	14.7
McLean et al., 1980 (Australia)	8	98.6

Studies	N of effect estimates	Sum of weights
Mounce & Pendleton, 1992 (USA)	3	23.4
Movig et al., 2004 (The Netherlands)	6	35.6
Peck et al., 2008 (USA)	4	601.1
Perneger & Smith, 1991 (USA)	12	683.9
Petridou et al., 1998 (Greece)	4	8.4
Poulsen et al., 2014 (New Zealand)	8	63.5
Redelmeier & Manzoor, 2019 (Canada)	2	486.7
Romano et al., 2018 (USA)	9	7 425.6
Santamariña-Rubio et al., 2009 (Spain)	1	9.7
Shyhalla, 2014 (USA)	1	548.4
Siskind et al., 2011 (Australia)	1	15.8
Smink et al., 2008 (The Netherlands)	1	3.9
Terhune et al., 1992 (USA)	6	79.7
Thygerson et al., 2011 (USA)	1	496.6
Voas et al., 2012, 2018 (USA)	11	4 206.9
Woratanarat et al., 2009 (Thailand)	4	15.8
Wu et al., 2014 (USA)	2	182.6
Zador et al., 2000 (USA)	11	14 176.5
MC crashes	**36**	4 107.5
Ahmed et al., 2020 (USA)	2	331.2
Høye et al., 2016 (Norway)	1	0.9
Kasantikul et al., 2005 (Thailand)	3	28.2
Lardelli-Claret et al., 2005 (Spain)	2	89.0
Moskal et al., 2012 (France)	20	2 131.9
Rappole et al., 2019 (USA)	2	62.8
Seesen et al., 2019 (Thailand)	1	17.9
Soderstrom et al., 1993 (USA)	1	6.7
Wiratama et al., 2020 (Taiwan)	2	1 432.6
Wu et al., 2018 (France)	2	6.2
SV crashes	**4**	1 185.6
Behnood Mannering, 2017 (USA)	1	1 082.3
Kim et al., 2013 (USA)	3	103.4
Young driver crashes	**8**	245.5
Lam, 2003 (Australia)	2	187.9
Mura et al., 2003 (France)	6	57.7
SUM	**440**	181 574.5

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V 2. Chapter 1 Introduction: Tables

Impairment and crash risk

Table 7: Impairment and crash risk – Driver age

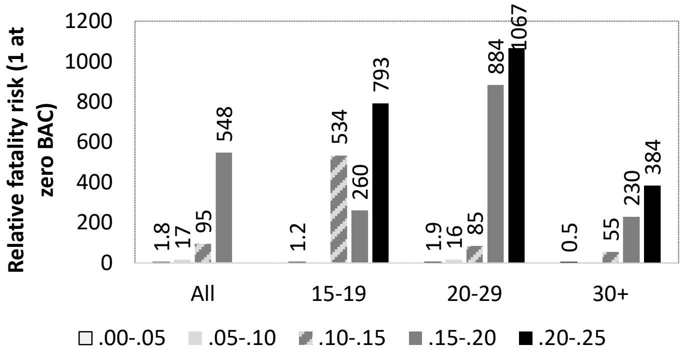
Impairment and crash risk – Drivers: Age	
Keall et al., 2004 (New Zealand)	Risk estimates: Fatally injured vs. non-crash involved drivers. **No consistent relationship** between age and association between BAC-level and relative fatality risk.: 
Kim et al., 2013 (USA)	Risk estimates: Fatally vs. non-fatally injured, BAC pos. vs. neg.. Increasing BAC is associated with **stronger increases** of fatality risk among **younger drivers** than among older drivers. ▪ 16-24 years: OR 3.56 ▪ 25-64 and 65+ years: OR 2.15 / 2.72
Mathijssen, 2005 (Netherlands)	Risk estimates: Fatally vs. non-fatally injured, BAC pos. vs. neg.. Increasing BAC is associated with **stronger increases** of fatality risk among **younger drivers** than among older drivers. ▪ 18-24 years: OR 6.1 ▪ 25-34 years: OR 4.3 ▪ 35-49 years: OR 3.4 ▪ 50+ years: OR 2.6
Peck et al., 2008	Risk estimates: Crash involved vs. non-crash involved drivers Being BAC-positive (.08+) is associated with **stronger increases** of fatality risk among **the youngest drivers** (below 21 years) than among older drivers. Among older drivers, the are no systematic differences between age groups.
Romano et al., 2018 (USA)	Increasing BAC is associated with **stronger increases** of fatality risk among **younger drivers** than among older drivers. Age groups investigated are: 16-21, 22-34, and 35+ years. Risk estimates: Fatally injured vs. non-crash involved.
Zador et al., 2000 (USA)	Increasing BAC is associated with **stronger increases** of fatality risk among **younger drivers** than among older drivers. The increase is mainly due to young males whose risk is almost 50 times as high at BAC above .15 than among drivers over 35 years. Among females, young drivers have only up to 40% higher risk than those above 35.

Table 8: Impairment and crash risk – pedestrian accidents

Impairment and crash risk – Pedestrian accidents	
Campbell et al., 2004 (USA)	Literature review. Studies from around 1990 show that about 40-50% of all fatally injured pedestrians in the US had a BAC at or above .10. ▪ Among fatally injured pedestrians, the greatest prevalence of alcohol was found in the age groups between 15 and 64, especially 25-44 years.

Impairment and crash risk – Pedestrian accidents	
Dultz et al., 2011 (USA)	Injured pedestrians struck by a motor vehicle at Level I trauma center. Alcohol use was associated with ▪ More serious injuries (higher injury severity score and lower Glasgow Coma Scale score) ▪ More crossing of streets against traffic lights or outside crosswalks.
Jang et al., 2010 (USA)	Injured pedestrians in motor vehicle collisions. Alcohol use (pedestrian) is associated with: ▪ Higher risk of serious or fatal injury (+50%).
Harmon et al., 2021 (USA)	Injured pedestrians at ED, seriously vs. non-seriously injured. Alcohol use (pedestrian) is associated with: ▪ Higher risk of serious injury: +249% (+179%; +337%)
Jehle & Cottington, 1988 (USA)	Pedestrians admitted to a trauma center after a collision with a motor vehicle. Those who had been under the influence of alcohol: ▪ On average more serious injuries than those not under the influence of alcohol.
Kim et al., 2008B (USA)	Pedestrians in fatal pedestrian crashes between 8 pm and 12 am. ▪ Pedestrians under the influence of alcohol are 2.5 times (95% CI (1.1; 5.7) as likely of being at-fault in the crash as sober pedestrians. ▪ Male drunk pedestrians have about 50% increased odds of being at-fault, compared to female drunk pedestrians.
Lasota et al., 2020 (Poland)	Injured pedestrians hit by passenger cars. Increasing BAC: ▪ Increasing injury severity according to some severity indicators among female pedestrians. ▪ Otherwise unrelated to injury severity among male pedestrians
Miles-Doan, 1998 (USA)	Population based study, crash involved vs. non-crash involved pedestrians. Compared to sober pedestrians, drunk pedestrians are: ▪ 7.5 times as likely of being killed and ▪ 2.9 times as likely of being killed or seriously injured in a pedestrian-motor vehicle collision as other pedestrians.
Zajac & Ivan, 2003 (USA)	Pedestrian-motor vehicle collisions in which the pedestrian was attempting to cross two-lane highways that were controlled by neither stop signs nor traffic signals. ▪ Statistically significant relationship between alcohol involvement (both among drivers of motor vehicles and among pedestrians) and the pedestrians' injury severity.

Table 9: Impairment and crash risk – bicycle accidents

Impairment and crash risk – Bicycle accidents	
Airaksinen et al., 2018 (Finland)	**Injured cyclists treated at hospital**. Drunk cyclists are more often unhelmeted and have more serious head injuries than cyclists who are not drunk.
Andersson & Bunketorp, 2002 (Sweden)	**Crash involved cyclists**. Factors that are overrepresented among drunk cyclists (compared to non-drunk cyclists): ▪ Night time, weekend ▪ Bing on their way to or from a party or a pub/restaurant, less experience with their route ▪ SV crash ▪ Head or face injury ▪ Less cycling per year, less experience with their bicycle ▪ Bicycles without a hand-brake or gears ▪ No helmet.
Asbridge et al., 2014 (Canada)	**Crash involved cyclists**, alcohol intoxication at the time of the crash and in two crash-free control periods (self-reported, within-subject design). OR for crash involvement with (vs. without) alcohol: **4.0** (1.6; 9.8).
Bíl et al., 2010 (Czech Republic)	**Cyclists** in **bicycle-motor vehicle collisions**, fatal vs. non-fatal injury (adult cyclists). OR for cyclist fatality when the at-fault party in a bicycle-MV collision tested positive for alcohol: +7% (-14; +33).

Impairment and crash risk – Bicycle accidents	
Helak et al., 2017 (USA)	**Cyclists** in **bicycle-motor vehicle collisions**. Cyclists had more severe injuries when the cyclist or the motor vehicle driver had been under the influence of alcohol (adjusted for speed limit, weather, time of day, and helmet use).
Kim et al., 2007 (USA)	**Cyclists** in **bicycle-motor vehicle collisions**, Fatal / KSI vs. other/no injury. OR for **KSI** (vs. other/no injury) when intoxicated: **+127%** (+61; +220) (without control for any other factors) OR for **fatal** (vs. other/no injury) when intoxicated: **+373%** (+187; +678) (without control for any other factors) OR for **fatal** (vs. other/no injury) when intoxicated: +174% (+61; +220) (with multivariate control for other factors)
Li et al., 2001 (USA)	**Fatally or seriously injured cyclists** vs. non-crash involved cyclists (case control study). Adjusted OR of fatal/serious injury among drunk cyclists, compared to BAC < .02: ▪ BAC .02+: **5.6** (2.2; 14.0) ▪ BAC .08+: **20.1** (4.2; 96.3). Drunk cyclists are far more often unhelmeted than non-drunk cyclists.
Martínez-Ruiz et al., 2013 (Spain)	**Crash involved cyclists, culpable vs. non-culpable.** OR for being culpable with (vs. without) alcohol or other drugs (no results for alcohol only): ▪ Culpable in collision with another vehicle: 4.5 (2.4; 8.3) ▪ Culpable in single crash (non-infractor): 5.1 (2.1; 12.3) ▪ Culpable in single crash (non-infractor): 12.3 (6.3; 24.1).
Olkkonen & Honkanen, 1990 (Finland)	**Injured cyclists** (non-fatal) in **motor vehicle and other crashes**, compared to random sample of non-crash involved cyclists. Alcohol (BAC > .01) increases injury risk (OR = **10**). Drunk cyclists mainly pose a danger to themselves, and seldom endanger other road users.
Sethi et al., 2016 (USA)	**Crash involved cyclists**. Multivariate analysis (with control for helmet use and several cyclist and crash related factors): ▪ Alcohol use is associated with more severe injury (Adjusted OR = **2.3** (1.4; 3.7). Factors that are overrepresented among crash involved drunk (vs. non-drunk) cyclists: ▪ No helmet ▪ Single bicycle crash, fallen from bicycle.
Twisk & Reurings, 2013 (Netherlands)	**Injured cyclists**. Cyclists are more often drunk at night and during weekends. Among injured cyclists, the proportion of drunk cyclists is higher in SV crashes (4.9%) than in MV crashes (1.9%).

Table 10: Impairment and crash risk – Combining substances

Impairment and crash risk – Combining substances	
Bogstrand et al., 2012 (Norway)	Comparison of the prevalence of substances in blood samples from injured drivers and from a random sample of non-crash involved drivers in the hospital catchment area. Relative crash risks: 4+ psychoactive substances: 39 (8; 185) Alcohol alone: 36 (13; 99) Non-alcohol substances only (no alcohol): No stat. sign. increase in crash risk **Alcohol and other substance**: **232** (33; 1615)
Chihuri et al., 2017 (USA)	Fatally injured drivers compared to non-crash involved drivers in road-side survey Relative fatality risk: Cannabis alone: 1.5 Alcohol alone 16.3 (14.23, 18.75) **Cannabis + alcohol: 25.1** The combined effect of cannabis and alcohol is **additive**.

Impairment and crash risk – Combining substances	
Dubois et al., 2015 (USA) (not in meta-analysis)	Fatal crash involved drivers, those who had committed at least one "potentially unsafe driving action" vs. those who had not. Relative risk of having committed a potentially unsafe driving action in a fatal crash (vs. not): Cannabis alone: 1.16 Alcohol, each 0.01 BAC unit increase: 1.10 **Cannabis and alcohol**, each 0.01 BAC unit increase (effect over alcohol or cannabis alone): **1.09**
Dussault et al. 2002 (Canada)	Alcohol/drug test results from fatally injured driver and non-crash involved drivers (road-side survey with voluntary testing). Relative fatality risk: Only other than alcohol: 2.4 (1.8; 3.3) Alcohol alone 9.2 (6.8; 12.5) **Alcohol + other 88.2 (37.4; 195.3)**
Gjerde et al., 2011 (Norway)	Fatally injured drivers vs. road-side survey data. Relative fatality risk (with 94% confidence intervals): Psychoactive medicinal drugs 8 (5; 13) Illicit drugs 22 (13; 38) Alcohol only 69 (37; 129) **Alcohol and drugs** (any drug/s) **353** (71; 1762)
Li et al., 2017 (USA)	**Fatal crash involved culpable** vs. fatal crash involved on-culpable drivers. Relative risks of being culpable: Cannabis alone 1.6 [1.4; 1.8] Alcohol only 5.4 [4.9; 5.9] **Alcohol and cannabis 6.4** [5.2; 7.9]
Li & Chihuri, 2019 (USA)	**Fatal crash involved** vs. non-crash involved drivers. Opioids 1.7 [1.4; 2.2] Alcohol only 17.9 [16.2; 19.8] **Alcohol and opioids 21.9** [14.4; 33.3] **No statistically significant interaction** effect was found between alcohol and opioids.
Mura et al., 2003 (France)	Injured vs. non-crash involved drivers, matched by age and gender. Relative injury risks: Cannabis only 2.5 (1.5–4.2) Alcohol only 3.8 (2.1; 6.8) **Alcohol and cannabis 4.6 (2.0; 10.7)**
Poulsen et al., 2004 (New Zealand)	**Culpable fatally injured** vs. non-culpable fatally injured drivers. Cannabis only 1.3 (0.8; 2.3) Alcohol only 13.7 (4.3; 43.8) **Alcohol and cannabis 6.9 (3.0; 16.0)**
Ramaeker et al., 2004 (review) (not in meta-analysis)	In most studies the combined effects of cannabis and alcohol on crash culpability appeared additive, although a weak suggestion of a synergistic effect was also apparent in some.

Incidence of impaired driving

Table 11: Incidence of impaired driving - Non-crash involved drivers – Drunk driving in Norway.

Incidence of impaired driving – Non-crash involved drivers – Drunk driving in Norway	
Bogstrand et al., 2012 (Norway)	0.32% with BAC above legal limit (0.02).
Furuhaugen et al., 2018 (Norway)	0.20% with BAC above legal limit (0.02).
Gjerde et al., 2011 (Norway)	0.22% with BAC above legal limit (0.02). 0.28% with BAC above legal limit (0.02) according to Elvik & Amundsen (2014), based on more detailed information about the results from Gjerde et al. (2011). Among these, 22% had BAC ≥ .10 and 11% had BAC ≥ .15.
Gjerde et al., 2013 (Norway)	0.25% with BAC above legal limit (0.02).
Glad, 1985 (Norway)	0.27% with BAC above legal limit (0.05). Among these, 52% had BAC ≥ .10 and 22% had BAC ≥ .15.

Table 12: Incidence of impaired driving – Non-crash involved drivers – Drug driving.

Incidence of impaired driving – Non-crash involved drivers – Drug driving		
Alcañiz et al., 2018 (Spain)	Stratified random sample of mandatory random road-side tests of illicit drugs. 16.4% of all drivers tested positively for at least one illegal drug. Distribution of substances (alone or in combination):	
	Any substance	**16.4**
	Illicit drugs	
	Cannabis	12.4
	Methamphetamine	3.4
	Amphetamine	2.2
	Cocaine	1.8
	Opiates	0.7
	Prescription drugs	
	Benzodiazepines	0.4

Incidence of impaired driving – Non-crash involved drivers – Drug driving			
Bogstrand et al., 2012 (Norway)	Road side study in 2008-2009, stratified random sample of anonymous and voluntary car/van drivers (unknown refusal rate).		
		Injured (N = 96)	**Non-crash involved (N = 5305)**
	Alcohol		
	Alcohol (total)	11.5 %	0.32 %
	Alcohol and other	4.2 %	0.04 %
	Alcohol only	7.3 %	0.28 %
	Other than alcohol and no alcohol	10.4 %	2.87 %
	Illicit drugs		
	Stimulant drugs	9.4 %	0.47 %
	Cannabis	3.1 %	0.74 %
	Opiates	1.0 %	0.34 %
	Prescription drugs		
	Z-Hypnotics	2.1 %	0.92 %
	Benzodiazepines	7.3 %	0.81 %
	Z-hypnotics include sleeping agents such as zopiclone. In total, 3.2% of all drivers tested positive for at least one substance. Most drivers tested positive for other substances than alcohol and not for alcohol (2.87%), 0.28% tested positive for alcohol only, and 0.04% tested positive for alcohol and at least one other substance.		
Christophersen & Gjerde, 2015 (Norway)	Fatally injured motorcycle riders (2001-2010):		
	Total alcohol and/or drugs	**27.1%**	
	▪ **Alcohol**	**17.4%**	
	▪ **Precription drugs, total**	**7.2%**	
	o Benzodiazepines	5.8%	
	o Diazepam	3.4%	
	▪ **Illicit drugs**	**9.2%**	
	o Amphetamine	5.3%	
	o Cannabis	4.3%	
	o Methamphetamine	3.9%	
Drummer et al., 2007 (Australia)	Random road-side drug tests, voluntary testing in Victoria (Australia).		
	Any drug	**2.4%**	
	▪ Methamphetamine	2.1%	
	▪ MDMA[3]	1.3%	
	▪ Cannabis	0.66%	
	▪ Amphetamines and cannabis	0.60%	
	▪ Alcohol	1.05	

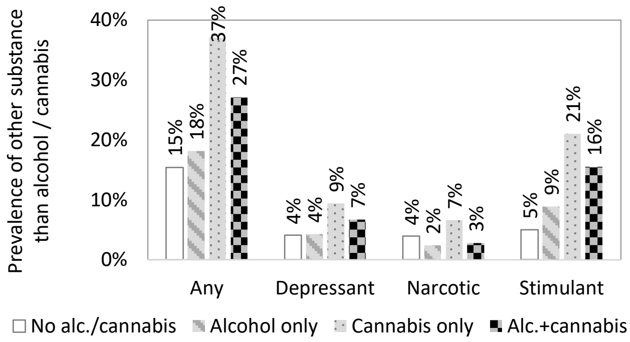
[3] Methylenedioxy-methamphetamine

Incidence of impaired driving – Non-crash involved drivers – Drug driving

Dubois et al., 2015 (USA)

Fatal crash involved drivers, those who had committed at least one "potentially unsafe driving action" vs. those who had not.

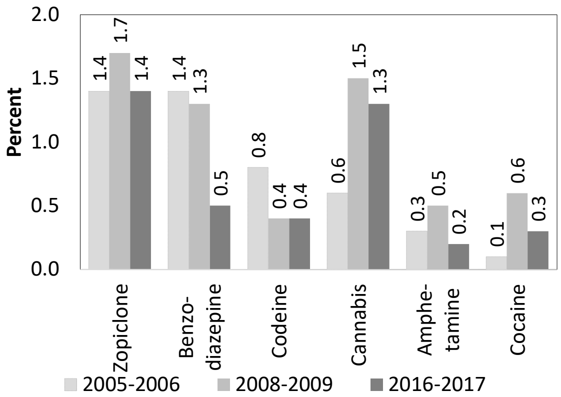
The incidence of other substances than alcohol/cannabis is far higher among drivers who were under the influence of alcohol and/or cannabis than among those who were not under the influence of neither alcohol nor cannabis:



Gjerde et al., 2008, 2013; Furuhaugen et al. 2018 (Norway)

Road side studies with voluntary and anonymous testing in 2005-2006, 2008-2009, and in 2016-2017.

Estimated percentages of all vehicle kilometers driven under the influence of some main categories of substances:



In total, 2.3% of all vehicle kilometers were driven under the influence of prescription drugs and 1.7% under the influence of illicit drugs. Over time, there has been a marked increase of the use of cannabis and a decrease of benzodiazepine.

Jamt et al., 2017 (Norway)

Drivers testing positively for at least one substance among drivers who agreed to a voluntary and anonymous road side tests. Proportions of positive test results:

Any substance	**4.3 %**
▪ Alcohol > 0.01 BAC	0.3 %
▪ Alcohol > 0.02 BAC	0.2 %
Psychoactive medicinal drugs	**2.5 %**
▪ Zopiclone (sleeping agent)	1.1 %
▪ Codeine (analgesic)	0.6 %
Illicit drugs	**1.6 %**
▪ Cannabis	1.1 %

Incidence of impaired driving – Non-crash involved drivers – Drug driving	
Starkey et al., 2017 (New Zealand)	Self-reported use among voluntary survey respondents; all results refer to intake under three hours before driving during the previous 12 months. Most used substances: **Alcohol** **13 %** Strong painkillers 11 % Antidepressants 7 % Anti-nausea medication 4 % Cannabis 4 % Anxiolytics 3 % Other illicit drug 0.1 % Combinations 12 % Combinations of drugs prior to driving were taken by 12%. In most cases, the combinations included painkillers (50%) and/or alcohol (38%).
Valen et al., 2017A (Norway)	Drivers suspected for drug-impaired driving apprehended by the Police, 1990-2015 (“drugs” include both illicit and prescription drugs for which legal limits are defined in Norway): ▪ Two third of all drivers who tested positively for drugs also tested positive for alcohol. ▪ Most drug-positive drivers were men (87%); men were also more often than women under the influence of alcohol in addition to drugs ▪ The most common drugs were: Benzodiazepines 57% Slightly decreasing trend since 2000 Stimulants 51% About unchanged over time; increase among drivers over 40 years Cannabis 34% Increasing trend since 2000, especially among young drivers Opioids 18% Slightly decreasing trend since 2000 ▪ In total, the proportion of drug-positive drivers above 40 years has increased for all types of drugs.
Voas et al, 2013 (USA)	Drivers with non-zero BAC levels: ▪ Are about five times as likely to test positive for illegal drugs ▪ Are also more likely to test positively for prescription drugs, but less than five times (ns difference between illegal and prescription drugs). A number of driver characteristics and the time and place of test are statistically controlled for.

Table 13: Incidence of impaired driving – Crash involved drivers in Norway

Incidence of impaired driving – Crash involved drivers in Norway	
Assum, 2005 (Norway)	Killed or seriously injured drivers in Norway. ▪ Any substance: 32% ▪ Alcohol: 14.9% o Alcohol only: 10.9% (6.9% above BAC .13) o Alcohol and other substance: 4.6% ▪ Other substance: 21.8% o Benzodiazepines alone: 3.4% o Amphetamine alone: 3.4% o Opiates alone: 2.3% o Cannabis alone: 1.1% o Ecstasy alone: 0% o Cocaine alone: 0% o Mix of different substances: 11.6%.

Incidence of impaired driving – Crash involved drivers in Norway	
Bogstrand et al., 2012 (Norway)	Injured drivers; distribution of substances: Any substance 21.9 % Alcohol 11.5 % Stimulant drugs 9.4 % Benzodiazepines 7.3 % Cannabis 3.1 % Z-Hypnotics 2.1 % Opiates 1.0 %
Ponce et al., 2019 (Norway, Brazil)	Fatally injured drivers in Norway, 2005-2015 (most likely the same as in Statens vegvesen (UAG). Percentage of alcohol-positive cases decreased: ▪ From 45.6% to 35.3% in Sao Paulo ▪ From 24.4% to 15.8% in Norway.
Statens vegvesen, 2019 (Norway)	In-depth analyses of fatal crashes in Norway in 2005-2018, conducted by the Norwegian Public Roads Administration. In 22% of all fatal crashes, DUI (including alcohol and drugs) has been a contributing factor: ▪ In about half of these crashes, a driver has been under the influence of alcohol alone ▪ In about 5% of crashes a drivers has been under the influence of drugs alone (illicit or prescription drugs) ▪ In the remaining crashes, a driver has been under the influence of alcohol and drugs.
Statens vegvesen (UAG), 2005-2014 (Norway)	In-depth analyses of fatal crashes in Norway in 2005-2018, conducted by the Norwegian Public Roads Administration. Distribution of alcohol and drugs among fatal crash involved drivers in Norway (2005-2014):  There are large differences between road user groups. In total, the prevalence of DUI is greatest among car drivers and least among heavy vehicle drivers. Alcohol is relatively most prevalent among pedestrians, followed by car drivers. Drugs are relatively most prevalent among heavy vehicle drivers (amphetamine or other stimulants in the majority of cases). Fatal crash involved drivers with illegal BAC levels had more often also been under the influence of other drugs (25%) than drivers who had not been under the influence of alcohol (16%).
Hesjevoll et al., 2022 (Norway)	In-depth analyses of fatal crashes in Norway in 2005-2018, conducted by the Norwegian Public Roads Administration. DUI (alcohol and/or other substances) was a crash contributing factor in 97 out of 372 fatal accidents (26%).

Factors related to DUI

Table 14: Factors related to DUI – Driver age and gender

Factors related to DUI – Driver age and gender	
Drunk driving	
Fabbri et al., 2002 (Italia)	Crash involved injured drivers at an emergency department. Risk of being BAC positive: ▪ Male (vs. female) drivers: 3.08 (2.36; 4.01)
Jamt et al., 2017 (Norway)	Alcohol and illicit drugs (especially cannabis) were strongly overrepresented among male drivers (none of the females was tested positively for alcohol). The relationships between prevalence and age were as follows: ▪ Alcohol: Highest prevalence among drivers 35-44 years ▪ Prescription drugs: Increasing prevalence with increasing age (from close to zero at < 25 years to around 4% at 65 years and above) ▪ Illicit drugs: Highest prevalence at 25-34 years (ca. 5.5%), then declining constantly (0% at 65 years and above).
Maxwell & Freeman, 2007 (USA)	Drivers entering a substance abuse treatment following a DUI offence: Female drivers had on average more serious problems with illicit drugs than males, such as higher levels of impairment, more drug dependence, and more psychiatric disorders.
NHTSA, 2002 (USA)	Fatally injured drivers (all road user group). Intoxicated by alcohol (BAC ≥ 0.10): ▪ 16-20: 15% ▪ 21-24: 27% ▪ 25-34: 24% ▪ 35-44: 22% ▪ 45-64: 14% ▪ 65+: 5% ▪ Male vs. female drivers: 29% vs. 21%. Fatally injured pedestrians: In total 33% were intoxicated by alcohol. ▪ Older pedestrians are underrepresented (65+ years: 9% intoxicated) ▪ Younger pedestrians are overrepresented (25-34 year: 49% intoxicated).
Peck et al., 2008 (USA)	Positive BACs in young drivers (<20 years) are associated with higher relative crash risks than would be predicted from the additive effect of BAC and age. Possible explanations: ▪ Driving skills are more adversely affected by alcohol among young drivers ▪ Other factors related to high crash risk are more likely to be present among younger drunk drivers than among older drunk drivers.
Schwartz & Beltz, 2018 (USA)	Far more drunk driving among male drivers: ▪ Strong decline in male DUI arrests over time (1985-2015), unchanged for females ▪ In 2015, there were about three times as many DUI arrests among male drivers as among female drivers.

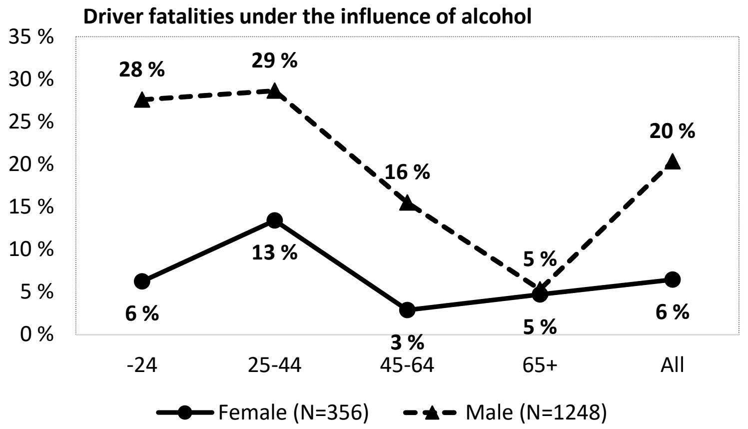
Factors related to DUI – Driver age and gender	
Statens vegvesen (UAG), 2005-2014 (Norway)	In-depth analysis of fatal crashes conducted by the Norwegian Public Roads Administration. Factors overrepresented among fatally injured drivers under the influence of alcohol:  ▪ Males are overrepresented (20% vs. 6% females), except in the oldest age group (65+ years; 5% each) ▪ Young drivers are overrepresented among males (28%/29% young males vs. 6%/13% young females in the age categories 0-24 years / 25-44 years). Among fatally injured car drivers the proportions are similar, but the proportions of drunk drivers in the youngest age groups is still higher (35% among men, 10% among women).
Valen et al., 2017A (Norway)	Most drug-positive drivers were men (87%). Men were also often than women under the influence of alcohol in addition to drugs.
Vehmas et al., 2012 (Finland)	Among all drivers with BAC above the legal limit (.05), 91.3% were male. Among professional drivers with BAC above the legal limit, all were male, most were 30-49 year old; the average BAC was .10.
Yao et al., 2018 (USA)	Crash involved drivers, compared to non-crash involved drivers. ▪ Odds of having BAC ≥ .05 is 38% lower for women than for men.
Drug driving	
Alcañiz et al., 2018 (Spain)	Random sample of non-crash involved drivers, mandatory testing. ▪ Drug driving: 18.4% among male truck drivers, 3.2% among female truck drivers (mandatory testing)
Davey et al., 2014 (Australia)	Random road-side drug tests, voluntary testing. ▪ Male drivers are overrepresented among those with positive drug tests (81% of all positive tests were from male drivers) ▪ Drivers aged 30-39 were overrepresented among those with positive drug tests ▪ Cannabis was more common among younger drivers, methamphetamine was more common among older drivers.
Dubois et al., 2015 (USA)	Fatal crash involved drivers, those who had committed at least one "potentially unsafe driving action" vs. those who had not. ▪ Male drivers are overrepresented among drivers under the influence of cannabis (male drivers: 85% for alcohol and cannabis, 78% for cannabis alone, and 83% for alcohol alone; 64% for alcohol- and cannabis-free drivers) ▪ Drivers under the influence of alcohol+cannabis are youngest (31), followed by cannabis alone (33), and alcohol alone (36); alcohol- and cannabis-free drivers: 46 years.
Jamt et al., 2017 (Norway)	▪ Illicit drugs (especially cannabis) are strongly overrepresented among male drivers. ▪ Prescription drugs: Increasing prevalence with increasing age (from close to zero at < 25 years to around 4% at 65 years and above) ▪ Illicit drugs: Highest prevalence at 25-34 years (ca. 5.5%), then declining constantly (0% at 65 years and above).

Table 15: Factors related to DUI – Road users

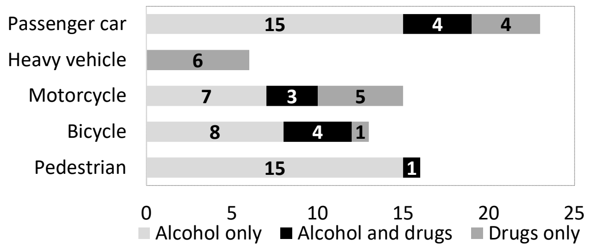
Factors related to DUI – Road users	
Christophersen & Gjerde, 2015 (Norway)	Fatally injured motorcycle riders and car/van drivers. BAC positive: ▪ Motorcycle riders: 27% ▪ Car/van drivers: 40 %.
Drummer et al., 2007 (Australia)	Random road-side drug tests, voluntary testing. ▪ Car drivers: 2.8% positive drug test results ▪ Truck drivers: 1.4% positive drug test results.
Høye et al., 2016 (Norway)	Among fatal crash involved motorcyclists, DUI (alcohol and/or drugs)is strongly overrepresented among those riding unregistered cross motorcycles (57% DUI, compared to 15% in total). Among riders of light motorcycles, only 3% had been under the influence of alcohol and/or rugs. Otherwise, there are no big difference between riders of different types of motorcycle.
Lin & Kraus, 2009 (USA)	Several studies from the USA showed that alcohol is far more prevalent among crash involved motorcycle riders than among other road users in fatal crashes. For example, according to Villaveces et al. (2003), the proportion of alcohol related fatalities was 49% among fatally injured motorcycle riders, compared to 26% among other motor-vehicle related fatalities.
NHTSA, 2002 (USA)	Fatal crash involved drivers with BAC above the legal limit: ▪ Passenger cars: 19% ▪ Light trucks: 20% ▪ Large trucks: 1% ▪ Motorcycles: 27% ▪ Pedestrians (16+ years): 33%
Statens vegvesen, 2005-2014 (Norway)	In-depth analysis of fatal crashes (2005-2014). Fatally injured drivers, percentages under the influence of alcohol and / or drugs: 

Table 16: Factors related to DUI – Heavy vehicle drivers

Factors related to DUI – Heavy vehicle drivers	
Alcañiz et al., 2018 (Spain)	Random sample of non-crash involved drivers, mandatory testing. Significantly higher likelihood of being positive for methamphetamines. Mainly male truck drivers are overrepresented (18.4% drug driving vs. 3.2% among female truck drivers)
Assum & Erke, 2009 (Norway)	Random sample of non-crash involved drivers, mandatory testing. Extremely low prevalence of drunk driving among heavy vehicle drivers. Only one of 2836 tested drivers had a BAC above the legal limit of 0.02. Among fatal crash involved heavy vehicle drivers, it is estimated that between zero and 1.21% have BAC above 0.02.
Drummer et al., 2007 (Australia)	Random road-side drug tests (non-crash involved drivers), voluntary testing. ▪ Car drivers: 2.8% positive drug test results ▪ Truck drivers: 1.4% ositive drug test results.
Lemire et al., 2002 (Canada)	Random sample of non-crash involved heavy vehicle drivers; voluntary testing (4% refused). Alcohol: 0.29% (0,22% with BAC 0.02-0.08, and 0.07% above 0.08 BAC). Illicit drugs: Cannabis 4.9%; amphetamine 2.9%; cocaine 1.4%.

Factors related to DUI – Heavy vehicle drivers	
Lund et al., 1988 (USA)	Random sample of non-crash involved heavy vehicle drivers, voluntary testing (12% refused). Stimulants: 19% of tested drivers tested positively for stimulants. Alcohol (alone or in combination with other substances): Below one percent of drivers.
NHTSA, 2002 (USA)	Fatal crash involved drivers: Only 1% of large truck drivers had BAC above 0.10 (vs. 18% of all drivers).
Rowden et al., 2011 (Australia)	Roadside drug tests (mandatory tests during the first four years after introduction of drug driving law according to which it is an offence to operate a vehicle with measurable amounts of cannabis, methamphetamine, or MDMA in the blood. ▪ Car drivers, positive test results: 3.2% (2007), 2.1% (2008-2010); most common drugs: methamphetamine (40 % of all positive test results) and cannabis (44%). ▪ Truck drivers, positive test results: 2.1% (2007), 1.2% (2008-2010); most common drug: methamphetamine (78% of all positive test results).
TISPOL, 2009 (21 European countries)	Police enforcement, heavy vehicle drivers. Alcohol: 0.19% of drivers tested positively (above the legal limit of the respective country).
Vehmas et al., 2012 (Finland)	BAC above legal limit (0.05): ▪ Heavy vehicle crashes: 2.5% ▪ Cars/vans in professional use: 6%.

Table 17: Factors related to DUI – Other factors

Factors related to DUI – Other factors	
Factors related to DUI – Socioeconomic status	
Campos et al., 2013 (Brazil)	Road side survey and voluntary breath testing (16% refused breath test). High income is associated with about 70% reduced odds of an illegal BAC-level.
Ferguson et al., 1999 (Australia)	Low socio-economic background, low education, blue collar occupation are overrepresented among recidivist drunk drivers.
Yao et al., 2018 (USA)	Crash involved drivers, compared to non-crash involved drivers. Odds of having BAC ≥ .05 is about the same for employed as for unemployed drivers.
Factors related to DUI – Other traffic violations	
Ferguson et al., 1999 (Australia)	**Literature study**. Drunk drivers have more previous traffic violations, alcohol related crashes, single vehicle crashes, and malicious behavior convictions.
Høye et al., 2016 (Norway)	**Fatal crash involved motorcycle riders**, 2005-2014. Riders who had been charged or convicted for at least one traffic related criminal offence during the last ten years before the crash, were more often under the influence of alcohol and/or drugs at the time of the crash (24%) than those who had no previous criminal charges/convictions (4%). Among those charged or convicted for traffic related and no other offences, only 9% under the influence of alcohol and/or drugs at the time of the crash. In summary, being convicted for previous traffic related criminal offences is positively related to DUI crash involvement, but other than traffic related criminal charges/convictions are a far stronger predictor.
Kasantikul et al., 2005 (Thailand)	**Crash involved MC riders.** Factors that are overrepresented in alcohol-related crashes: ▪ Traffic signal violations ▪ Inattention.

<table>
<tr><th colspan="2"><u>Factors related to DUI – Other factors</u></th></tr>
<tr><td>Romano & Voas, 2011 (USA)</td><td>Fatally injured drivers in single vehicle crashes.
Compared to drivers with zero BAC, drivers with a BAC of 0.08 or more were
4.2 times as likely to have been speeding
2.8 times as likely not to have used the seat belt
2.4 times as likely to have been inattentive
1.6 times as likely to have failed to obey/yield.
Drivers with a BAC between 0.05 and 0.08 were
2.3 times as likely to be speeding
1.8 times as likely not to have used the seat belt.</td></tr>
<tr><td>Soderstrom et al., 1993 (USA)</td><td>Injured motorcycle riders: BAC-positive riders
Were more often than others impaired by other substances than alcohol (29% vs. 7%), speeding (74% vs. 58%), or driving recklessly (68% vs. 44%).es (53% vs. 29%)</td></tr>
<tr><th colspan="2">Factors related to DUI – Seat belt use</th></tr>
<tr><td>NHTSA, 2002 (USA)</td><td>Fatally injured drivers: Seat belt use among fatally injured drivers decreases with increasing BAC levels; sober drivers 51%, impaired drivers (BAC 0.01-0.09) 32%, intoxicated drivers (BAC 0.10+) 22%.</td></tr>
<tr><td>Kweon & Kockelmann, 2010 (USA)</td><td>An increasing number of drinks per drinking day and an increasing number of days with drinking and driving during the past 30 days is significantly related to reduced seat belt use.</td></tr>
<tr><td>Romano & Voas, 2011 (USA)</td><td>Fatally injured drivers in single vehicle crashes with a BAC of 0.08 or more were 2.8 times as likely not to have used the seat belt than fatally injured sober drivers in single vehicle crashes.</td></tr>
<tr><th colspan="2">Factors related to DUI – Criminal history</th></tr>
<tr><td>LaBrie et al., 2007 (USA)</td><td>Convicted DUI offenders with a criminal history of crime against people were found to have about twice as high recidivism rates as those who had committed DUI-offences only.</td></tr>
<tr><td>Hubicka et al., 2008 (Sweden)</td><td>DUI suspected drivers, voluntary survey. Drivers with criminal offences (selr-reported) during the preceding five years:
64% all criminal offences, including traffic violations
40% non-traffic related criminal offences.
No comparisons (non-DUI drivers) are available, but an average driver has probably fewer criminal offences.</td></tr>
<tr><td>Høye et al., 2016 (Norway)</td><td>Fatal crash involved motorcycle riders, 2005-2014.
Riders who had been charged or convicted for criminal offences during the last ten years before the crash, were far more often under the influence of alcohol and/or drugs at the time of the crash (27%) than those who had no previous criminal charges/convictions (4%). Among those charged or convicted for other than traffic related offences, even more were under the influence of alcohol and/or drugs at the time of the crash (33%)
Among riders accused or convicted for offenses related to illicit drugs (including possession and sales, as well as DUI, amongst other things), far more had been riding under the influence of alcohol and/or drugs at the time of the crash (56%) than among riders not previously accused or convicted for offenses related to illicit drugs (11%).
In summary, previous criminal behavior in general is a predictor for DUI. Previous criminal charges related to illicit drugs are an even stronger predictor.</td></tr>
<tr><th colspan="2">Factors related to DUI – Alcohol problems and addiction</th></tr>
<tr><td>Baker et al., 2002 (USA)</td><td>Fatally injured drivers (N = 818).
The proportion of drivers who had at least one indicator of potential problem drinking increases with increasing BAC-level at the time of the crash:<table><tr><td>BAC .15+</td><td>68%</td></tr><tr><td>BAC .10 - .14</td><td>41%</td></tr><tr><td>BAC .01 - .09</td><td>32%</td></tr><tr><td>BAC .00</td><td>7%</td></tr></table></td></tr>
</table>

Factors related to DUI – Other factors	
Campos et al., 2013 (Brazil)	Road side survey and voluntary breath testing (16% refused breath test). Drunk drivers have about twice as often a regular weekly drinking pattern than other drivers.
Charlton et al, 2010 (review)	Drivers with alcohol dependency have on average between 2.1 and 5.0 times as high crash risk as other drives.
Dow et al., 2013 (review)	Drug abuse is on average related to an increase of crash risk by 32%.
Dunn et al., 1997 (USA)	Patients with an **alcohol problem** are nearly five times more likely to **die in motor vehicle crashes** than patients without alcohol problems (cited from Solomon et al., 2009).
Fell, Tippetts & Voas, 2010 (USA)	About half of all drivers arrested for DUI are problem drinkers, repeat offenders, or hardcore drinking drivers.
Ferguson et al., 1999 (Australia)	Among DUI convicted drivers, the following problems are overrepresented: ▪ Regular alcohol consumption and alcohol problems ▪ "Deviant attitudes" to drunk driving and a social context that is supportive of drunk driving
Ferguson, 2012 (USA)	Among "hard core" drinking drivers, far from all have alcohol problems or are otherwise socially deviant. A hard core drinking driver is one who drives with BACs of 0.15 g/dL or higher, or one with more than one alcohol-related offense. The majority of alcohol impaired drivers involved in fatal crashes have no prior DUI convictions are not regarded as problem drinkers
Flowers et al., 2008 (USA)	About half of all drivers arrested for DUI are problem drinkers, repeat offenders, or hardcore drinking drivers. This proportion was substantially higher than among drivers killed in traffic crashes with a BAC above 0.15. Both binge drinking and heavy drinking are strongly associated with drunk driving.
Hedlund & McCartt, 2002 (USA)	23% of all drunk drivers have alcohol problems (vs. 5% among all drivers). Drivers with alcohol problems account for 41% of all drunk driving trips in the US in 1999.
Valencia-Martín et al., 2008 (Spain)	The frequency of **traffic crashes increased progressively across categories of alcohol consumption** (with non-drinkers as the reference category): a. Moderate drinkers with no binge drinking b. Moderate drinkers with binge drinking c. Heavy drinkers with no binge drinking d. Heavy drinkers with binge drinking (only statistically significant category; OR 2.01 [1.00; 4.09]).
Vaa, 2003 (review)	Drivers with alcohol dependency have on average at least twice as high crash risk as other drives.
Yao et al., 2018 (USA)	Heavy drinkers without diagnosed alcoholism drive far more often with illegal BAC limits, especially at night. Drivers with alcoholism are less often involved in crashes than other drivers, most likely because they are driving less. Crash risk can be expected to be higher.
Factors related to DUI – Crash types	
Ahlm et al., 2009 (Sweden)	Fatally vs. non-fatally injured drivers. BAC-positive drivers were on average more often involved in SV crashes than sober drivers. Percentages of BAC-positive drivers: ▪ Fatally injured: 56% (SV) vs. 13% (MV) ▪ Non-fatally injured: 28% (SV) vs. 7% (MV).
Christophersen & Gjerde, 2015 (Norway)	Fatally injured motorcycle riders, 2001-2010 (N = 207). Prevalence of alcohol (BAC ≥.02) by crash type: ▪ Single vehicle crashes: 45% ▪ Multi-vehicle crashes: 15%.
Høye et al., 2016 (Norway)	Fatal crash involved motorcycle riders, 2005-2014. Riders who had been under the influence of alcohol were far more often than others involved in SV crashes than sober riders.

Factors related to DUI – Other factors	
Kasantikul et al., 2005 (Thailand)	Crash involved MC riders. Alcohol-impairment is overrepresented in: ▪ SV crashes, loss of control ▪ Non-intersection collisions ▪ Inattention related crashes.
Soderstrom et al., 1993 (USA)	Injured motorcycle riders: BAC-positive riders ▪ Were more often than others involved in SV (vs. MV) crashes (53% vs. 29%)
Statens vegvesen, 2005-2015 (Norway)	61% of all fatal crashes in which the driver was under the influence of alcohol or other drugs were single vehicle off-road crashes.
Factors related to DUI – Time of day and week	
Fabbri et al., 2002 (Italia)	Crash involved injured drivers at an emergency department. Risk of being BAC positive: ▪ Nighttime: 3.48 (2.46; 4.91) ▪ Weekend nights: 1.21 (1.05; 1.41)
Kasantikul et al., 2005 (Thailand)	Crash involved MC riders. Alcohol-impairment is overrepresented in: ▪ Nighttime ▪ Weekend ▪ Rider on his way home.
NHTSA, 2000 (USA)	Alcohol involvement by time of day/week: ▪ Fatal crashes: Night-time 61% vs. daytime 18% ▪ All crashes: Night-time 17% vs. daytime 4% ▪ Fatal crashes: Weekend 53% vs. other days 30% ▪ All crashes: Weekend 15% vs. other days 6%.
Factors related to DUI – Vehicle age	
Statens vegvesen, 2005-2013 (Norway)	In-depth analyses of fatal crashes, 2005-2013. Drunk drivers involved in fatal crashes on average are driving older cars (13.0 years on average) than other drivers involved in fatal crashes (10.3 years on average). Relationship between vehicle age and proportion of fatal crashes in which a driver was under the influence of alcohol or drugs:

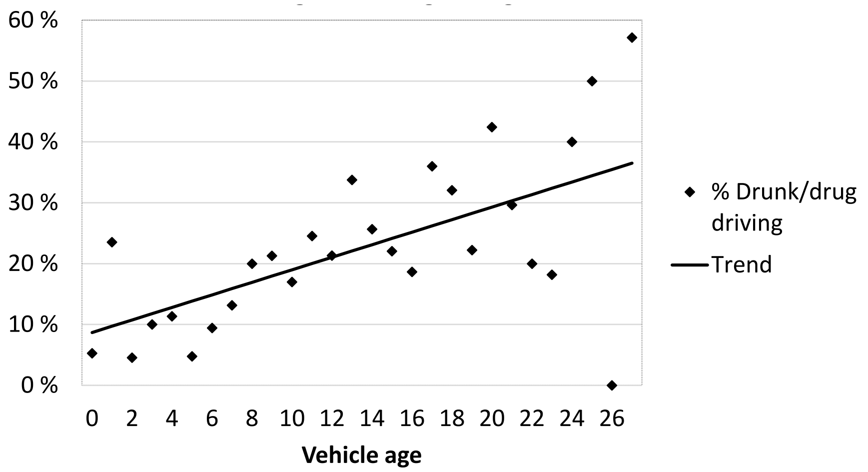


Table 18: Factors related to repeat offending

Factors related to repeat offending	
Baca et al., 2001 (USA)	Among convicted drunk drivers (N = 4993), reoffending could be predicted relatively well based on these risk factors: ▪ Younger age ▪ Few years of education ▪ Higher BAC at first arrest ▪ Results from a self-report instrument for assessing alcohol-related problems and a personality test. There were also more reoffenders among male convicted drunk drivers than among females.
Bishop, 2011 (USA)	Predictors of DUI recidivism: ▪ Scores on Driver Risk Inventory (DRI), scales alcohol risk, driver risk and drug risk ▪ DSM-IV substance abuse and dependence classifications.
Christophersen et al., 2002 (Norway)	Norwegian DUI offenders who reported driving under the influence of illicit drugs had twice the re-arrest rate of drunken drivers.
Ferguson et al., 1999 (literature review)	Factors overrepresented among recidivists are: ▪ Young (18-24 years) ▪ Male ▪ Low socio-economic background, low education, blue collar occupation ▪ Single or divorced, low self-esteem. High BAC-levels at first arrest were previously considered to be a predictor of recidivism, but this is probably not the case because high BAC occurs not only among heavy problem drinkers, but also among people who binge drink occasionally.
Fu, 2008 (USA)	Relative risks for repeat DUI crashes: Male (vs. female) 2.11 Age (vs. under 21) 21-24 0.83 25-34 0.69 35-44 0.82 45-54 0.62 55+ 0.47 Previous violations 1.93 Hit and run 1.67
Hedlund & McCartt, 2002 (USA)	Some repeat offender facts: ▪ Repeat offenders and drivers with high blood alcohol levels contribute prominently to the problem. ▪ About one-third of all drivers arrested or convicted of DWI are repeat offenders.
Hubicka et al., 2008 (Sweden)	Literature review. Risk factors for DUI and recidivism: ▪ Psychiatric problems ▪ Alcohol abuse, heavy drinking patterns ▪ Poor driving history, unlicensed driving ▪ Non-traffic related offenses, violent crime ▪ High BAC-levels
Holmgren et al., 2008 (Sweden)	About 14% of all first-time DUI offenders are rearrested (up to 10 times). Men are more often reoffending: Among male DUI offenders, 7.9% are reoffenders, compared to 0.6% among women. Men were re-arrested on average 2.5 times compared with 2.3 times for the women ($p > 0.05$). 93% of multiple offenders are men vs. 89% of all first offenders. Drug drivers who had been under the influence of illicit drugs, especially at high levels, were found to be rearrested far more often than drunk drivers (68% vs. 14%). Those under the influence of prescription drugs were rearrested about as often as drunk drivers (17%). The blood concentration of amphetamine was twice as high among reoffenders as among first-time offenders.

Factors related to repeat offending	
Keating et al., 2019 (USA)	Repeat DUI offenders have on average more and more serious psychiatric disorders, both during the last year and lifetime. The number of positive screens was more predictive of repeat DUI than specific diagnoses.
Lapham et al., 2006 (USA)	Repeat DUI offenders are generally resistant to successful rehabilitation.
Møller et al., 2015 (Denmark)	Factors related to recidivism among persons involved in a drunk driving incident, results from logistic regression: ▪ Male ▪ Age between 30 and 60 ▪ Not living with a partner ▪ Not living in Copenhagen ▪ Only basic education ▪ Below median income ▪ Unemployment.
Nochajski and Stasiewicz, 2006 (USA)	Literature review. Factors related to reoffending: ▪ Male ▪ Young ▪ Low level of education, unemployment ▪ Unmarried, divorced, or widowed ▪ Poorer driving records: Prior DUI offences, crashes, and traffic violations ▪ Prior non-traffic related criminal offences ▪ Use of illicit drugs ▪ Psychiatric problems. Regarding BAC-level at the time of arrest, results from different studies are inconsistent. Repeat offenders are generally more resistant to interventions than first-time offenders.
Purssell et al., 2010 (Canada)	Proportions of drivers with subsequent drunk driving convictions or a new drunk driving crash after involvement in a crash in which the driver has been injured: ▪ BAC above 0.08 at the time of the crash: 31% ▪ BAC .01 - .08: 24% ▪ BAC .00: 7% Being injured in a motor vehicle crash while being drunk does not seem to deter from subsequent drunk driving.
Rauch et al., 2010 (USA)	Arrest rates for drivers with different numbers of arrests prior to the study period: ▪ No prior arrests: 3.4 ▪ One prior arrest: 24.3 ▪ Two prior arrests: 35.9 ▪ Three or more prior arrests: 50.8. Drivers with more prior arrests are on average arrested more often in the future than drivers with fewer prior arrests.
Robertson et al., 2009 (USA)	Factors associated with higher re-arrest rates: ▪ Male ▪ Young (under 30 years) ▪ Lower level of education (weak relationship) ▪ Prior DUI conviction ▪ Alcohol problems / addiction
Shaffer et al., 2007 (USA)	Repeat DUI offenders evidenced, compared with the general population, higher lifetime and 12-month prevalence of: ▪ Alcohol use and drug use disorders ▪ Conduct disorder ▪ Posttraumatic stress disorder ▪ Generalized anxiety disorder ▪ Bipolar disorder. Almost half qualified for lifetime diagnoses of both addiction (i.e., alcohol, drug, nicotine, and/or gambling) and a psychiatric disorder.

Factors related to repeat offending	
Statens vegvesen (UAG), 2005-2013 (Norway)	In-depth analysis of fatal crashes (2005-2013)Fatal crash involved drivers with illegal BAC levels had more often also been under the influence of other drugs (25%) than drivers who had not been under the influence of alcohol (16%).

V 3. Chapter 2 DUI Legislation: Tables

BAC limits

Table 19: BAC limits

DUI -legislation – BAC limits	
Per se laws	
Reviews and meta-analyses	
Elvik et al., 2009 (meta-analysis)	Based on eight studies, fatal crashes are reduced by 6% (-7; -5) The result refers to introduction of a .10 law or reducing the BAC limit from .10 to .08. Time trends and effects of other DUI laws are controlled for in all studies and the results are unlikely to be affected by publication bias. The results may be affected by endogeneity, i.e. the introduction of per se BAC laws was more likely in states with initially higher proportions of fatal accidents involving alcohol than in other states. Results from individual studies are inconsistent with regard to differential effects on drivers with different BAC levels.
Grant, 2010b (literature review)	Effects of per se BAC limits in earlier studies were more favorable than in later studies. Based on studies from all years, 1983-2004, the overall effect of a per se .08 BAC limit is a non-significant reduction of fatality numbers by about 1%. More favorable effects were also found in earlier studies of other DUI-laws (minimum legal drinking age and zero tolerance laws), compared to later studies of these laws. Possible explanations for less favorable effects in later studies are larger data bases, improved methods, the inclusion of states that adopted the laws less voluntarily, and longer included time periods (and decreasing effects over time).
Tippetts et al., 2005 (time-series / meta-analysis)	The effects of the introduction of the .08 law in 18 states and the District of Columbia from 1982 to 2000 was studied with time-series analysis and meta-analytic techniques, with control for relevant confounding factors (such as administrative license suspension/revocation and safety belt laws, and economic conditions). Estimated effect on drunk-driving fatal crashes: -14.8% (statistically significant). Per se BAC laws are most effective in states with: ▪ Administrative license suspension/revocation laws ▪ Frequent sobriety checkpoints.
Other studies	
French & Gumus, 2015 (USA)	0.08 BAC limits have increased hit-and-run traffic fatalities by 13-16 percent. The most likely explanation is that intoxicated drivers increasingly flee a crash scene because DUI sanctions often are more severe than non-DUI hit-and-run penalties.
Reduced BAC limit: .08 to .05	
Albalate, 2006 (eight EU countries)	Crash reductions between 0% and 6% in the individual countries (Austria, Belgium, Danmark, Germany, Greece, Spain, France, Italy) Summary effect on all fatal crashes for eight countries: -4% (-10; +2). Practically the same effect with and without additional introduction of random breath testing. The effects of the BAC limit changes were detectable only after a time lag of two years.
Bartl & Esberger, 2000 (Austria)	DUI-related crashes decreased by 10% (-14; -6). The effect was greater among novice drivers (-31%) than among experienced drivers (-6%). At the same time as the BAC limit was reduced, more severe sanctions were introduced and the number of BAC tests conducted by the police increased. It is therefore likely that the change in the number of alcohol accidents is not due to the changed BAC limit alone.
Blais et al., 2015 (Canada) *Not included in summary effect reported above.*	DUI-related driver fatalities decreased statistically significantly among drivers with all DUI-levels. The decrease was slightly smaller for drivers with BAC ≥ .08 and BAC ≥ .15 than among drivers with BAC ≥ .05. Among drivers with BAC = .00, driver fatalities increased (statistically significant effect, about the same absolute size as for drivers with BAC ≥ .05). Level of DUI-related offences were about unchanged.

DUI -legislation – BAC limits	
McLean et al., 1995 (Adelaide, Australia) *Not included in summary effect reported above.*	Short lived reduction in the percentage of late night drivers with BAC .08+. No effects on the proportion of fatally injured drivers with BAC .08+. Although no effects could be detected, the reduced BAC limits may have contributed to the general downward trend of both late night and fatally injured drivers with BAC levels above .08.
Mercier-Guyon, 1998 (France) *Not included in summary effect reported above.*	Alcohol-related crash fatalities decreased by about 36%. Cited from Fell & Voas (2006); unknown whether trend or confounding factors are controlled for.
Smith, 1988; Homel, 1994; Henstridge et al., 1995 (Australia)	The summary effect from all three studies is a crash reduction (all crashes, regardless of severity) by 11% (-14; -9).
Bernhoft & Behrensdorff, 1998 (Denmark)	DUI injury crashes decreased by 8% (-16; -1). For DUI fatal crashes, a non-significant increase was found (-24 [-3; +58]). Drivers reduced the average number of drinks they allowed themselves two hours before driving. Among DUI-offenders, average BAC levels decreased.
DUI Legislation – BAC limits –BAC limits below .05	
Andreuccetti et al., 2011 (Brazil)	**.06 to .02** (and increased enforcement) Fatalities decreased 7-16%, injury numbers decreased by about 2%. Increased enforcement may have contributed to the crash reductions. Crash reductions were maintained only as long as the increased enforcement was maintained (Madruga et al., 2011).
Assum, 2010 (Norway)	**.05 to .02** DUI-related fatal crashes (proxy): +9% (-9; +30). The proportion of drivers who state that they won't drink before driving, increase from 82% to 91%. However, the results do not indicate changes in drinking-and-driving intentions at BAC-levels above .05.
Borschos, 2000 (Sweden)	**.05 to .02.** Additional measures: Limit for aggravated drunk driving reduced from 0.15 to 0.10 and increased sanctions for aggravated drunk driving; additionally, the number of random breath tests was doubled (Glad & Vaa, 1997). Reduced BAC limit (.05 to .02): ▪ Fatal crashes: -10% (-18; -1) ▪ Injury crashes: -10% (-19; +1) Reduced limit for aggravated DUI: ▪ Fatal crashes: -13% (-21; -4) ▪ Injury crashes: -6% (-16; +4).
Nagata et al., 2008 (Japan)	**.15 to .03** (and increased penalties to the tenfold and increased penalty points). DUI injury crashes: -25% (-27; -23) DUI fatal crashes: -23% (-32; -13). Adjustment for trend, but not for changed penalties or other potential confounding factors.
Norström & Laurell, 1997 (Sweden)	**.05 to .02.** (same as Borschos, 2000). ▪ All crashes: -7% ▪ SV crashes: -11% ▪ Fatal crashes: -10%. Results may be affected by confounding factors and a part of a general downward trend of crash numbers.
Desapriya et al., 2007 (Japan)	**.15 to .03** (and increased penalties to the tenfold and increased penalty points). Slightly larger effects among young drivers (-40% fatal DUI crashes) than among adult drivers (-34% / -35% for female / male drivers, respectively). Crash effects are greater than in the other Japanese study (Nagata et al., 2006), most likely because of a weaker study design.

DUI -legislation – BAC limits	
Otero & Rau, 2017 (Chile)	**.05 to .03** DUI-related crashes: -32% (38; -26) (controlled for trend, gas sales, and enforcement) Effects decreased over time. Average BAC-levels among arrested drivers decreased, except in the upper percentiles. this indicates that the reduced BAC limit has not been a deterrent for heavy drinkers.

Table 20: DUI Legislation – Minimum legal drinking age (MLDA)

DUI Legislation – Minimum legal drinking age (MLDA)	
Increased minimum legal drinking age	
Chang et al., 2012 (USA)	State level study, eight alcohol related policies. Dependent variable: Alcohol related fatality rate (relative to total fatalities; not specified by age group). Control for other alcohol policies, population, speed limit, economic factors. Effects of MLDA: ▪ Most effective policy for reducing alcohol-related fatalities (besides zero-tolerance). ▪ Total fatalities: No statistically significant effect (reduced).
Elvik et al., 2009 (Meta-analysis)	Meta-analysis of 10 studies that have investigated effects on crashes of increased MLDA: Naor & Nashold, 1975 Ferreira & Sicherman, 1976 Brown & Maghsoodloo, 1981 Wagenaar, 1982 Hingson et al., 1983 Cook & Tauchen, 1984 Males, 1986 Dyke & Womble, 1988 Eisenberg, 2001 Voas et al., 2003 Most studies have controlled for accidents involving drivers not directly affected by the legal changes. These studies have found a significant decrease of the ▪ Total number of accidents involving drivers in the relevant age groups: -16% (-24; -7) ▪ Accidents involving vs. not involving alcohol: No significant differences.
Grant, 2010B (review and meta-analysis)	Review and meta-analysis of 70 studies of the effects of MLDA on crashes Summary effects: ▪ Studies from all years (1978-1988): Fatalities -3% ▪ Later studies (1985-1988): Fatalities about unchanged. Earlier studies found more favorable effects of increasing the MLDA than later studies. Earlier studies were based on crash statistics from fewer years and methodologically for the most part weaker than the later studies. Later studies are more often based on data from states that that adopted a MLDA of 21 involuntarily.
O'Malley & Wagenaar, 1991 (USA)	Higher MLDA is associated with lower levels of alcohol use among young drivers.
Shults et al., 2001 (review)	Review of published journal articles of the effects of a MLDA of 21 years. 33 effect estimates from 29 studies are included in the review. Results are reported as median effects and ranges of effect sizes: ▪ Fatal crashes (nine effect sizes): -17% (-30; -7) ▪ Injury crashes (four effect sizes): -15% (-33; -21).
US General Accounting Office (1987; cited from Hedlund et al., 2001)	Review and synthesis of 49 studies of the effects of a minimum legal drinking age of 21. Increased MLDA has reduced drinking, drunk driving, and alcohol related crashes among young drivers.

DUI Legislation – Minimum legal drinking age (MLDA)	
Voas, Tippetts, & Fell, 1999 (USA)	Multi-state study. MLDA 21 years: ▪ Alcohol-related fatal crashes: -19% (-33; -1)
Wagenaar & Toomey, 2002 (Review)	Review of peer-reviewed published studies of the effects of a MLDA of 21 years (increase or decrease of MLDA; 102 effect estimates from 57 studies). 51% of all effect estimates indicate a statistically significant inverse relationship between MLDA and crashes and 12% a non-significant inverse relationship. Only 2 effect estimates indicate a positive relationship. MLDA and alcohol consumption (33 studies): 33% of studies found an inverse relationship while only one study found the opposite.
Reduced minimum legal drinking age	
Elvik et al., 2009 (Meta-analysis)	Summary effect of a reduction of the minimum legal drinking age 21 to 18 years in several states of the USA, based on three studies from 1975-1981: ▪ Crashes involving drivers in the relevant age group: +22% (+6; +40).
Shults et al., 2001 (review)	Review of published journal articles. Results are reported as median effects and ranges of effect sizes: ▪ Fatal crashes (three effect sizes): +8% (+2; +38) ▪ Injury crashes (four effect sizes): +5% (-2; +22).

Availability of alcohol

Table 21: Availability of alcohol - Alcohol consumption and drunk-driving crashes

Availability of alcohol - Alcohol consumption and drunk-driving crashes	
Arranz & Gil, 2009 (Spain)	Crash prediction models for fatal crashes in Spain in 1998-2002. Increase of alcohol consumption by 1% is associated with an increase of total crash fatalities by 0.305%.
Dang, 2008 (USA)	Contribution of several factors to the decrease of the proportion of drunk drivers in fatal crashes (from about 30% in 1980 to 23-34% in 1998 and then almost unchanged until 2005): ▪ 4% of the decrease were due to decreased per capita alcohol consumption (especially beer). ▪ Other contributing factors: 56% of the decrease are due to demographic factors, and 41% of the decrease are due to state alcohol laws.
French & Gumus 2015 (USA)	State level data, 1990-2010, fatal crashes. Statistically significant relationships of alcohol consumption per capita to hit-and-run and other crashes. The relationship is stronger for hit-and-run crashes (coefficients around 1.6) than for other crashes (coefficients around 1.16).
Hosseinichimeh et al., 2022 (USA)	State level data, 1985 to 2019, fatal crashes. Statistically significant relationships of alcohol consumption per capita to fatal crashes.
Kalsi et al., 2018 (Finland)	Alcohol taxes were reduced by about 33% on average in 2004. Alcohol consumption increased by 12.4% from 2003 to 2005 and there was a strong negative correlation between alcohol prices and consumption. There were strong negative correlations between alcohol consumption and the total number of fatal crashes and between alcohol prices and the total number of fatal crashes. The results cannot be interpreted as causal effects because confounding factors are not controlled for and because the results refer to all fatal crashes and not specifically to alcohol related crashes.
Kaplan & Prato, 2007 (USA)	State level analysis, 1990-2004, statistic control for BAC-limit, ALR-laws, unemployment rate and traffic volume. Alcohol consumption per capita is positively related to fatalities and total crashes. The relationship is: ▪ Stronger among male drivers than among female drivers ▪ Strongest among elderly drivers, followed by young drivers, weakest among other adult drivers.

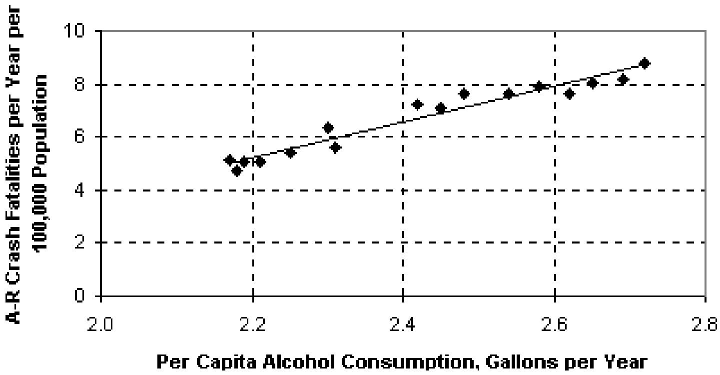
Availability of alcohol - Alcohol consumption and drunk-driving crashes	
NHTSA, 2001 (USA)	USA, 1982-1997. Alcohol consumption per capita is strongly and positively related to alcohol-related fatal crashes (per 100.000 population). An increase of alcohol consumption from 2.2 to 2.6 gallons per years (+20%) is associated with an increase of fatalities by about 60%. 
Noland & Quddus, 2004 (USA)	Positive relationships between per capita alcohol expenditure and the number of killed or severely injured pedestrians and cyclists (unknown whether this is because of drunk drivers of motor vehicles or drunk cyclists / pedestrians). No relationships with the numbers of slightly injured pedestrians or cyclists.
Romano et al., 2015 (USA)	Multivariate analysis, 51 US-jurisdictions, 1982-2010 fatal alcohol-related crashes among underage drivers (15-20 years; relative to total fatal crashes in the same age group). Beer consumption among those aged 15 years and older is one of the three strongest predictors for alcohol-related fatal crashes among minors (besides proportion of young male vs. female drivers and fake identification retail law).
Skog, 2003 (Canada)	Time-series analysis of annual mortality rates (15–69 years) in relation to per capita alcohol consumption; control for the number of registered motor vehicles in the analyses for motor vehicle accidents. Increasing alcohol consumption is statistically significantly related to overall fatal accident rates (for males in all provinces; for females in all provinces except for Ontario). Motor vehicle accidents: A statistically significant relationship between alcohol consumption and road accidents was only found among males, not among females.
Stringer, 2018 (USA)	Country level analysis (1993-2015), effects of a large number of alcohol related variables on the number of alcohol-related fatal crashes. Total per capita alcohol consumption is positively and statistically significantly related to the number of alcohol-related fatal crashes per county. The proportion who regularly goes to bars/taverns is not related to alcohol related fatal crashes, although more than half of DUI trips originate at bars, taverns, and restaurants.
Walsh, 1987 (Ireland)	Increasing alcohol consumption per capita is associated with decreasing fatalities.
Young & Bielinska-Kwapisz, 2006 (USA)	State level analysis (1982-2000). An increase of per capita alcohol consumption by 10% is on average associated with an increase of fatality numbers by about 10%.

Table 22: Availability of alcohol - Prohibition

Availability of alcohol - Prohibition	
Adams & Cotti, 2008 (USA)	Smoking bans in bars: Fatal accidents involving alcohol increased in areas and states with a smoking ban. The most likely explanation is that many smokers driver longer distances to bars where smoking still is allowed.

Availability of alcohol - Prohibition	
Dills et al., 2005 (USA)	During the prohibition that was introduced in the USA in 1920, both liver cirrhosis and the number of **drivers arrested for drunk driving was strongly reduced**. After the end of the prohibition in 1933, liver cirrhosis and the number of drivers arrested for drunk driving increased strongly. The changes in the occurrence of liver cirrhosis indicate that the changes in the number of arrested drunk drivers was not only due to changes in police enforcement.
Eger, 2006 (USA, Kentucky)	County-level data on local alcohol prohibition and enforcement, with control for other relevant factors (such as age groups, number of DUI convictions and suspended licenses in the county and road related variables). Alcohol prohibition **reduces the number of injury crashes** within a county by 38%. Increasing law enforcement personnel, increasing DUI convictions and decreasing numbers of suspended licenses are also associated with decreasing number of injury crashes.
Elvik et al., 2009 (review)	Local alcohol prohibition in a number of counties and states of the USA. 10 studies (from 1983-2008). The results are too heterogeneous for calculating a summary effect. Most studies found ***more* crashes or fatalities in counties with local alcohol prohibition** ("dry counties") than in counties without local alcohol prohibition ("wet counties"). Possible explanations include: ▪ In dry counties, people may drive more in order to buy or consume alcohol ▪ Dry counties may differ from wet counties in terms of geographical or social factors (such as less urbanization, longer driving distances, more men with alcohol and drug problems) ▪ Local alcohol prohibitions may be more likely to be introduced in counties with many (alcohol related) accidents. When controlling for the number of alcohol-related fatal crashes before the introduction of local alcohol prohibition, two studies found that **dry counties have fewer – not more – crashes** than wet counties (Baughman et al., 2001; Brown et al., 1996).
Stringer, 2018 (USA)	County level analysis, effects of a large number of alcohol related variables on the number of alcohol-related fatal crashes. **No statistically significant differences** in the number of alcohol-related fatal crashes were found between dry, wet, and moist counties (differences were also inconsistent between models).
Webster et al., 2008 (USA)	DUI convicted drivers in counties with different degrees of limitations on alcohol sales. **Conviction rates** (per 100,000 population) were **65% higher in the most liberal counties**, compared to the more restrictive counties. DUI convicted drivers in the more restrictive counties were more often male, had more substance abuse disorders and were less likely to comply with education or treatment referrals.

Table 23: Availability of alcohol - Alcohol taxes and prices

Availability of alcohol - Alcohol taxes and prices	
Arranz & Gil, 2009 (Spain)	Crash prediction models for fatal crashes in Spain in 1998-2002. Higher beer prices are associated with fewer total fatalities. As beer prices increase by 1%, total crash fatalities decrease by 0.19%.
Chang et al., 2012 (USA)	State level study, eight alcohol related policies. Dependent variable: Alcohol related fatality rate (relative to total fatalities). Control for other alcohol policies, population, speed limit, economic factors. Higher beer taxes are related to fewer alcohol-related fatalities (highly statistically significant).
Cotti & Tefft, 2011 (USA)	Quarterly data (2000-2009), state level (whole country). Statistical control for unemployment, gasoline taxes, personal income, and vehicle miles travelled. Increasing beer taxes are associated with fewer alcohol-related fatalities and unrelated to non-alcohol related fatalities.

Availability of alcohol - Alcohol taxes and prices	
Elvik et al., 2009 (**review**)	**Review** of 15 US-studies (from 1987-2007) of the relationship between alcohol taxes or indicators of alcohol prices and crashes. No summary effect can be computed since all studies have used different indicators of alcohol prices or alcohol taxes. The results are inconsistent. The main impression is that alcohol prices do not directly affect the number of accidents. Amongst other things, several studies found relationships between alcohol prices and total road fatalities, but no specific effects on alcohol related fatalities.
Kalsi et al., 2018 (Finland)	Alcohol taxes were reduced by about 33% on average in 2004. Alcohol consumption increased by 12.4% from 2003 to 2005 and there was a strong negative correlation between alcohol prices and consumption. There were strong negative correlations between alcohol consumption and the total number of fatal crashes and between alcohol prices and the total number of fatal crashes. The results cannot be interpreted as causal effects because confounding factors are not controlled for and because the results refer to all fatal crashes and not specifically to alcohol related crashes.
McClelland & Iselin, 2019 (USA)	Large increases in alcohol excise taxes in Illinois in 1999 and 2009. No effect on alcohol-related fatal crashes. Only in counties not bordering to another state, a temporary drop in alcohol-related fatalities was observed after the tax increase in 2009.
Morrisey & Grabowski (2011)	State level study (1985-2006) among young drivers (15-24 years). Higher beer taxes are associated with fewer total fatalities among young drivers (18-24 years). As beer taxes increase by 10%, total young driver fatalities decrease by 1.3%; among those 15-17 years, no effect was found.
Mäkelä & Österberg, 2009 (Finland)	Changes in Finnish alcohol policy in 2004: Quotas for travellers' tax-free imports of alcoholic beverages from EU countries abolished, alcohol excise taxes reduced by one-third. Alcohol consumption increased (+10%); liver disease deaths increased (+46%). According to Kalsi et al., 2018, these effects cannot necessarily be interpreted as causal effects of the changed alcohol policies). Effects on alcohol-related fatalities are unclear (increase in 2004, decrease to the level from 2003 in 2005).
Ponicki et al., 2007 (USA)	State level analysis 1975-2001. Higher beer taxes are associated with fewer total fatalities (statistically significant for drivers above 20 years, not among younger drivers).
Romano et al., 2015 (USA)	Multivariate analysis, 51 US-jurisdictions, 1982-2010 fatal alcohol-related crashes among underage drivers (15-20 years; relative to total fatal crashes in the same age group). Increasing alcohol tax rate: ▪ Fewer vehicles miles travelled (statistically significant) ▪ Not statistically significantly related to alcohol-related fatal crashes.
Saar, 2015 (Estonia)	Average alcohol excise taxes are strongly and negatively related to alcohol-related crashes. No relationship was found between alcohol excise taxes and non-alcohol related crashes.
Sen & Campbell, 2010 (USA)	Beer taxes were found to be negatively related to fatalities among child motor vehicle occupants.
Wagenaar et al., 2009 (**meta-analysis**)	**Meta-analysis** of 112 primary studies of the relationship between alcohol prices or taxes and alcohol sales or consumption. Significant negative relationships were found between alcohol prices or taxes and alcohol sales or consumption. The strongest relationship was found for spirits, followed by wine and beer. Among heavy drinkers, alcohol consumption is less affected by alcohol prices or taxes than alcohol consumption in total.
Walsh, 1987 (Ireland)	An increase of alcohol prices by 10% is associated with a decrease of total road fatalities by 4%. Death due to liver cirrhosis also decrease by 4%. However, alcohol consumption is more strongly affected by incomes and unemployment than by alcohol prices.
Young & Bielinska-Kwapisz, 2006 (USA)	State level analysis (1982-2000). An increase of alcohol prices by 10% reduces total fatalities by 5.8%. The effect is larger on weekend nights (-6.9%) than otherwise and greater among youths (-9%) than among older drivers.

Table 24: Availability of alcohol – Limiting the availability of alcohol – Alcohol outlet density

Availability of alcohol – Limiting the availability of alcohol – Alcohol outlet density	
Campbell et al., 2009 (review)	Increasing outlet density was in several studies found to be associated with increases in alcohol consumption and violent crime.
Chen et al., 2009 (USA)	Higher outlet density (zip-code level) is related to increasing frequency and amount of alcohol purchases among youth aged 14-16.
Elvik et al., 2009 (review)	Nine studies of the relationship between alcohol outlet density and alcohol related crashes (from 1983-2007). The studies are too heterogeneous for calculating a summary effect. The results resemble the results from studies of local alcohol prohibition. Some studies found more accidents in areas with a high outlet density, while others found no relationship. A possible explanation for the inconsistent results is that low outlet density may affect crashes in different ways: Low outlet density may be associated with ▪ Reduced alcohol availability (longer distances, higher prices), which may reduce alcohol related accidents ▪ More driving related to the purchase and consumption of alcohol, which may increase accidents. Moreover, areas with a high outlet density are generally more densely inhabited areas, which also may affect the number of alcohol-related accidents (McCarthy, 2003).
Gruenewald & Johnson, 2010 (USA)	Cross-sectional time-series (four years) spatial analyses, 144 geographic units from six communities. 10% increase in alcohol outlet density: 0-150% increase in SV nighttime crashes.
Hobdon & Meuleners, 2018 (Australia)	Geographical distribution of alcohol-related vs. non-alcohol related crashes ▪ Crashes near on-premise outlets are more likely to be alcohol-related ▪ Crashes near central business district are less likely to be alcohol-related ▪ Association between number of bottleshops and alcohol-related crashes is inconsistent.
Lapham et al., 2004 (USA)	Spatial relationships between drive- through alcohol sales and alcohol-related crashes in Albuquerque, New Mexico. No statistically significant relationships were found between the density of drive-through outlets and alcohol-related crashes. However, the rate of alcohol- to non-alcohol related crashes was increasing before drive-through alcohol outlets were banned, and they decreased afterwards.
Morrison et al., 2016 (Australia)	Relationship between land use and demographics and alcohol-related crashes, small spatial units (mean land area = 0.5 m^2). Greater bar density: Greater rates of alcohol-related crashes in surrounding areas, but not within the local area. Greater off-premise outlet density: Fewer alcohol-related crashes in local areas (most likely because origins and destinations of alcohol-affected journeys are in distal locations relative to outlets).
Nordlund, 2010 (Norway)	The number of alcohol outlets in Norway increased around the year 2000 and self-service was introduced in the shops. Alcohol consumption in municipalities that got new monopoly shops decreased, which was due to a decrease of the consumption of illegal alcohol; consumption of spirits from the monopoly shops increased. In municipalities that had monopolies since before 2000, alcohol consumption increased, which reflects an overall increase of alcohol consumption (no effect of the change was expected in these municipalities).
Ponicki et al., 2013 (USA, California)	Spatial panel analysis, 1999-2008. Statistically controlled for: Population density and demographic variables, income, total retail density. Increasing bar/pub density: Increasing alcohol-related injury and SV night-time crashes, but not with total injury crashes. Increasing restaurant density: Increasing total injury crashes, not related to alcohol-related or SV night-time injury crashes. Increasing off-premise density: Decreasing total injury and SV nighttime crashes.

Availability of alcohol – Limiting the availability of alcohol – Alcohol outlet density	
Ramsted, 2002 (Sweden)	Effects of re-monopolization of sales of medium-strength beer on six alcohol-related outcomes. Results are inconsistent (detailed results for different age groups, different effects for different age groups). Crashes were found to be reduced by 14%, but not in all age groups. Other alcohol-related harms among youth were also found to decrease.
Rickard et al., 2013 (USA)	When total alcohol consumption is held constant, a higher share of wine is related to lower traffic fatality rates, while a higher share of beer is associated with increasing fatality rates. Thus, limiting the availability of wine at grocery stores is unlikely to have favorable road safety effects.
Romano et al., 2015 (USA)	Multivariate analysis, 51 US-jurisdictions, 1982-2010 fatal alcohol-related crashes among underage drivers (15-20 years; relative to total fatal crashes in the same age group). Alcohol outlet density: ▪ Predictor of alcohol use among under 21-year olds ▪ No direct effect on alcohol-related fatal crashes among young drivers ▪ Statistically significant positive relationship with alcohol-related fatal crashes among young drivers (indirect effect via beer consumption; beer consumption, proportion of young male drivers, and fake identification laws are the strongest predictors).
Rowland et al., 2014 (Australia)	Increasing alcohol outlet density is statistically significantly and positively related to alcohol purchases among underage youth (under 18 years). The strongest effects were found for club and takeaway density.
Treno et al., 2007 (USA)	Panel data zip-level analysis, 1995-2000. Increasing outlet density and increasing was associated with increasing total fatalities and increasing alcohol-related fatalities.

Table 25: Availability of alcohol – Limiting the availability of alcohol – State monopoly

Availability of alcohol – Limiting the availability of alcohol – State monopoly	
Colon, 1982 (USA)	Cross-sectional study; control for miles driven, urbanization and percentage of male drivers. No relationship was found between state monopoly and SV fatalities.
He et al., 1999 (review)	Review of studies of the privatization of alcohols sales. Privatization commonly involves higher density of outlets, longer hours, more days of sale, and a decline of alcohol prices. These factors can be expected to increase alcohol consumption.
Pulito & Davies, 2012 (USA)	State level panel study (fifty states; 1982-2002). No association between state monopoly and alcohol-related fatalities. However, low levels of state control of alcohol sales are associated with increased alcohol-related fatalities.
Rossow et al., 2008 (Norway and Finland)	Young people were more often refused to buy alcohol in state monopoly shops than in other shops. This may be due to larger economic interest in selling alcohol in other shops compared to the state monopoly shops. (Effects on crashes not reported)
Stockwell et al., 2009 (Canada)	Cross-sectional analysis; alcohol outlets and alcohol sales in 89 local health areas in British Columbia with statistical control for social, economic, and demographic factors. An increasing percentage of private (vs. government owned) liquor stores is associated with increased alcohol sales when controlling for the total numbers of liquor stores. (Effects on crashes not reported)
Trolldal, 2005 (Canada)	Privatization of the retail sale of alcohol in Alberta (continued monopolization on wholesale level; no alcohol sales in grocery stores). Motor vehicle registrations as control variable. Interrupted time series (1950-1998). No statistically significant effect on total motor vehicle fatalities (-11% [-34; +19]). No effect on total alcohol sales.
Zullo et al., 2013 (USA)	Cross-sectional study (few details reported). There is a trend towards lower total fatality rates with increasing strength of state monopoly, but without reaching statistical significance.

Table 26: Availability of alcohol – Limiting the availability of alcohol –Other

Availability of alcohol – Limiting the availability of alcohol –Other	
Regulating days and hours of sales	
McMillan & Lapham, 2006 (USA)	Time series (1990-2000) analysis of the effects of the ban on Sunday packaged alcohol sales in New Mexico. Alcohol-related fatalities and crashes increased after Sunday alcohol sales were permitted (+29%; +42% for alcohol-related fatalities on Sundays).
Popova et al., 2009 (**review**)	Systematic review; 15 studies of the effects of hours or days of alcohol sales on alcohol consumption, drinking patterns and damage from alcohol. A general finding is that restricting the availability of alcohol can reduce alcohol related harm, but the effect on motor vehicle crashes has only been investigated in one of the studies (McMillan & Lapham, 2006).
Stehr, 2010 (USA)	Effects on traffic fatalities of relaxing or repealing restrictions on Sunday sales of packaged alcohol in 13 states of the US. A significant increase of motor vehicle fatalities was only found in one state (New Mexico). In this state total beer sales increased by 10.3% and motor vehicle fatalities increased by 1.0%. The increase of alcohol sales in the remaining states where no effect on fatalities was found, was smaller. Other studies yielded conflicting results regarding the effects of Sunday sales of alcohol, but these are according to Stehr (2010) either outdated, based only on single states or have failed to control for other factors.
Fake identification laws	
Fell, Scherer, Thomas, & Voas, 2014 (USA)	Before-after study of three fake identity laws (and two social host civil liability laws) (based on FARS, 1982-2010). Fatal alcohol-related crashes among underage drivers: ▪ Fake-ID supplier laws: -1% (statistically significant). ▪ Retailer support for fake ID and transfer/production of fakte-ID laws: No statistically significant effects.
Romano et al., 2015 (USA)	Multivariate analysis, 51 US-jurisdictions, 1982-2010 fatal alcohol-related crashes among underage drivers (15-20 years; relative to total fatal crashes in the same age group). ▪ Laws against use of fake identification by minors: -14.1% underage alcohol-related fatal crashes ▪ Laws targeting retailers: -9.3% alcohol-related underage fatal crashes.
Laws regulating alcohol advertisements	
Smith & Geller, 2009 (USA)	FARS-data county-level (Idaho, 2010-2015). No statistical control for other differences between counties. Law prohibiting alcohol advertising that targets minors: ▪ Alcohol-related SV fatalities among young drivers: -33%.

Drug driving laws

Table 27: Drug driving laws – Legalization of cannabis

Drug driving laws – Legalization of Cannabis	
Anderson et al., 2013 (USA)	Legalization of cannabis for medical use: ▪ Total fatalities decreased by 8-11% after legalization for medical use. ▪ The decrease was greater for alcohol-related fatalities than for non-alcohol related fatalities. The likely explanation is that cannabis substitutes alcohol for many drivers, i.e. drunk driving is reduced because more drivers use cannabis instead of alcohol before driving.
Aydelotte et al., 2017 (USA)	Year-to-year changes of fatal crashes before and after recreational marijuana legalization (Washington and Colorado) compared to similar states without legalization. ▪ No statistically significant difference in total fatal crashes between states with vs. without recreational marijuana legalization.

Drug driving laws – Legalization of Cannabis	
Dills et al., 2016 (USA)	Time series of fatal crashes in Washington, Colorado, Arizona, and Oregon before and after legalization of marijuana for recreational use. ▪ No clear changes in trends of total fatal crashes in any of the three states (no detailed statistical analyses are reported; all results refer to total fatalities, not specifically cannabis-related fatalities).
Hansen et al., 2018 (USA)	Time series of fatal crashes in Washington and Colorado before and after legalization of marijuana for recreational use with control for confounding factors. ▪ No statistically significant effect on cannabis-related fatalities.
Keric et al., 2018 (USA)	Survey among members of a national trauma surgical organization; register data from two level 1 trauma centers. Study of the effects on alcohol and marijuana on injury form motor vehicle collisions. ▪ Survey data: No observed effects on injury from legalization of marijuana (114 respondents from states in which marijuana was legalized) ▪ Trauma center register data, California: No change in incidence of marijuana in trauma center patients after legalization of marijuana
Lane & Hall, 2019 (USA)	Time series of fatal crashes in Washington, Colorado, and Oregon before and after legalization of marijuana for recreational use with control for confounding factors. ▪ No statistically significant effect on cannabis-related fatalities.
Lee et al., 2018 (USA)	State-level analysis of associations between marijuana law changes and marijuana-involved fatal traffic crashes. ▪ **Medical legalization**: No change in marijuana-involved fatal traffic crashes (Arizona and New Jersey). ▪ Other types of legalization: Increased marijuana-involved fatal traffic crashes (increases range from +32% to +175%) (Massachusetts, Connecticut, Washington, Colorado).
Monfort, 2018 (USA)	Before-after study of the effects of marijuana legalization in Colorado, Oregon, and Washington; neighboring states as comparison. Monthly rates of police-reported crashes, statistical control for several demographic variables. ▪ Crash rates increased on average by 5.2% from pre- to post-legalization relative to comparison states.
Nazif-Munoz et al., 2020 (Uruguay)	Time-series analysis of weekly traffic fatality rates, motor vehicle drivers and motorcyclists (2012-2017); cannabis was legalized for recreational use in December 2013. ▪ Total motor vehicle drivers fatalities increased after legalization (+52% [+11; +93]). Fatalities increased mainly in urban areas, and not in rural areas. ▪ No change in motorcyclist fatalities.
Salomonsen-Sautel et al., 2014 (USA)	Legalization of **cannabis for medical use** (Colorado): Changes over time of fatal crashes in Colorado and 34 states without medical marijuana legalization. ▪ Increasing trend in marijuana-positive drivers in fatal crashes (unchanged in comparison states) ▪ Unchanged proportion of fatal crash involved drunk drivers (BAC > .08).
Santaella-Tenorio et al., 2017 (USA)	Legalization of cannabis for medical use: ▪ Total fatalities decreased by about 10% after legalization for medical use, especially among drivers aged 25 to 44 years.
Woo, 2019 (USA)	Legalization of marijuana in Washington state and fatal crashes; different methods. ▪ Legalization of marijuana for recreational use (2012): Increase in THC-positive drivers involved in fatal crashes ▪ Opening of marijuana retail shops (2014): Unchanged THC-positive drivers involved in fatal crashes ▪ Cannabis was *not* a predictor for speeding, driver error or "undesirable outcomes" in fatal crashes.
Young, 2019 (USA)	State-level analysis over time (23 years); effects of the legal status of cannabis (recreational /medical use) on fatalities per 100,000 vehicles miles travelled. ▪ No relationship between legalization (medical / recreational) of marijuana and total fatalities per vehicle miles travelled.

Other laws

Table 28: Other laws

Other laws	
Implied consent laws	
Benson et al., 1999 (USA)	No effects on crashes.
Ruhm, 1996 (USA)	Inconclusive results.
Whetten-Goldstein et al., 2000 (USA)	State level analysis, 1984-1995. Dependent variable: Total and alcohol-related fatalities. Implied consent laws: No effects on fatal crashes (all / alcohol-related).
Dram shop laws	
Elvik et al., 2009 (meta-analysis)	Meta-analysis; five US-studies from 1996-2001. ▪ Fatal crashes: -14% (-21; -5) ▪ Fatal alcohol-related crashes: -17% (-24; -9). There is statistically significant heterogeneity in the results. The small difference between the effects on alcohol-involved and other fatal crashes indicates that other factors than dram shop laws are likely to have contributed to the results.
Romano et al., 2015 (multi-state study)	Multivariate analysis, 51 US-jurisdictions, 1982-2010 fatal alcohol-related crashes among underage drivers (15-20 years; relative to total fatal crashes in the same age group). Dram shop laws: No effect on the total number of fatal crashes.
Whetten-Goldstein et al., 2000 (USA)	State level analysis, 1984-1995. Dependent variable: Total and alcohol-related fatalities. Bar can be sued for serving minors: Fatal crash reductions, but only slightly larger for alcohol-related than for all fatal crashes. ▪ Fatal crashes: -28% (-41; -13) ▪ Fatal alcohol-related crashes: -34% (-52; -8).
Social host liability	
Romano et al., 2015 (USA)	Multivariate analysis, 51 US-jurisdictions, 1982-2010 fatal alcohol-related crashes among underage drivers (15-20 years; relative to total fatal crashes in the same age group). Social host liability laws: ▪ Total number of fatal crashes: -4.4%. ▪ Underage drinking: Practically no effect.
Fell, Scherer, Thomas, & Voas, 2014 (USA)	Before-after study of social host prohibition and social host civil liability laws (and three fake identification laws) (based on FARS, 1982-2010). ▪ Fatal alcohol-related crashes among underage drivers: No effect.
Whetten-Goldstein et al., 2000 (USA)	State level analysis, 1984-1995. Dependent variable: Total and alcohol-related fatalities. Social host can be sued for serving minor: ▪ Total fatalities: +5% (0; +10) ▪ Alcohol-related fatalities: -2% (-9; +7).
Child endangerment laws	
Kelley-Baker & Romano, 2016 (USA)	Multivariate study, fatal crashes 2002-2012. ▪ No effect on the number of impaired drivers among those driving with children. ▪ Possible explanations: Lack of publicity, enforcement.

Table 29: Economic conditions

Economic conditions
Economic conditions and crashes

Economic conditions	
Chi et al., 2011 (USA)	Regression models, monthly data (2004-2008) from Mississippi. Statistical control for alcohol consumption, gasoline prices, and seat belt use. Increasing unemployment: ▪ More total crashes (stat. sign. for PDO (p<.001) and total (p<.10)) ▪ Fewer drunk driving crashes (fatal and injury) (ns) ▪ More drunk driving PDO crashes (p < .10)
Cotti & Tefft, 2011 (USA)	Quarterly data (2000-2009), state level (whole country). Statistical control for beer taxes, gasoline taxes, and vehicle miles travelled. Increasing unemployment: ▪ Fewer alcohol related fatalities (stat. sign.) ▪ No effect on non-alcohol related fatalities (ns decrease). State personal income: ▪ Unrelated to alcohol- and non-alcohol related fatalities (negative to alcohol-, positive to non-alcohol related fatalities)
He, 2016 (USA)	State-level panel data (2003 to 2013). Increasing unemployment: ▪ Decreasing fatality rate (-2.9% fatality rate per percentage point increased unemployment) ▪ Same relationship for drunk-driving and other fatalities.
Krüger, 2013 (Sweden)	Country-level (Sweden) time series and regional panel data analysis. Economic booms: Total fatalities per VMT increase, alcohol sales and drunk driving increase. Increasing unemployment: ▪ Decreasing total fatalities (among modes of transport the effect is strongest for drivers and moped riders, and weakest for passengers). ▪ Decreasing drunk driving (stat. sign.).
Economic conditions and drinking	
Ásgeirsdóttir et al., 2016 (Iceland)	Individual level longitudinal survey data. ▪ During the crisis, heavy drinking (and other health-compromising behaviors) decreased. ▪ During recovery, most health-compromising behaviors (incl. heavy drinking) continued to decline (except for sweets). ▪ The continued decline of heavy drinking cannot be explained by increasing alcohol prices.
Dee, 2001B (USA)	Survey data 1984-1995. ▪ Overall drinking decreases in bad economic times. ▪ The likelihood of drinking 60 or more drinks per month decreased as well. ▪ Binge drinking (five or more drinks on a single occasion) increased, even among those who remained employed.
Gili et al., 2012 (Spain)	Randomized samples of patients attending primary care centers before and after the economic crisis in 2008 (7940 patients in 2006-07 and 5876 in 2010-11). ▪ Increased mental health disorders, including alcohol problems (alcoholism +4.6%; alcohol abuse +2.4%)
Ólafsdóttir, 2015 (Iceland)	Summary paper, different sources. ▪ During good times, consumption increased (from 4.8 to 7.5 liters per inhabitant over 15 years during 1995-2007), including consumption of alcohol (especially strong liquor and champagne) and illicit drugs (especially cocaine). ▪ During the economic crisis, alcohol taxes increased, and consumption decreased (to 6.7 liters in 2011, i.e. still well above the level from earlier years).
Ruhm & Black, 2002 (USA)	Survey data, 1987-1999, relationship between macroeconomic conditions and drinking. ▪ Drinking decreases in bad economic times ▪ Heavy drinkers reduce drinking more than occasional drinkers ▪ The changes in drinking for the most part are due to changes in the amount of drinking among existing drinkers (few who started / stopped drinking) ▪ Some individuals increased alcohol use as "self-medication", but that this effect is more than offset by an overall reduction of drinking.

Table 30: Gasoline prices

Gasoline prices	
Romano et al., 2015 (USA)	Multivariate analysis, 51 US-jurisdictions, 1982-2010 fatal crashes; outcome variable: ratio of alcohol-related to non-alcohol related fatal crashes. Increasing gas tax rate: ▪ Fewer vehicles miles travelled (statistically significant) ▪ No statistically significant relationship with alcohol-related fatal crashes.
Chi et al., 2011 (USA)	Regression models, monthly data (2004-2008) from Mississippi. Statistical control for alcohol consumption, state unemployment, and seat belt use. Increasing gasoline prices: ▪ Fewer drunk driving and total crashes (stat. sign. for PDO and total; no effect on fatal crashes)
Cotti & Tefft, 2011 (USA)	Quarterly data (2000-2009), state level (whole country). Statistical control for unemployment, beer taxes, personal income, and vehicle miles travelled. Increasing gasoline taxes: ▪ No stat. sign. effect on alcohol- or non-alcohol related fatalities (small positive coeff.)

V 4. Chapter 3 DUI enforcement: Tables

Table 31: Intensity of enforcement and DUI arrest rates

Intensity of enforcement and DUI arrest rates	
Arranz & Gil, 2009 (Spain)	**Higher arrest rate – fewer fatalities.** Crash prediction models for fatal crashes in Spain in 1998-2002. ▪ Increase of the number of sanctions for drunk driving by 1%: -0.34% fatalities.
Dula et al., 2007 (USA)	**Higher arrest rate – unrelated to alcohol-related crashes.** Relationship between DUI arrest rates and alcohol-related crashes (county-level analysis 2001 and 2003): ▪ Weak and non-significant relationship (-.06) between arrest rate and DUI-crashes.
Elvik, 2010; Elvik & Amundsen, 2014 (Norway)	**Higher detection rate – less drug driving.** An increase of the detection rate by 60% on average reduces the incidence of drug driving by 45%, while a decrease of the detection rate by 60% increases the incidence of drug driving by 83%. *(part of TSH chapter 8.15)*
Fell et al., 2014 (USA)	**Higher arrest rate – fewer alcohol-related crashes.** Relationship between the intensity of enforcement and the prevalence of impaired driving crashes in 22–26 communities in 2007. ▪ A 10% increase in the DUI arrest rate is associated with a 1% *reduction* in the drinking driver crash rate
Fell et al., 2015 (USA)	**Higher arrest rate – less drunk driving.** **More enforcement – less drunk driving.** Relationship between the intensity of enforcement and the prevalence of drunk driving at weekend nights in 2007. ▪ Increasing DUI-arrest rates are related to *fewer* BAC-positive drivers ▪ Increasing number of traffic stops per 10,000 population are related to fewer BAC-positive drivers (stronger relationship for higher BAC-levels)
Rezapour et al., 2018 (USA)	**More police - fewer fatalities.** Relationships between budget, number of offices, and active hours in the field and fatality rates: ▪ Increasing enforcement is related to decreasing fatality rates (not statistically significant for active hours in the field)
Sevigny, 2018 (USA)	**More police – fewer cannabis-related crashes.** Estimated effects of changing the number of police officers per 100.000 population on the proportion of fatally injured drivers with measurable cannabis: *(part of TSH chapter 8.15)* ▪ +60% Police officers: -25% cannabis-related crashes ▪ -60% Police officers: +33% cannabis-related crashes.
Stringer, 2019 (USA)	**More DUI arrests – fewer alcohol-related fatal crashes.** Relationship between DUI arrests and fatal alcohol related crashes in US counties 1985-2015. ▪ Increases in DUI arrests are related to decreased fatal alcohol related crashes. ▪ The relationship varies across states. ▪ The relationship is non-linear: There is a **point of diminished returns** where increased arrests are no longer related to reductions in fatalities.
Welki & Zlatoper, 2009 (USA)	**More DUI arrests – fewer fatal crashes.** Time series over 26 years from Ohio. Statistically significant negative relationships between DUI arrest rates (DUI arrests per million vehicle miles) and fatal crashes with cars, LTVs, pedestrians and cyclists.

Intensity of enforcement and DUI arrest rates	
Wiliszowski & Jones, 2003 (USA)	**More DUI enforcement – <u>fewer</u> alcohol-related crashes.** ▪ Effects of a program for improving DUI enforcement: General improvements of DUI enforcement, including new organizational arrangements and procedures. ▪ DUI arrest and conviction rates were almost doubled ▪ Number of drivers involved in fatal crashes with a BAC of 0.01 or more decreased statistically significantly by 25% ▪ Number of drivers involved in fatal crashes with a BAC of 0.10 or more decreased non-significantly by 19%.
Yao et al., 2016 (USA)	**More DUI arrests – <u>fewer</u> alcohol related crashes.** 30 states, 297 state-years, time-series of the ratio of drivers involved in fatal crashes with BAC > .08 vs. BAC = .00. Statistical control for covariates: Vehicle miles travelled, distributions of age, gender, and ethnicity, average income, employment rates, geographical factors. ▪ Increasing arrest rates are associated with reduced alcohol related fatalities ▪ Reductions are stronger in urban than in rural areas.

Table 32: Random roadside drug testing

Random roadside drug testing	
Baldock & Wooley, 2013 (Australia)	Review of evaluations of roadside drug testing: Only process evaluations and studies based on detection rates or self-report data. Crash effects have not been investigated. General conclusions: ▪ Increased detection of drug drivers ▪ Positive effects according to self-report data.
Freeman & Davey, 2008 (Australia)	Survey, random sample of 462 Queensland drivers after introduction of random roadside drug testing. ▪ Low awareness of the new testing method ▪ Lower certainty of apprehension is associated with higher likelihood of offending intentions ▪ Past behavior is a prominent predictor of future behavior.
Horyniak et al., 2017 (Australia)	Individual level study among 1913+3140 regular drug users who also were driving. ▪ On average, experience of road-side drug testing increased over time while self-reported drug driving decreased; there may be but is not necessarily a causal relationship ▪ On the individual level, there was no association between experiencing a road side drug test and drug driving, indicating that such testing does **<u>not</u>** have any <u>specific deterrent effect</u>.
Rowden et al., 2011 (Australia)	A new drug driving law was introduced in 2006. According to this law, it is an offence to operate a vehicle with measurable amounts of cannabis, methamphetamine, or MDMA in the blood. Starting after introduction of the law, roadside drug tests were introduced. ▪ The percentage of positive test results was reduced from 2.7% during the first year after the introduction of the legislation to 1.9% during the second to fourth year (the decrease cannot necessarily be interpreted as a direct effect of the new low or the introduction of roadside drug testing).

Table 33: Other/combined measures

Other / combined measures	
Ames et al., 2016 (USA)	Introduction of **“no refusal” blood draw program**. Before-after with comparison group study. ▪ Statistically significant reductions of alcohol-related crash rates after introduction of the program.
McCartt et al., 2009 (USA)	**Program directed at drunk driving among college students**: Increased DUI enforcement with sobriety checkpoints and police patrols, increased enforcement of the minimum legal drinking age and a multimedia campaign. ▪ Reduced drunk driving among young drivers.
Ramirez et al., 2008 (USA)	**Program targeting establishments that produce high levels of DUI arrests:** Identification of establishments (based on DUI arrest reports containing information about the place of last drink), education and training for these establishments and targeted enforcement. ▪ No effect on retail practices (number of establishments serving alcohol to intoxicated patrons) ▪ Reduced number of DUI arrests and average BAC of DUI arrestees in the intervention areas

V 5. Chapter 4 DUI-specific sanctions: Tables

Relationships between violations, convictions, and crashes

Table 34: Previous convictions and future crashes

Previous convictions and future crashes	
Barraclough et al., 2016 (meta-analysis)	**Violations ⇒ Crashes: Weak positive correlation, decreasing over time** Meta-analysis of 99 studies: ▪ Previous violations have limited value as a predictor of future crash involvement: average correlation of .18 over the mean time period of 3.2 years. ▪ The correlation decreases over time.
Carnegie & Eger, 2009 (USA)	**Violation ⇒ Crashes: Positive relationship** Driving records among drivers suspended for driving vs. non-driving reasons. Drivers suspended for driving reasons (compared to those suspended for non-driving reasons): ▪ More moving violations while suspended (30% vs. 15%) ▪ More driving while suspended (3.4% vs. 2.7%) ▪ More crashes (3.4% vs. 0.09%).
Gebers & Peck, 2003 (USA)	**Violations ⇒ Violations/crashes: Significant positive correlations** Random sample of licensed California drivers (n=246,600) in 1992. ▪ Prior (3 years) citations) predict future crash involvement and citations.
Fabbri et al., 2005 (Italy)	**DUI in previous crash ⇒ Crashes: Strong positive correlation** 5-year follow-up of 2,354 adult subjects treated in the ED after a motor vehicle crash; 16.8% of survivors had a new crash ▪ Alcohol involvement in first crash was the strongest predictor for future crash (controlled for sex, age, and nighttime) (OR = 3.73 [3.00; 4.64])
Goldenbeld et al., 2013 (Netherlands)	**Violations ⇒ Crashes: Strong positive correlation, especially for serious violations (speed)** Traffic offence and crash data, vehicle-level, 2005-2009. ▪ Crash risk increases more than linearly with the number of previous minor speed offences ▪ Crash risk increases about quadratic with the number of previous major speed offences
Høye et al., 2016 (Norway)	**Criminal charges ⇒ Crashes: Strong positive correlation, specific for violation/crash type** In-depth analyses of fatal motorcycle crashes, 2005-2014: ▪ Previous criminal charges among fatal crash involved motorcycle riders are related to major crash contributing factors in fatal crashes (types of criminal charges investigated: illegal drugs, DUI, speeding, unlicensed driving/riding).
Jørgenrud et al., 2018 (Norway)	**Violations ⇒ Crashes: Positive relationship** Road side surveys (voluntary), self-reported crash involvement and previous speeding tickets ▪ Previous speeding tickets associated with crahs involvement (OR = 1.39 [1.08; 1.80])
Kim et al., 2016 (Korea)	**Violations ⇒ Crashes: Positive relationships** Traffic offence and crash data, driver-level, 2004-2005 for violations, 2006 for crashes. ▪ Previous drunk driving or hit-and-run violation: 6% more crashes than an average driver ▪ Previous violation of signal, central line, or speed regulation more than once: 15% more crashes than an average driver
Redelmeier et al., 2003 (Canada)	**Violations ⇒ Crashes: Weak negative correlation (short-term only)** Individual level study: ▪ Reduced crash risk during the first month after a conviction (-35%) ▪ The effect decreased rapidly decreasing and was gone after three months.
Strathman et al., 2007 (USA)	**Violations ⇒ Crashes: No relationship** Driving records of suspended drivers. ▪ No substantial relationship between previous convictions and future crashes ▪ Previous crashes were strongly related to future crashes.

Previous convictions and future crashes	
Walter & Studdert, 2015 (Australia)	**Violations ⇒ Crashes: <u>Positive</u> relationship, decreasing over time** Driver-level data on infringements and crash involvement: ▪ Crash risk is about three times as high among drivers convicted for reckless driving as for drivers without previous convictions. ▪ Crash risk is about twice as high among DUI drivers as for drivers without previous convictions ▪ Effects decreased during the first 6 months ▪ A likely explanation for the increased crash risk among drivers with previous convictions for traffic violations is that previously convicted drivers on average have a generally more risky driving style

Table 35: Previous crashes and future crashes or violations

Previous crashes and future crashes or violations	
Carnegie et al., 2009 (USA)	**Crashes ⇒ Crashes: <u>Positive</u> relationship** Evaluation of New Jerseys driver improvement program, longitudinal database of driver history records. ▪ Crash recidivism is more than three time as high among 16-17 year old drivers, and about twice as high among 18-24 year old drivers, as among drivers above 25 years. ▪ Crash recidivism is also twice as high among male drivers than among female drivers.
Chandraratna et al., 2005 (USA)	**Crashes ⇒ Crashes: <u>Positive</u> relationship (stronger than for convictions)** Crash prediction model based on individual driver records. ▪ Previous crash involvement (both at-fault and non-at-fault crashes) predicts future crashes ▪ Previous speeding violations predict future crashes ▪ Previous crash involvement is a better predictor of future crashes than previous convictions
Chen et al., 1995 (Canada)	**Crashes ⇒ Crashes: <u>Positive</u> relationship (stronger than for convictions)** Logistic regression analysis, predictors in a pre-period for post-period at-fault crashes: ▪ Previous at-fault crashes are positively related to at-fault crashes ▪ Previous convictions are also related to at-fault crashes, but the relationship is weaker than for previous crashes.
Stradling, 2005 (Scotland)	**Crashes ⇒ Violations (speeding): <u>Positive</u> relationship** Survey data from two studies ▪ Previous crash involvement is a predictor of speeding.
Strathman et al., 2007 (USA)	**Crashes ⇒ Crashes: <u>Positive</u> relationship (no relationship for convictions)** Driving records of suspended drivers. ▪ Previous crash involvement is a better predictor of future crashes than previous convictions.
Watson et al., 2017 (Australia)	**Crash+violation ⇒ Violation: <u>Negative</u> relationship, only short-term** Driving records of convicted drunk driving offenders: ▪ Crash involved drivers (crash + UID offence at the same time) had lower re-offence rates than those who had not been involved in a crash. ▪ This effect did not endure over time. ▪ Crash involvement may deter.

License suspension and revocation

Table 36: Exposure and risk of apprehension among drivers with a suspended or revoked license

Exposure and risk of apprehension among drivers with a suspended or revoked license	
DeYoung et al., 1997 (USA)	Quasi-induced exposure, estimated exposure and fatal crash rates. ▪ Exposure rates of 8.8% and 3.3% for suspended/revoked and unlicensed drivers (vs. licensed drivers)
Lenton et al., 2010 (Australia)	Interviews with DUI recidivists. ▪ Most recidivists had driven while under suspension. The reported reasons where low probability of detection and high social and economic costs of not driving.
Parrish & Masten, 2015 (USA)	Drivers with a suspended or revoked license who were stopped at DUI checkpoints (were drivers licenses were routinely checked as well for all drivers), ▪ 41% of drivers had avoided detection because they had not returned their license cards as required.
Peck & Voas, 2002 (USA)	Up to 75% of drivers with a suspended license continue to drive.

Table 37: Crash risk of drivers with suspended or revoked licenses vs. licensed drivers

Crash risk of drivers with suspended or revoked licenses vs. licensed drivers			
		Relative crash risk (licensed drivers = 1)	
	Dependent variable	S/R drivers	Never licensed drivers
Blows et al., 2005 (Australia)	Case control[a]		
	Injury crashes		
	o Unadjusted effect	**12.1** (3.8; 38.4)	
	o Adjusted for VMT and other variables[b]	**3.9** (0.7; 22.4)	
	(not distinguished between S/R or never licensed; 83% of S/R drivers had never been licensed)		
Brar, 2012 (USA)	Quasi-induced exposure (indir. adj. for VMT):		
	▪ **Fatal crashes**	**2.59**	**2.72**
	▪ **At-fault fatal crash** (vs. not at-fault)	**1.6-4.9**	**1.8-4.1**
Watson, 2004 (Australia)	Quasi-induced exposure (indir. adj. for VMT):		
	▪ **Serious injury crashes**	**2.73** (1.06; 7.05)	**5.43** (1.24; 23.72)
	▪ **Total crashes**	**3.84** (2.39; 6.16)	**5.38** (2.63; 10.99)
	▪ **Serious (vs. slight) injury crash**	**1.96** (1.67; 2.31)	**2.01** (1.66; 2.43)
DeYoung et al., 1997 (USA)	Quasi-induced exposure (indir. adj. for VMT):		
	▪ **At-fault** (vs. not-at-fault) **fatal crashes**	**3.7**	**4.9**
Watson, 1997 (Australia)	Crash severity:		
	▪ **Serious** (vs. slight) **injury crash**	**2.25** (1.89; 2.68)	**2.16** (1.88; 2.48)
Watson & Steinhardt, 2006 (Australia)	Crash severity:		
	Car drivers:		
	▪ **Fatal** (vs. **seriously** injured)	**2.02** (1.53; 2.66)	**1.49** (0.89; 2.50)
	▪ **KSI** (vs. slight **injury**)	**1.83** (1.63; 2.04)	**2.25** (1.86; 2.74)
	Motorcycle riders:		
	▪ **Fatal** (vs. **seriously** injured)	**1.63** (0.81; 3.29)	**1.49** (0.64; 3.48)
	▪ **KSI** (vs. slight **injury**)	**3.36** (2.22; 5.11)	**2.21** (1.45; 3.36)

[a] Cases: Drivers killed or injured (KSI) at hospital; controls: random drivers recruited at the same times and places as case drivers.

[b] Adjusted for age, gender, ethnicity, education, driving exposure, passenger carriage, time of day, sleepiness, year of car manufacture, BAC-level, seatbelt use, and speed at the time of crash.

Table 38: Typical risk factors among drivers with suspended or revoked license

Typical risk factors among drivers with suspended or revoked license	
Bernhoft & Behrensdorff, 2000 (Danmark)	About 50% of all drivers who were involved in injury accidents and who had an illegal BAC level (above 0.5), had no valid driving license.
Blows et al., 2005 (Australia)	Case control study (injury crash involved vs. other drivers) with structured interviews: ▪ Unlicensed drivers have far higher injury crash risk than drivers with a valid license. ▪ Factors that contribute to the high risk of unlicensed drivers include: **Low education, ethnicity, driving exposure, time of day, sleepiness, old vehicle, passengers, non-use of seatbelts, non-zero BAC, high speed**.
Brown et al. (2008)	It is relatively common among convicted DUI offenders who have to absolve a relicensing program in order to retain their driving license, to delay relicensing. Those who delay relicensing, have on average more past **DUI convictions**, they drive more often **drunk** per kilometer, and they have more often participated in **substance abuse programs** than those who do not delay relicensing (Brown et al., 2008). They are also more often **recidivating** after they become eligible for license reinstatement than those who do not delay license reinstatement (Voas et al., 2010). These results indicate that those who delay relicensing have higher risk, both of reoffending and of getting involved in crashes, if they continue to drive.
MacLeod et al. (2012)	Drivers in fatal **hit-and-run** pedestrian crashes were more than four times as likely to have a suspended or revoked license (OR = 4.25) and also more likely to have a previous license suspension (OR = 1.47) than other drivers in fatal pedestrian crashes.
Sagberg, 2016 (Norway)	Among unlicensed fatal crash involved drivers, 85% had been either <u>drunk, speeding or driving</u> a **stolen car** (Sagberg, 2016).
Statens vegvesen (UAG), 2005-2015 (Norway)	In-depth analyses of fatal crashes in Norway 2005-2014 show that unlicensed driving is far more common among fatal crash involved drivers who had been **impaired** or **speeding** than among other drivers. Proportions of drivers without a valid license: ▪ 30% among those who had been under the influence of alcohol or other substances ▪ 17% among those who had excessive speed ▪ 11% among those who had inappropriate speed ▪ 1,7% among those who had been sober and not driving too fast.
Watson & Steinhardt, 2006 (Australia)	Comparison of crash involved unlicensed motor cycle riders vs. unlicensed car drivers. ▪ The proportion of crash involved unlicensed **motorcycle** riders is higher than the proportion of unlicensed car drivers. ▪ Typical contributing factors in crashes involving unlicensed riders/drivers include **alcohol** or **drugs**, **speeding**, **inexperience** and **inattention** (these are overrepresented in crashes with unlicensed riders/drivers compared to crashes with licensed riders/drivers).

Table 39: Specific deterrence: Effects of license suspension on crashes among suspended drivers

Specific deterrence: Effects of license suspension on crashes among suspended drivers	
Carnegie et al., 2009 (USA)	<u>License suspension</u> (two years) vs. control group (driver re-education, warning letter about demerit points and fee); study and control group are *not comparable*. <u>During/after suspension</u> vs. two years before sanction: ▪ **Crashes: Reduced** ▪ **Violations: Reduced**
Fell & Scherer, 2017 (USA)	Multivariate multi-state study (state level data). <u>Administrative license suspension law:</u> Length of suspension period and effect among all drivers vs. drivers DUI convictions during the previous three years. ▪ General deterrence: **Longer suspension periods** are associated with **larger reductions of fatal DUI crashes** among drivers without previous suspensions. ▪ Specific deterrence: ALS laws and length of suspension period have **no effects among with previous DUI convictions**.
Masten & Peck, 2004 (review and meta-analysis)	<u>Meta-analysis</u>: Mainly randomized controlled trials. <u>License suspension</u> (vs. non-suspended drivers) – effects while suspended: ▪ **Crashes: -17**% (sign.)

	▪ **Violations: -21**% (sign.) ▪ **No effect** after suspension. Probation (threat of license suspension; vs. licensed drivers without probation) ▪ **Crashes: +7**% (sign.) ▪ **Violations: -13**% (sign.) Effects on crashes and violations in quasi-experiments were about five times as large as those found in experiments. Results from other studies that have not randomized the assignment to license suspension and comparison conditions may be **overestimated** as well. Results are not reported separately for during and after suspension, but Masten & Peck (2004) conclude that there is «as yet no evidence that the effects of suspension on DUI offenders endure beyond the term of the suspension».
Siskind, 1996 (USA)	License suspension: Drivers with suspended licenses during and after suspension; follow-up period on average 3.9 years (min. 3 years). ▪ During suspension: Crashes and violations are about one third lower than after suspension (comparison to before suspension is not available)
Stephen, 2004 (USA)	License suspension (penalty points; with a voluntary driver improvement license suspension would have been avoided). Effects on crashes during suspension: ▪ Comparison group driver improvement course (same number of penalty points, participation in exchange for license suspension): **Crashes -57**% (-62; -50) ▪ Comparison group no sanctions (one penalty point, below limit for sanctions): **Crashes -82**% (-84; -80)
Strathman et al., 2007 (USA)	License suspension: Drivers with suspended license after suspension vs. 1.5 years before license suspension. Controlled for regression to the mean; crash effect may be affected by change in reporting practice. After suspension (1.5 years): ▪ **Crashes: -11**% (at least partly due to changed reporting routines) ▪ **Violations: -13**%
Watson et al., 2017 (Australia)	Offences among drivers who had got their license suspended for DUI; three study periods: ▪ Between the index offence and the start of the license suspension period: More offences than during and after license suspension. DUI offenders are particularly likely to reoffend while they are waiting to be sanctioned. ▪ During license suspension ▪ After license suspension: DUI and other offences is about doubled (compared to during suspension). The increase is greater among repeat offenders than among first-time offenders and somewhat greater for other than DUI offences than for DUI offences. The conclusion drawn by Watson et al. (2017) is that DUI offenders should be sanctioned as quickly as possible after being caught to keep the risk of reoffending as low as possible.

Table 40: Administrative license suspension laws

Administrative license suspension laws	
Brubacher et al. (2017)	Greater effects of the introduction of an administrative license suspension and vehicle impoundment law in areas with more alcohol-serving establishments. There are two likely explanations: ▪ More room for improvement in such areas (more drunk drivers and more DUI crashes) ▪ High media-coverage with reports about how the new law reduced alcohol sales.
Campbell & Ross, 1968 (USA)	All drivers, one year after vs. one year before introduction of ALS law: Total number of crashes reduced by 4% (non-significant).

Darnell 2015 (USA)	Time series for BAC- vs. non-BAC fatal crashes in eight states (US). Overall, no stat-sign. effects of ALS laws. 3 years post vs. 3 years pre (no summary effect reported and none can be calculated); in some cases, increases were found. The results are partly based on alcohol-related crashes and partly on single vehicle night-time crashes (as a proxy for alcohol-related crashes). Very short suspension periods (for example, seven days) are less likely to have a large deterrent effect than long suspension periods (for example, a year). General weaknesses of other studies: Effects mostly investigated for relatively short time periods, failure to control for relevant confounding variables; effects of ALS can only be expected when there is media coverage (drivers who are not aware of an ALS law can hardly be deterred by it), but at the same time the author criticizes other studies for not controlling for media coverage and general changes of attitudes towards DUI.
Fell & Scherer (2017, USA)	A statistically significant effect of administrative license suspension laws on DUI-involved fatal crashes was found only among drivers without previous DUI convictions, but not among drivers with previous DUI convictions. Larger effects were found for longer suspension periods (from below 91 days to over 180 days).
Maconald et al., 2013 Brubacher et al. 2014, 2017 (Canada)	Crash effects of administrative DUI legislation that was introduced in British Columbia (Canada) in 2010. Sanctions under the new legislation included administrative license suspension and vehicle impoundment. ▪ Fatal DUI-crashes: -40% (-64; -2) ▪ Injury DUI-crashes: -23% (-33; -12) Results refer to the first two years after the introduction of the new legislation. Under the administrative legislation, far less police resources were spent on charging drivers and at court, and the police were able to spend far more time on detecting drunk drivers, which can be expected to contribute to increased deterrence.
Romano et al., 2015 (USA)	Multivariate analysis, 51 US-jurisdictions, 1982-2010 fatal crashes; outcome variable: ratio of alcohol-related to non-alcohol related fatal crashes. ALS/ALR laws reduce the number of alcohol-related fatal crashes on average by 7%.

Vehicle impoundment and confiscation

Table 41: Specific deterrence effects of vehicle impoundment and similar measures

Specific deterrence effects of vehicle impoundment and similar measures			
	Drivers	**Comparison group**	**Results**
Beirness et al., 1997 (Canada, Maintoba)	**Vehicle impoundment** and administrative license suspension for **driving while suspended or DUI**	Drivers with similar offences *before* introduction of impoundment law	***Two years after:*** ▪ Rearrest rate: -41%
Crosby (1995)	**Vehicle forfeiture** for **driving while suspended** (when suspension resulted from **DUI**)	Drivers not having had their vehicle forfeited	***After vehicle forfeiture:*** ▪ Traffic violations: Ca. -50%
Deyoung, 1999 (USA, California)	**Vehicle impoundment** for **S/R driving**	Matched group of drivers without impounded vehicles, caught the year *before* introduction of impoundment law	***One year after; first / repeat offenders:*** ▪ **Crashes: -25% / -37%** ▪ License-related convictions: -24% / -34% ▪ Traffic convictions: -18% / -22%
Leaf & Preusser, 2011 (USA, Minnesota)	**License plate impoundment** for **DUI** (first-time offenders BAC > .20)	Drivers with BAC-levels slightly below the limit for pate impoundment *Size of effects and statistical significance not reported*	***During plate impoundment:*** ▪ Reduced DUI and S/R driving ***After plate impoundment:*** ▪ Reduced DUI and S/R driving (effects persisted)
Rosenbloom & Eldror, 2013 (Israel)	**Vehicle impoundment** (30 days; in addition to license suspension) for **several violations** (S/R driving, DUI, overload, passenger over-quota, hit-and-run crash involvement, amongst others)	Drivers with similar violations the year *before* introduction of impoundment law (multivariate analysis with previous crashes and convictions among the predictor variables)	***One year after:*** ▪ **Crashes: No stat. sign. effect** ▪ Violations (all and violations encompassed by impoundment law): Ca. -95% *Model specifications may have contributed to biased results*
Rodgers, 1994 (USA, Minnesota)	**License plate impoundment by court** for **DUI** third-time offenders	Drivers without impounded license plates; two comparison groups	***After plate impoundment:*** ▪ Recidivism: No effect
Rodgers, 1994 (USA, Minnesota)	**Administrative license plate impoundment** for **DUI** third-time offenders	Drivers without impounded license plates; two comparison groups	***After plate impoundment:*** ▪ Recidivism: Reduced (ca. -50%)
Voas et al., 1997 (USA, Oregon)	**License plate sticker** for **S/R** driving among drivers convicted for **DUI**	Drivers with similar violations but no sticker (suspended license only because of unavailability of stickers, weather, or inability to check driving record)	***During plate stickering:*** ▪ **Crashes: -13%** (ns) ▪ Violations: -41% (sign.) ▪ DUI: -35% (sign.) ▪ Driving while suspended: -58% (sign.)
Voas et al., 1998 (USA, Ohio, Hamilton County)	**Vehicle impoundment** for **S/R** driving among drivers convicted for **DUI**	Drivers without impounded vehicles; statistically controlled for age and prior offences	***During impoundment:*** ▪ S/R driving: -42% ▪ DUI: -39% ***Two years after:*** ▪ S/R driving: -25% ▪ DUI: -25%

Table 42: General deterrence - Vehicle impoundment law as a single measure

General deterrence - Vehicle impoundment law as a single measure			
	Measure	Method	Results
Byrne et al., 2016A (Canada, Ontario)	**Long-term vehicle impoundment** (45, 90, or 180 days for drivers with no, one or 2+ previous impoundments) **for driving while suspended** (mostly for DUI offences)	Time series (one state)	▪ Driving with a suspended license (multiple offenders): -19% (-29; -6) ▪ Driving with a suspended license (all offenders): Termination of previous upward trend of driving while suspended
Byrne et al., 2016B (Canada, Ontario)	**Seven-day vehicle impoundment** (administrative, in addition to previously existing 90-day license suspension) for **driving while suspended or DUI**	Time series (one state)	▪ **Injuries/fatalities: No statistically significant effect** (all drivers and different target groups of high-risk, novice drivers, and BAC>.08 drivers)
Cooper et al., 2000 (USA, California)	**Vehicle impoundment** (30 days) for driving with a **suspended/revoked license**	Multivariate analysis	▪ **Injury crashes: -3,4%** for each 10% increase of the cumulative number of vehicle impoundments [a]
DeYoung, 1998 (USA, California)	**Vehicle impoundment** for driving with a **suspended/revoked license**	Time series; comparison: Non-S/R drivers	▪ **Crashes with S/R drivers: -6%** (non-significant and dissipated after four months)
McKnight et al., 2013 (USA, Washington state)	**Motorcycle impoundment** for **unlicensed riding**	Time series; comparison: Fatal crashes in the rest of the country and all crashes from neighboring state	▪ **Motorcycle crashes: -1.6%** (non-significant) ▪ **Motorcycle crashes involving unlicensed riders: -22%** (statistically significant) ▪ New motorcycle licenses: +6.2% (non-significant)
Smith et al., 2019 (Canada)	**Short-term adm. vehicle impoundment laws**	Time series in three states with and two states without the law	▪ **Alcohol-related fatalities** (vs. non-alcohol-related fatalities): **No effect** (-46% in one state, no effect in the two other states; large reductions in the two states without the law)

Table 43: General deterrence - Vehicle impoundment law as one of several measures

General deterrence - Vehicle impoundment law as one of several measures			
	Measure	Method	Results
Beirness & Beasley, 2014 (Canada)	**Vehicle impoundment, extended period** (3 and 30 days for BAC .05-.08 and .08+,respectively), increases license suspension periods, increased penalties, alcolock and education program for BAC .08+, for **DUI**	B-A without comparison group	▪ **BAC positive drivers: -30%** (BAC .01-.05), **-21%** (BAC .05-.08), **-59%** (BAC > .08)
Brubacher et al., 2014 (Canada, British Columbia)	**Vehicle impoundment**, administrative license suspension, increased license suspension periods, and penalties added as sanctions for **DUI and speeding**	Times series; comparison: neighboring jurisdictions	▪ **Fatal crashes: -21%** (-26; -15) ▪ **Hospital admissions: -8%** (-15; -1) ▪ **Ambulance calls: -7%** (-13; -1) ▪ **Alcohol-related fatal crashes: -52** (-70; -35)
Brubacher et al., 2017 (Canada, British Columbia)	**Vehicle impoundment** (same as Brubacher et al., 2014)	Times series	▪ **Single vehicle night-time crashes (insurance claims): -12%** (-15; -9)

General deterrence - Vehicle impoundment law as one of several measures			
	Measure	**Method**	**Results**
Macdonald et al., 2013 (Canada, British Columbia)	**Vehicle impoundment** (same as Brubacher et al., 2014)	Times series; comparison: non-DUI crashes	▪ **DUI-fatal crashes: -40%** (-2; -64) ▪ **DUI-injury crashes: -23%** (-12; -33) ▪ **DUI-PDO crashes: -20%** (-11; -28)
Byrne et al., 2016A (Canada, Ontario)	**Seven-day vehicle impoundment** (administrative, in addition to previously existing 90-day license suspension) for **driving while suspended and DUI**	Time series (one state)	▪ Driving with a suspended license (90-day suspension period): -33% (-45; -18) ▪ DUI recidivism (three months following license suspension period): -29% (-47; -5)
Gargoum & El-Basyouni, 2017 (Canada, 3 provinces)	**Vehicle impoundment**, immediate license suspension and high fines for **excessive speeding** And new DUI law in BC and distracted driving law in Quebec; effects from the different laws cannot be separated	Time series; comparison: None	Results for Ontario / British Columbia / Quebec, respectively: ▪ **Fatal crashes: -18%** (stat.sign.) / **-22%** (stat. sign.) / **-6%** (ns) ▪ **Injury crashes: decrease** (ns) / **increase** (stat. sign.) / **decrease** (stat. sign.)
Meirambayeva et al., 2014A (Canada, Ontario)	**Vehicle impoundment** (7 days), license suspension, high fines, and possible jail for **excessive speeding** (>50 km/h above speed limit)	Time series; comparison: Non-speed related injury crashes	▪ **Speed-related injury crashes with young male drivers: -18% - -50%** ▪ **Speed-related injury crashes with other drivers: No statistically significant effect** Results refer to all crashes with excessive or inappropriate speed, incl. but not limited to 50+ km/h above limit
Meirambayeva et al., 2014B (Canada, Ontario)	**Vehicle impoundment** (7 days), license suspension, high fines, and possible jail for **excessive speeding** (>50 km/h above speed limit)	Time series; comparison: None	▪ Extreme speeding convictions per licensed driver, male drivers: -35%; female drivers: -12%

Table 44: General deterrence – License plate stickers

General deterrence – License plate stickers			
	Measure	**Method**	**Results**
Voas et al., 1997 (USA, Oregon)	**License plate sticker** (while license suspended) for **DUI**	Time series; comparison: Drivers with reinstated licenses (differences in exposure are not controlled for)	▪ **Crashes: -11%** (sign.) ▪ Violations: -13% (sign.) ▪ DUI: +5% (ns)
Voas et al., 1997 (USA, Washington)	**License plate sticker** (while license suspended) for **DUI**	Same as Voas et al. (1997, Oregon)	▪ **Crashes: +10%** (ns) ▪ Violations: -11% (ns) ▪ DUI: +28% (ns)

Alcohol ignition interlock

Table 45: Alcolock

Alcolock	
Alcolock – Secondary prevention – Specific deterrence (crash effects)	
Bjerre, 2005 (Sweden)	Voluntary alcolock (two years) in exchange for license suspension, available for DUI offenders, except those with continually high alcohol consumption. DUI offenders with vs. without alcolock. Matched comparison: Voluntary participants from states without alcolock program. Injury crashes among those who completed the program: ▪ While installed: -100% (ns) ▪ After removal: +65% (ns) Injury crashes among those who were dismissed from the program: ▪ While installed: -61% (ns) ▪ After removal: +277% (ns)
Bjerre & Thorsson, 2008 (Sweden)	Same measure and method as Bjerre (2005). Injury crashes among those who completed the program: ▪ After removal: -27% (ns)
DeYoung et al., 2005 (USA, California)	Alcolock court order; mandatory alcolock for all eligible DUI offenders (not all judges actually order alcolock for all eligible offenders). Matched comparison group. All crashes: ▪ 1st time offenders: No effect ▪ 2nd time offenders: -19% DUI offenders who installed alcolock in exchange for a reduced license suspension period. Matched comparison group. All crashes: ▪ All offenders: +84% ▪ 2nd time offenders: +130%.
Kerns, 2017 (USA, Maryland)	Alcolock for multiple offenders, voluntary alternative to prolonged license suspension. DUI offenders with vs. without alcolock (no control for other differences between groups). Alcohol- related crashes: ▪ While installed: -29% (-40; -16) ▪ After removal: +14% (-4; +35)
Teoh et al., 2018 (USA)	Alcohol interlock laws (different types of law). State level study, 2001-2014; effects of each of the types of law on alcohol related (BAC > .08) fatal car crashes compared to no law: ▪ All-offender interlock laws: -16% (three states in 2001, 22 states in 2014) ▪ Repeat offender and high BAC interlock laws: -8% ▪ Repeat offender interlock laws: -3% (non-significant).
Vanlaar et al., 2017 (Canada, Nova Scotia)	Voluntary alcolock for 1st time «low risk» offenders, mandatory alcolock for repeat and «high risk» offenders. DUI offenders with vs. without alcolock (no control for other differences between groups). Fatal or serious alcohol related crashes: ▪ No statistically significant effect (effects not reported) ▪ No statistically significant differences between voluntary and mandatory participants.
Watson et al., 2015 (Australia, Victoria)	Mandatory alcolock for all except 1st time low BAC offenders; license suspension period reduced with alcolock. Drivers with vs. without alcolock. DUI injury crashes (with alcolock installed): No statistically significant effect.

<table>
<tr><th colspan="2"><u>Alcolock</u></th></tr>
<tr><td>Vezina, 2002 (Canada, Quebec)</td><td><u>Voluntary</u> alcolock in exchange for shorter period of license suspension for 1st time and repeat offenders. Drivers with vs. without alcolock, adjusted for age and gender.
<table>
<tr><th></th><th></th><th>1st time offenders</th><th>Multiple offenders</th></tr>
<tr><td>SV nighttime crashes</td><td>While installed</td><td>-5 %</td><td>-54 %</td></tr>
<tr><td></td><td>After removal</td><td>+47 %</td><td>+394 %</td></tr>
<tr><td>All crashes</td><td>While installed</td><td>+256 %</td><td>+117 %</td></tr>
<tr><td></td><td>After removal</td><td>+65 %</td><td>+287 %</td></tr>
</table></td></tr>
<tr><th colspan="2">Secondary prevention – Recidivism while installed</th></tr>
<tr><td>Elder et al., 2011 (review)</td><td>Studies included in meta-analysis by Willis et al. (2004) and four more recent studies, all of them with similar results (no summary effects reported):
Substantially reduced recidivism during the alcolock period
No effects after removal of alcolock.
To maximize the effects of interlock programs:
Longer alcolock periods
Combining alcolock with a rehabilitation program
Increase participation; e.g. include first-time offenders, mandatory participation, more severe sanctions as alternative option (e.g. home confinement)
Installation at the time of arrest (instead of conviction)
More difficult circumvention of interlock device
Other measures for preventing offenders from driving non-interlock equipped cars.
Interlocks are as effective with first-time DUI offenders as they are with repeat offenders.</td></tr>
<tr><td>McCartt et al., 2013A (USA)</td><td>Mandatory interlock for first-time DUI offenders with BAC between 0.08 and 0.15 reduced recidivism rates in the two years following the first arrest by 12%, although only one third actually installed interlocks (alcolocks were installed for one year).</td></tr>
<tr><td>McCartt et al., 2018 (USA)</td><td>Update of McCartt et al. (2013A). Changes to DUI-law:
Interlock order requirement extended to all DUI convicted drivers
Allowing an interlock in lieu of an administrative driver’s license suspension
Proof of interlock installation required to reinstate the driver’s license.
Alcolock installation rates increased, both among first and repeat offenders. Effects on recidivism:
First-time DUI offenders: -26% recidivism
Repeat offenders: Non-significant decrease of recidivism.</td></tr>
<tr><td>Rauch et al., 2011 (USA)</td><td>Random assignment of alcolock-eligible multiple offenders to alcolock (two years) or alternative sanctions.
During intervention (two years): Recidivism reduced by 36%
Post-intervention (two years): Recidivism reduced by 26%
Post-intervention (four years): Recidivism reduced by 32%.</td></tr>
<tr><td>Vanlaar et al., 2017 (Canada, Nova Scotia)</td><td><u>Voluntary</u> alcolock for 1st time «low risk» offenders, <u>mandatory</u> alcolock for repeat and «high risk» offenders. DUI offenders with vs. without alcolock (no control for other differences between groups).
Recidivism reduced of up to 90%
Decrease in alcohol-related serious and fatal crashes
Decreasing program violations over time, suggesting learning behavior.</td></tr>
<tr><td>Willis et al., 2004 (meta-analysis)</td><td>Average reduction of rearrest rates of 75% among DUI offenders participating in an alcolock program.
Only randomized controlled trial included in the meta-analysis (Beck et al., 1999): Recidivism rate reduced 64% (random assignment of DUI offenders to alcolock or control group, with standard sanctions for the control group).</td></tr>
<tr><td>Zador et al., 2011 (USA)</td><td>Close monitoring of participants was accompanied by lower non-compliance rates (such as breath test failures, retest refusals, interlock disconnects), compared to participants of alcolock programs without such monitoring.</td></tr>
<tr><th colspan="2">Secondary prevention – Recidivism after removal</th></tr>
</table>

Alcolock	
Bjerre & Thorsson, 2008 (Sweden)	Recidivism was reduced among alcolock participants compared to a matched control group of similar drivers who said that they would have participated in the program but who had not opportunity because they were from counties that did not participate in the alcolock program. The participants had chosen a two-year alcolock requirement with regular medical checkups instead of a one-year license suspension. Drivers with continuously high alcohol consumption were excluded from the program. Additionally, drinking habits had improved and sick leave was reduced after license reinstatement among participants in the alcolock program. License reinstatement required close to zero attempts to start their car with illegal BAC-levels and sobriety during the second year of the program.
Brown, 2009 (Canada)	Alcolocks may be more effective than educational measures or psychotherapy for DUI offenders with cognitive impairments.
Marques et al., 2003, 2001 (USA)	Recidivism rates after completing an alcolock program are related to the proportion of failed interlock tests: ▪ More than two fails at a BAC of 0.08% or above (strongest predictor) ▪ Rate of interlock warnings at low BAC (0.02–0.04%) and fails at BAC > 0.04%.
Marques et al., 2010 (USA)	There was no change in the level of biomarker indicators of heavy drinking among DUI offenders participating in an alcolock program, although high BAC breath samples on the interlock decreased during the study.
Rauch et al., 2011 (USA)	Random assignment of alcolock-eligible multiple offenders to alcolock (two years) or alternative sanctions. The program focuses mainly on multiple offenders and included monitoring of breath test data. Post-intervention recidivism rates were reduced by 26% during the first two years and by 32% during the first four years.
Vezina, 2002 (Canada)	Recidivism increased by 91% after alcolock was removed from the vehicles of multiple offenders (24 months with alcolock), compared to 22% among first-time offenders (12 months with alcolock). The installation of alcolock was voluntary and in exchange for a shorter period of license suspension. These results indicate that multiple offenders are less likely to change drinking habits, even with alcolock, than first-time offenders.
Voas et al., 2013 (USA)	Recidivism rates after alcolock removal were highest among participants who had an extended period with alcolock because of poor interlock performance. Among other participants the recidivism rate was 2% both during the license revocation period which in this study was mandatory for all alcolock participants, and after the removal of alcolock, and 0.4% with alcolock.
Voas et al., 2016 (USA)	Participants in the alcolock program were mandated to participate in an alcohol use disorder treatment program after the third time the interlock device had prevented them from starting the vehicle. During 12 to 48 months after alcolock had been removed from their vehicles, those drivers who had participated in the treatment program, had 32% fewer new DUI convictions than a matched group of drivers who had not participated in the treatment program.
Alcolock – Secondary prevention – General deterrence	
Kaufman & Wiebe, 2016 (USA)	Mandatory alcolock laws for all DUI offenders State level: 18 states with vs. 32 states without mandatory alcolock law (some of them with partial interlock law). Time series, adjusted for state and year effects Fatal DUI crashes: -15% (from three years after implementation of law)
McCartt et al., 2013A (USA, Washington)	Mandatory alcolock law; alcolock (one year) mandatory for 1st time offenders with BAC < .15 in addition to 1st time high BAC and multiple offenders. In exchange, license suspension is reduced from 90 to 30 days. One state study, time series analysis, two other states as comparison. ▪ SV late night crashes: -8% (first three years after law change) ▪ Other effects: Alcolock installation increased from 3-6% to over 30%
McCartt et al., 2013B (USA)	Mandatory alcolock laws, different types: For repeat offenders, for high-BAC offenders, and for 1st time offenders. State level study, time series analysis, states without alcolock laws as comparison. ▪ SV late night fatal DUI crashes: Small and not statistically significant effects for all types of law.

<table>
<tr><th colspan="2"><u>Alcolock</u></th></tr>
<tr><td>McGinty et al., 2017 (USA)</td><td><u>Mandatory / partial alcolock laws</u> for all DUI offenders.
State level, time series analysis, accounted for between-state variation
<table>
<tr><th></th><th>Mandatory alcolock laws</th><th>Partial alcolock laws</th></tr>
<tr><td>Fatal DUI crashes (BAC > .08)</td><td>-7% (-9; -4)</td><td>+1% (-1; +3)</td></tr>
<tr><td>Fatal DUI crashes (BAC > .15)</td><td>-8% (-10; -5)</td><td>±0% (-2; +2)</td></tr>
</table>
All effects from the months in which the laws were enacted; partial law are effective from two years after implementation.</td></tr>
<tr><td>Soper, 2020 (USA)</td><td>All-offender interlock laws, state level time-series analysis.
No consistent evidence of an effect of all-offender interlock laws on total numbers of DUI arrests.</td></tr>
<tr><td>Ullman, 2016 (USA)</td><td>Mandatory alcolock laws: Mandatory alcolock for 1st time offenders with BAC > .08 or > .15.
State level, time series analysis,
Fatal DUI crashes: Alcolock for 1st time offenders with …
BAC ≥ .08: -9% (statistically significant)
BAC ≥ .15: No statistically significant effect.</td></tr>
<tr><td>Vanlaar et al., 2017 (Canada, Nova Scotia)</td><td>Mandatory alcolock laws for all DUI offenders
One province, before-after time series, controlled for population, unemployment, heavy drinking, and alcohol sales
Fatal and serious injury alcohol-related crashes: Small but statistically significant effect from 11 months after law implementation.</td></tr>
<tr><th colspan="2">Alcolock – Primary prevention</th></tr>
<tr><td>Assum & Hagman, 2006 (Norway)</td><td>Alcolock installed in buses.
High acceptance among bus drivers
No delays or cancelled departures because of alcolock
No attempts of drunk driving with alcolock.</td></tr>
<tr><td>Bjerre & Kostela, 2008; Bjerre, 2005 (Sweden)</td><td>Alcolock installed in all vehicles of companies: Pilot project in three commercial transport companies (buses, trucks, taxis; Bjerre, 2005) and survey among 118 companies, Bjerre & Kostela, 2008).
The proportions of all engine starts that was prevented by alcolock were well below 0.5%. Most of the positive test results occurred during weekends and morning hours.
The acceptance of alcolock and its effects on drunk driving (and alcohol problems in general) depend on how it is implemented and integrated into the company`s alcohol policy
Passengers in buses and taxis were most positive towards the use of alcolock
Almost none of the companies in the study by Bjerre and Kostela (2008) considered resistance from trade unions being an obstacle. Still, about 25% of drivers experienced negative impacts of alcolock.
Some companies reported reduced sick leave (not systematically evaluated). In some cases, alcohol problems could be revealed and subsequently treated.</td></tr>
<tr><td>Høye, 2019 (Norway)</td><td>Eliminating all drunk driving, may reduce the total numbers of killed or seriously injured in crashes involving motor vehicles by up to 11.1%.
The effect of installing alcolock in all motor vehicles would most likely be smaller. Drunk drivers have most likely above average crash risk even when not drunk and some may replace alcohol before driving with other substances. Moreover, some drivers may succeed in circumventing alcolock.</td></tr>
<tr><td>Silverans et al., 2007 (Norway, Spain, and Germany)</td><td>Alcolock installed in some company vehicles.
The proportions of all engine starts that was prevented by alcolock were well below 0.5%
Acceptance was high.</td></tr>
<tr><td>Vehmas et al., 2012 (Finland)</td><td>Alcolock installed in all vehicles of companies
alcolock may become unpopular if drivers have to provide breath samples each time the vehicles is started or at random intervals while driving</td></tr>
</table>

DUI-courts and intensive supervision programs

Table 46: DUI-courts and intensive supervision programs

DUI-courts and intensive supervision programs	
Bouffard & Bouffard, 2011 (USA)	**No effects on alcohol-related crashes.** Time series analysis without control group: Evaluation of the introduction of a DUI court in a county of Washington: ▪ Sanction swiftness improved ▪ Certainty of punishment remained stable ▪ Severity of punishment even declined. ▪ Alcohol-related crashes: No effect Conclusion: The court did not have a deterrent effect.
Bouffard et al., 2010 (USA)	**No effect on recidivism among repeat DUI-offenders.** Hybrid DUI court (drug court model, same procedures for alcohol and drug related offences). Comparison group: Sentenced DUI offenders on parole after prison sentence; matched on age, gender, race, current offense (e.g., drug possession, DUI), and criminal histories (prison followed by parole is the standard sanction for repeat DUI offenders). ▪ Re-arrests for DUI (4 years): +167% (ns) ▪ Time to first re-arrest for DUI: -37% (-75 %; +63 %).
Carey et al., 2008 (USA)	**Reduced recidivism.** Outcome evaluation of Michigan's DUI courts. ▪ Reduced recidivism and alcohol / drug use (compared to traditional sentencing and probation) ▪ shorter waiting period between arrest and sentencing ▪ Cost savings for the criminal justice system.
Eibner et al., 2006 (USA)	**Reduced DUI.** Evaluation of Rio Hondo DUI court, a therapeutic court intervention targeted to repeat DUI offenders. ▪ Improvements in alcohol-related and criminal behavior.
Fell et al., 2010 (USA)	**Large reductions of rearrest rates.** DUI court vs. standard sanctions. Comparison 1: DUI offenders from similar counties without DUI courts. ▪ Re-arrests (4 years): -64% Comparison 2: DUI offenders from the same county before DUI courts were established. ▪ Re-arrests (4 years): -79%
Ferguson et al., 1999 (review)	**DUI-rehabilitation: reduced DUI.** Literature review: ▪ DUI rehabilitation programs can reduce recidivism by about 7.9% ▪ Programs that include several types of interventions (e.g. counselling, education, probation) and that are combined with sanctions were found to be more effective than programs with only a single component and programs that are not combined with sanctions.
Jones and Lacey, 1999	**No effect on recidivism.** Evaluation of a Day Reporting Center for reducing DUI recidivism among repeat DUI offenders. ▪ No effect on recidivism (compared to standard sanctions) ▪ More cost effective and relieves pressure from jail system.
Jones et al., 1996 (USA)	**Reduced recidivism.** Evaluation of two alternative sanctions for repeat DUI including treatment, monitoring, and supervision vs. traditional sanctions. ▪ Reduced rearrest rates by between one half and one third ▪ Cost savings compared to incarceration.
Lapham et al., 2006 (USA)	**Reduced recidivism.** Court-based intervention for repeat impaired-driving offenders. Comparison group and statistical control for confounding variables. ▪ Reduced rearrest rates (-48% [-44; -24])

DUI-courts and intensive supervision programs	
MacDonald et al., 2007 (USA)	**No effects on DUI or recidivism.** DUI court vs. traditional criminal court. Experimental study (random assignment). ▪ DUI (24 months): No effects ▪ Recidivism (24 months): No effects
Miller et al., 2015 (**review**)	Systematic review of interventions for convicted DUI offenders in reducing recidivism. Results regarding DUI courts: ▪ The specific measures applied can be very different between DUI courts ▪ **Greater effects** have been found of **more restrictive programs**, and among drivers with **less criminal background**.
Mitchell et al., 2012 (**meta-analysis**)	**Drug courts: Ambiguous effects on recidivism, varying effects for different types of courts.** Meta-analysis of 154 drug court evaluations. Effects on recidivism: ▪ Ambiguous findings in experimental studies ▪ In weaker studies reduced on average from 50% to 38% (effects may last for up to three years) ▪ Smaller effects for courts including violent offenders (but on an individual level, drug courts can be at least equally effective among violent as among non-violent offenders) ▪ Smaller effects for juvenile drug courts ▪ Intensive supervision programs: Reduced recidivism (3 studies, two of these experimental studies), mixed results (1 study).
Ronan et al., 2009 (USA)	**Reduced recidivism (valid result?).** DUI court vs. traditional criminal court. Comparison group matched by age and gender; eligible but declined to participate. There were general differences between study and the choice of comp. group may have contributed to reduced recidivism. ▪ Recidivism (4.5 years): -38% (stat.sign.)

Table 47: Sobriety requirements

Sobriety requirements	
Caulkins & DuPont, 2010 (USA)	«24/7 Sobriety» program (South Dakota), implementation starting in the 1980s. The program requires multiple DUI offenders to submit two breath tests every day as a condition of bail. The program was extended to comprise drug tests to discourage substitution. Failed tests are punished with immediate incarceration for 24 hours. Compliance rates were high (two thirds had no failed or positive tests, only 6% had more than two failed or positive tests. ▪ The number of **fatalities in DUI crashes decreased** by about 50% from 2004 to 2008 (not a formal evaluation).
Kubas et al., 2015 (USA)	«24/7 Sobriety» program (North Dakota), including twice a day BAC- and drug-testing. Failure to comply leads directly to jail. ▪ **Reduced crash and citation rates** among drivers after enrolling in the program (refers most likely to the sobriety requirement period) ▪ Longer sentencing periods are associated with stronger deterrent effects ▪ Higher recidivism rates among those participating multiple times ▪ No or only small improvements among high-risk offenders with alcohol abuse problems.
Stevens, 2016 (USA)	«24/7 Sobriety» program (Montana), same type of program as described by Caulkins & DuPont (2010). Before-after study with comparison group (comparison = counties without the program). ▪ **Unchanged** number of monthly **DUI arrests** after implementation of the program.

V 6. Chapter 5 Treatment and educational programs: Tables

Table 48: Treatment of DUI-convicted drivers

Treatment of DUI-convicted drivers			
Study	**Description of the measure**	**Method**	**Results**
Duwe, 2010 (USA)	**Prison-based chemical dependency (CD) treatment** Education and individual/group counseling Target group: Imprisoned offenders with alcohol/substance abuse or addiction problems.	Case control study. Comparison group: Untreated prisoners (not offered treatment; propensity score matching) N=1852 (926 in treatment group) ***Selection bias unlikely***	42 months after period. ▪ **Rearrest**: -17% (-29; -5) ▪ **Reconviction**: -21% (-36; -6) ▪ **Reincarceration**: -25% (-43; -8)
Freiburger & Sheeram, 2019 (USA)	**Treatment and probation** to opt for reduced jail time (voluntary participants) Target group: 2nd and 3rd time DUI offenders	Case control study. Comparison group: Similar group of DUI offenders. ***Selection bias possible*** because of voluntary participation and exclusion of participants not obeying program rules or with new arrests during the program	**Recidivism**: ▪ Reduced considerably (possible selection bias)
Hagen et al., 1979 (USA)	**Alcohol abuse treatment** as alternative to license suspension or revocation for repeat DUI offenders.	Case control study. Multivariate control for confounding factors. ***Possible selection bias***.	Recidivism during treatment period: ▪ No effect.
Langworthy & Latessa, 1993; 1996 (USA)	**Treatment and education** of repeat DUI offenders. Short- and long-term evaluation.	Case control study with statistical control for potential confounding variables. ***Selection bias present*** ***Possible regression to the mean***.	**Recidivism:** ▪ Reduced recidivism (non-significant; stat. sign. among multiple offenders). ▪ Effects sustained over four years.
Miller et al., 2015 (**systematic review**)	Systematic review of **DUI treatment/intervention programs**	Systematic review (44 studies) ***Lack of high-quality evidence***	**Recidivism:** ▪ Programs including intensive supervision *may* be effective. ▪ Heterogeneity of DUI offenders has to be considered.
Sadler et al., 1991 (USA)	**Alcohol abuse treatment** as alternative to license suspension or revocation for repeat DUI offenders.	Case control study. ***Possible selection bias***.	Recidivism (four years incl. treatment period of one year): ▪ no effect on alcohol related crashes ▪ +70% non-alcohol related crashes ▪ +30% total crashes.
Woodall et al., 2004 (USA)	**Treatment in jail** (28 days; and 6 months post-discharge monitoring) Target group: First-time convicted drunk drivers.	Case control study. Comparison group: First time convicted drivers (varying sentences, jail and other) ***Limited generalizability***	**Crashes:** ▪ No effect (small non-significant reductions for both alcohol-related and other crashes)
Wells-Parker et al., 1995 (**meta-analysis**)	**Education and treatment programs** for DUI convicted drivers	Meta-analysis (105 studies) ***Possible selection bias***	**Crashes and recidivism**: ▪ -7% - -9% (not statistically significant; possible selection bias)

Table 49: Education of DUI-convicted drivers

Education of DUI-convicted drivers			
Study	**Intervention**	**Method**	**Results**
af Wåhlberg, 2011, 2013 (Great Britain)	**E-learning for young offenders.** Voluntary participation in exchange for fine and demerit points	Two comparison groups: General driver population / drivers sanctioned for speeding ***Possible regression-to-the-mean***	Self-reported, 6 months after ▪ **Crashes: -13%** ▪ Violations: Fewer ▪ Seat-belt use: Increased (result for seat-belt course)
Barta et al., 2016 (USA)	**Home confinement**, pre-release psycho-**education** and close post-release **supervision** for DUI offenders sentences to jail, as replacement for a part of the jail period	Comparison group: DUI offenders sentenced to jail only ***Selection bias unlikely***	Four years after period: ▪ Recidivism: Reduced
Bartl et al., 2002 (Austria)	**Education program for DUI convicted** drivers without addiction problems; focus on self-reflection rather than education	Review of six Austrian studies.	1-6 years after: ▪ Recidivism: Ca. -50%
California DMV, 2008 (USA)	**Course for drivers convicted of alcohol-related reckless driving** (reports from 2002-2008)	Before-after studies with control for trend ***Possible selection bias***	One year after completion: ▪ **Crashes: -5%** (-13; +4)
Ekeh et al., 2011 (USA)	**«Drive Alive» educational program (DUI / speeding)**, trauma center based Target group: Young drivers (mean age 17.4 years) referred to the program for speeding or DUI	Case control. Comparison group: Young drivers with similar convictions not referred to the program N=488 ***Possible selection bias.***	**Recidivism:** ▪ 6 months: -18% ▪ 9 months: -11% ▪ 12-60 months: No effect

Education of DUI-convicted drivers			
Study	**Intervention**	**Method**	**Results**
Ker et al., 2005 (**meta-analysis**)	**Remedial driver education** Target group: Drivers with poor previous driving records	Meta-analysis of 20 studies (most from USA) ***Possible bias (publication / selection bias)***	12 (most studies) or 24 months after: ▪ **Crashes: -2%** (-4; +1) ▪ **Injury crashes: +17 %** (-11; +54) ▪ Violations: -4% (-6; -2)
	Summary of results from Ker et al. (2005): ▪ Remedial driver education reduces crashes by 2% (-4; +1) and violations by 4% (-6; -2). Injury crashes increase by 17% (-11; +54). ▪ The effects refer to the up to two years after the intervention (most to the first year). ▪ The results are likely to be affected by publication bias, selection bias, and other biases. Thus, the reductions of crashes and violations are likely to be overestimated.		
Klipp et al., 2019 (Germany)	**Driver improvement** course for driver with accumulated **demerit points**.	Case control.	Violations: ▪ No effect.
Lyon et al., 2013 (USA)	**Warning letters** for drivers receiving demerit points **Demerit point related interviews** for drivers receiving demerit points **70+ program** for crash-involved (at-fault) older drivers (3-part driving test: vision, written, road) to keep the license	Case control. Comparison group: Drivers without intervention but "similar" driving records in the before period ***Likely selection bias*** (all drivers who met criteria for treatment received the treatment)	**Crashes:** ▪ Warning letters: -8% (-10; -5) ▪ Demerit point related interviews: -12% (-16; -8) ▪ 70+ program: -33 (-42; -24)
Masten & Peck, 2004 (**meta-analysis**)	**Different types of remedial interventions for drivers with poor driving records**	Meta-analysis of 35 studies. All studies are experimental or quasi-experimental studies that have reported subsequent crash and violation rates.	Effects on **crashes** / violations: ▪ **Information material: -1%** / -1% (both ns) ▪ **Group meeting: -5%** / -8% (both stat. sign.) ▪ **Individual meeting: -8%** / -10% (both stat. sign.) ▪ **Warning letter: -4%** / -6% (both stat. sign.)
	Summary of results from Masten & Peck (2004): ▪ Small but statistically significant crash reductions were found for warning letters, group meetings, and individual meetings. However, none of these measures was as effective as license suspension or revocation. ▪ Information brochures were not associated with crash reductions. ▪ Effects on crashes were generally far smaller than effects on violations. ▪ The effects are relatively stable during the first two years post-intervention, but no effects were found over two years after the intervention. ▪ Experimental studies found far smaller effects than quasi-experimental studies.		
Mills et al., 2008 (Australia)	**New South Wales Sober Driver Programme (SDP), educational program with elements of group cognitive behavioral therapy** in relation to DUI, in conjunction with punitive sanctions; focus primarily on drunk driving (not drinking). Target group: Repeat DUI offenders.	Case control. Comparison group: Drivers before program implementation with similar penalties. N=2451; N=1740 in study group) ***Selection bias unlikely***	Two year after period. **Recidivism**: ▪ All participants: -43% (-53; -28) ▪ Completers: -53% (-63; -40)

Education of DUI-convicted drivers			
Study	**Intervention**	**Method**	**Results**
Ouimet et al., 2013 (Canada)	**Brief Motivational Intervention (BMI)**, 30-min. motivational interview Target group: Repeat DUI-offenders with signs of problem drinking; voluntary participation	Experimental study (random assignment) Comparison: 30-min. delivery of information and advice about drinking and driving N=180 (85 in BMI group) ***Selection bias unlikely***	4.6 years after period ▪ **Crashes: -27%** (-80; +169) ▪ Recidivism: -31% (-75; +86)
Rider et al., 2007 (USA)	**Preventing Alcohol-Related Convictions (PARC)**, educational 12-hour program focusing on controlling driving (not to drive to drinking events) Target group: 1st time DUI offenders	Experimental post-test only (random assignment) Comparison group: traditional 12-hour DUI N= 9,571 (5,463 of which in intervention group) ***Selection bias unlikely***	**Recidivism:** ▪ First year: -43% (-59; -20) ▪ Second year: -27% (-44; -5)
Robertson et al. (2009)	**Court-mandated intervention** program Target group: 1st time DUI offenders	Case control Comparison group: Non-participants and non-completers; statistical control for alcohol problems and driver characteristics (age, gender, education)	Three year after period: ▪ Recidivism: -34%
Schermer et al., 2008 (USA)	**Trauma Center Brief Intervention**, 30-min. intervention performed by a social worker or a trauma surgeon Target group: Crash involved DUI-drivers treated at trauma center	Experimental study (random assignment of patients) Comparison: Standard care N=126 (50% of which in intervention group) ***Selection bias unlikely***	Three year after period: ▪ Recidivism: -68% (-89; -4)
Villaveces et al., 2011 (USA)	**Postviolation Driver Improvement Class**, 8-hour class for drivers with <u>speeding</u> convictions	Case control study. Comparison group: Speeding convicted drivers not assigned to the class. ***Selection bias possible***	1-3 years after period: ▪ New speeding violation: +3%; -5; +12) ▪ **Crashes: -17%** (-23; -9)

Table 50: Victim impact panels

Victim impact panels	
C'de Baca et al., 2001 (USA)	Case control study. Mandatory participation at VIP vs. not. Statistical control for potential confounding factors. ▪ <u>No effect</u> of VIP on recidivism. ▪ <u>Possible increase</u> among female drivers.
Crew & Johnsen, 2011 (USA)	Case control study. ▪ <u>No effect</u> of VIP on recidivism.
Fors & Rojek, 1999 (USA)	Case control study with matched comparison group. One year follow-up. ▪ <u>Reduced recidivism</u> among white men, ages 26-35 years with and one prior DUI arrest ▪ Otherwise <u>no</u> statistically significant <u>effects.</u>
Goodwin et al., 2015 (**literature review**)	Literature review (no systematic review): Four studies (C'de Baca et al, 2001; Wheeler et al., 2004; Crew & Johnson, 2011; : ▪ <u>No effect</u> of VIP on recidivism.

Victim impact panels	
Joyce & Thompson, 2017 (USA)	Case control study. Random assignment of offenders to judges, one of whom never ordered VIP participation (selection bias unlikely). Multivariate control for potential confounding factors. Recidivism after 6 months, one year, and two years. ▪ Reduced recidivism (-40% after two years) ▪ Larger effects among second-time participants.
Landenberger & Lipsey, 2005 (**meta-analysis**)	Meta-analysis of 58 studies of the effects of cognitive-behavioral therapy (VIP *and other measures*) on the recidivism of adult and juvenile offenders (*not specifically focusing on DUI offenders*). ▪ Inclusion of VIPs reduced the effectiveness of treatment programs on recidivism.
Miller et al., 2015 (**systematic review**)	Systematic review (7 studies from 1995-2011, all except one are from 2004 or earlier): ▪ Three studies: No effects of VIP on recidivism ▪ Three studies: Reduced recidivism ▪ One study: Increased recidivism among females and no effect otherwise.
Polacsek et al., 2001 (USA)	Randomized controlled trial, participants vs. non-participants in VIP in addition to "DWI school", with one- and two-year follow-up. ▪ No effect of VIP on recidivism.
Sprang, 1997 (USA)	Case control study. ▪ Reduced recidivism.
Rojek et al., 2003 (USA)	Case control study, five-year follow-up. ▪ Reduced recidivism during the first two years ca. -50%) ▪ No effect in year three to five.
Shinar & Compton, 1995 (USA)	Case control study. ▪ No long-lasting effect of VIP on recidivism. ▪ Possible effect among offenders above 35 years.
Wheeler et al., 2004 (USA)	Experimental study with random assignment to VIP among participants of a court-ordered program for first-time DUI offenders. ▪ No effect of VIP on recidivism.

V 7. Chapter 6 Demerit point systems: Tables

Table 51: Demerit point systems – effects on crashes

Demerit point systems – effects on crashes					
Country (demerit point system since)	**Study**	**Dependent variable**	**Results[b]**	**Months after**	**Method: Controlled for**
Czech Republic (2006)	Montag, 2010*	Fatalities	-9% (-16; -1)	30	Crashes in neighboring country
France (1992)	Chatenet, 1993 (cited after Izquierdo et al., 2011)	Injury crashes	«Large decrease»	Unknown	Unknown
Ireland (2002)	Lenehan et al., 2005*	Injuries	-44% (-52; -36)	12	Non-traffic related injuries
Italy (2003)	DePaola et al., 2013	Fatalities Injuries Crashes	-30% -18% -9%	12	Weather, police enforcement, speed cameras, gasoline prizes, unemployment
	Farchi et al., 2007*	Fatalities	-4% (-14; +7)	12	Age, gender, place of residence (Rome vs. other)
	Zambon et al., 2007*	Fatalities	-18% (-20; -16)	17	Trend (crash numbers), traffic volume
		Injuries	-19% (-24; -14)	17	Trend (crash numbers), traffic volume
Kuwait (2006)	Akhtar & Ziyab, 2012*	Injuries	-15% (-28; +1)	42	Trend (crash numbers)
Norway (2004)	Stene et al., 2008	KSI	No effect	48	None
Norway (2011)	Sagberg, 2016*	Crashes with young drivers	-10% (-15; -5)	36	Trend (crash numbers among drivers above 19 years)
Spain (2006)	Novoa et al., 2010*	Fatalities	-8% (-15; -0,2)	18	Trend (crash numbers)
	Pulido et al., 2010*	Fatalities	-15% (-23; -6)	18	Trend (crash numbers), other road safety measures introduced in 2004
	Martínez-Gabaldón et al., 2019	Fatalities	-15%	24	Trend, other safety measures

* Included in calculation of summary effect.

[a] The effect refers to traffic convictions of individual drivers in general; the effect for convictions with demerit points was greater than that for other convictions; the effect lessened substantially after two months, and disappeared from the third month after a conviction.

[b] Results refer to crash/injury number on country level, unless denoted otherwise.

Table 52: Demerit point systems – effects on driver behavior

Demerit point systems – effects on driver behavior			
Country (demerit point system since)	**Study**	**Dependent variable**	**Result**
Effects in the general driver population			
Arab Emirates	Mehmood, 2010	Speed (observed)	**No effect** on average; most likely due to a lack of police enforcement.

Demerit point systems – effects on driver behavior			
Country (demerit point system since)	**Study**	**Dependent variable**	**Result**
Canada (Quebec) (1992)	Dionne et al., 2011	Traffic violations (observed)	**Traffic violations reduced** by 15% after introduction of a demerit point system that is part of an insurance rating scheme.
Italy (2003)	DePaola et al., 2013	Traffic violations (observed)	**Violations addressed by the demerit point system decrease** more than other violations.
	Zambon et al., 2007	Seat belt use (observed)	**Increased seat belt use** among rear seat passengers (+120%), drivers (+52%), and front seat passengers (+42%).
	Zambon et al., 2008	Seat belt use (observed)	**Increased seat belt use** (+38%). Larger increase among men than among women (seat belt use was lower among men, both before and after introduction of the demerit point system).
Norway (2004)	Stene et al., 2008	Speed (observed)	**No effect** on average speed.
Spain (2006)	Gras et al., 2014	Speed, DUI, seat belt use (self-reported)	**Reduced speed and DUI, and increased seat belt use** among young drivers, improvements are greatest among women.
	Izquierdo et al., 2010	Speed, seat belt use, helmet use (observed)	**Fewer (large) speed limit violations, increased use of seat belts and motorcycle helmets.** Publicity and generally increased focus on road safety in media may have contributed to the effects.
Effects among drivers with demerit points			
Denmark (2005)	Abay, 2015	Traffic violations (observed)	**Reduced violations**; drivers with demerit points are less likely to get new demerit points, especially drivers with many demerit points. Greatest effects were found among drivers who depend on their car. The effect vanishes as the demerit points expire.
Germany (2005)	Schade, 2005	Crashes and violations (observed)	**More violations and crashes:** Drivers with penalty points are more often involved in crashes and violations than drivers without penalty points and larger numbers of penalty points are associated with more crashes and violations.
Norway (2004)	Stene et al., 2008	Traffic violations (self-reported)	**Fewer traffic violations** among drivers with six demerit points (six points: warning letter is issued; eight points: license suspension). No effect among drivers with fewer or no demerit points.
Norway (2004, 2011)	Sagberg & Ingebrigtsen, 2018	New demerit points (observed)	**U-shaped relationship** between previous and future demerit points: Drivers who have demerit points are more likely to get (new) points than drivers without demerit points; drivers who are only one point from license suspension are less likely to get new points.
	Sagberg & Sundfør, 2019	Traffic violations (self-reported)	**Fewer traffic violations:** More demerit points are associated with larger effects on violations. Even drivers without any demerit points report that their driving was influenced by fear of penalty points.
Spain (2006)	Montoro & Roca, 2008; Roca & Tortosa, 2008 (both after Izquierdo et al., 2010)	Speed, mobile phone (self-reported)	**Larger improvements** were found among drivers who had got demerit points during the previous year than among drivers who hadn't.

V 8. Chapter 7 Fines and imprisonment: Tables

Table 53: Mandatory minimum fines and jail sentences – general effects

Mandatory minimum fines and jail sentences – general effects	
Elvik et al., 2009 (**meta-analysis**)	**Minimum fines/jail sentences as DUI sanctions – general effects:** ▪ **No effects (total / alcohol-related crashes).** Review of US studies; state level studies with statistical control for confounding variables. Minimum jail sentences are between two and ten days. Evans et al., 1991 Ruhm, 1996 Young & Likens, 2000 Whetten-Goldstein et al., 2000 Dee, 2001 Eisenberg, 2001 Sen, 2001 Wagenaar et al., 2007 No effects on crashes (either involving or not involving alcohol): ▪ Minimum fines: -1% (-9; +7) ▪ Mandatory jail sentences: -2% (-5; +2).
Elvik et al., 2009 (**review**)	**Imprisonment as a standard DUI sanction – general effects on crashes and recidivism:** ▪ **No effects** Review of studies of the effects of imprisonment as a standard sanction for DUI convicted drivers in the USA (state level studies) on the total number of accidents in the respective states. Ross et al., 1990 Epperlein, 1987 Robertson et al., 1973 Jones et al., 1988 None of these studies have found any effects on accidents or recidivism.
Wagenaar et al., 2000 (**review**)	**Minimum fines/jail sentences as DUI sanctions – general effects :** ▪ **No effects / more crashes (total / alcohol-related crashes).** Summary of review (cited from Goodwin et al., 2015): Mandatory jail for DUI is generally ineffective and may be counterproductive and increase alcohol-related crashes.
Wagenaar et al., 2007 (**review**)	**Minimum fines/jail sentences as DUI sanctions – general effects:** ▪ **Possible effects (crashes/recidivism)** ▪ **No effects among heavy drinkers (crashes/recidivism).** Studies of minimum fines or jail sentences as DUI sanctions from 1992-2006. ▪ DUI fines: o Six out of 19 studies found reduced crashes/recidivism o Conclusion: "… there is some, but not strong, evidence that legislated DUI fines alone, or in combination with jail terms, may deter drink-driving and may decrease traffic mortality, perhaps mainly among young drivers." (p. 983). ▪ DUI jail sentences: o Two out of six studies found reduced crashes. o Four studies found reduced recidivism. o Jail sentences may deter, but not heavy drinkers.

Mandatory minimum fines and jail sentences – general effects	
Wagenaar et al., 2007 (USA)	**Minimum fines/jail sentences as DUI sanctions – general effects:** ▪ **No effects (fatal crashes / SV nighttime crashes).** State-level study, times series. Outcome: Alcohol-related fatal crashes. Mandatory minimum fine (26 states), mandatory minimum jail (18 states). Mandatory minimum fine / Mandatory minimum jail SV nighttime: no effect / -6% Low BAC (0.01–0.07): no effect / no effect Medium BAC (0.08–0.14): no effect / no effect High BAC (≥0.15).: -8% / no effect
Young & Likens, 2000 (USA)	**Mandatory minimum penalty for drunk driving – general effects:** ▪ **No effects (total / alcohol related fatalities).** State level cross sectional study. Existence of mandatory fines is generally unrelated to motor vehicle fatality numbers (total and alcohol related).

Table 54: Increasing penalties / fines– general effects

Increasing penalties / fines– general effects	
Briscoe, 2004 (Australia, NSW)	**Doubled penalties for drunk driving – general effects:** ▪ **No effect (fatalities)** ▪ **More crashes (DUI-proxy injury crashes)** Study in in New South Wales of doubling DUI penalties in 1998: ▪ Fatal accidents: No effect ▪ Injury accidents: Increase ▪ DUI-proxy injury crashes: Increase.
Castillo-Manzano et al., 2011 (Spain) Novoa et al., 2011 (Spain)	**More severe penalties and jail sentences – general effects:** ▪ **Possible reductions of fatalities and injury crashes (lacking control for other factors)** Evaluation of a reform of the Spanish Penal Code which upgraded several traffic violations to criminal offences, thus more offences could be punished by severe fines and jail. Time-series analysis, control only for car use and economic conditions. ▪ Overall fatalities: Reduced ca. 15-25%, lasting effect ▪ Injury crashes, male drivers: Reduced -7% (-11; -3) ▪ Injury crashes, female drivers: No effect The effects may also be due to other factors that are not statistically controlled for.
Chang et al., 2012 (USA)	**Increased penalties for drunk driving – general effects:** ▪ **No effect (alcohol related fatalities).** State level study, eight alcohol related policies. Dependent variable: Alcohol related fatality rate (relative to total fatalities). Control for other alcohol policies, population, speed limit, economic factors. Effects of increased fines for drunk driving: ▪ Total and alcohol-related fatalities: Reduced (stat. sign.) ▪ However: The effect on total fatalities is greater (coeff. = -0.044) than on alcohol-related fatalities (coeff. = -0.017) ▪ Conclusion: The reduction of alcohol-related fatalities is most likely due to other factors.
Hingson et al., 1987 (USA)	**Increased penalties for drunk driving – general effects:** ▪ **Possible short term reduction (SV nighttime fatal crashes).** Simple before-after comparisons without control for trend or confounding variables. ▪ SV nighttime fatal crashes: Possible short term effect, no long term effect. ▪ Self-reported drunk driving and perceived risk of apprehension: No effect. ▪ Many drivers thought that the odds of being punished if caught by the police had increased but the perceived risk of apprehension was still very low.
McCartt & Northrup, 2003 (USA)	**Enhanced sanctions for drunk drivers with high BAC (> .20) – general effects:** ▪ **No long-term effects (drunk driving).**

Increasing penalties / fines– general effects	
Neustrom & Norton, 1993 (USA)	**Increased penalties for drunk driving – general effects.** ▪ **Fewer crashes (DUI-proxy crashes; uncertain effect).** First three years after introduction of increased DUI penalties; lack of control for potential confounding factors. ▪ Night-time injury crashes: -9% (-11; -8); change may be due to other factors.
Young & Likens, 2000 (USA)	**Magnitude of penalties for drunk driving – general effects.** ▪ **No effects (total / alcohol related fatalities).** State level cross sectional study. Magnitude of fines is generally unrelated to motor vehicle fatality numbers (total and alcohol related).

Table 55: Penalties vs. jail – general effects

Penalties vs. jail – general effects	
Ross & Klette, 1995 (Norway and Sweden)	**Differentiated sanctions (penalties, conditional/unconditional jail) instead of jail as a standard DUI sanction – general effects on crashes.** ▪ **Fewer fatal crashes, no effect on injury crashes** Time series, controlled for trend only; several other changes in the study period have not been taken into account, e.g. an increase of police enforcement and the reduction of the illegal BAC limit from 0.05 to 0.02 in Sweden. ▪ Injury crashes: -3% (-8; +2) ▪ Fatal crashes: -18% (-25; -10). Results cannot be generalized because of methodological weaknesses. However, one may conclude that mandatory jail sentences not under all conditions are more effective than monetary penalties.

Table 56: Jail vs. other sanctions (specific effects) (overview of results)

Jail vs. other sanctions (specific effects) (overview of results)			
Study	**Measure**	**Effect**	**Comment**
Caudy et al., 2018 (USA)	**Jail** instead of probation	**More** recidivism.	Greatest increase among high risk offenders / those needing treatment
de Figueiredo, 2016 (USA)	**Jail** (6 to 24 hours) and fines vs. no sanction	**No** difference in recidivism and crashes	1st time offenders
DeYoung, 1995 (USA)	**Jail** instead of license suspension/treatment	**More** recidivism	1st time offenders
Green & Winik, 2010 (USA)	Type and severity of sanction (**jail**, probation, supervision)	**No** difference in rearrest rates	Drug offenders Experimental study
Martin, 1993 (USA)	**Jail** (two days) instead of penalties	**No** difference in recidivism	1st time DUI offenders Experimental design
Trevena & Weatherburn, 2015 (Australia)	**Jail** (up to 12 months) instead of license suspension	**No** difference in reoffending	Methodological weakness: Less driving while suspended not taken into account
Villettaz et al., 2006 (**review**)	**Jail** vs. other sanction	**No** difference / **more** reoffending	Not limited to road traffic related offences; better studies are more favorable for jail
Weatherburn & Moffatt, 2011 (Australia)	Jail vs. higher **fines**	**No** difference in recidivism	
Weinrath & Gartrell, 2001 (Canada)	Longer **jail** terms (up to 5-6 months)	**Less** recidivism	No further reduction of recidivism for imprisonment above 6 montsh

Table 57: Jail vs. other sanctions (specific effects) (detailed results)

Jail vs. other sanctions (specific effects) (detailed results)	
Caudy et al., 2018 (USA)	**Jail vs. probation for any kind of offence – specific effects:** ▪ **Jail instead of probation – more recidivism (especially among high risk offenders).** Multivariate analyses with control for individual risk factors. Offenders sentenced to jail vs. comparable offenders sentenced to probation. Jail increases risk for recidivism, especially among offenders at high risk for recidivism and those needing treatment.
de Figueiredo, 2016 (USA)	**Jail and fines (and license suspension) for drunk driving – specific effects:** ▪ **Jail (6 to 24 hours) and fines vs. no sanction – no difference in recidivism and crashes (1st time offenders)** Quasi-experimental study comparing different types of sanctions for drunk driving. Conclusions: For drunk drivers, incapacitation is the most effective mechanism, while specific deterrence is less important/effective. Jail incapacitates only temporarily and may is "prone to "hardening" and negative peer learning".
DeYoung, 1995 (USA)	**Jail vs. license suspension and treatment for DUI – specific effects:** ▪ **Jail instead of license suspension/treatment – more recidivism.** Recidivism rates compared between different sanctions (jail only, jail & suspension / program / restriction, program only, program & restriction), statistical control for potential cofounding variables: First time DUI-offenders: Highest recidivism after jail only, all other sanctions have considerably lower recidivism rates (may be partly due to differences between offenders, despite statistical control).
Green & Winik, 2010 (USA)	**Jail / severity of jail and probation – rearrests.** ▪ **Type and severity of sanction (jail, probation, supervision) – no effects on rearrest rates (*drug offenders; experimental study design*)** Rearrest rates among drug offenders compared between different types and severities of sanctions (jail, probation, supervision). Offenders were randomly assigned to judges who differed in what type of and how severe sanctions they were using. There were no differences in rearrest rates, depending on which judge the offenders were assigned to.
Guenzburger & Atkinson, 2014 (USA) Ferguson, 2012 (USA)	**Comparison of jail sentences and actually served jail times.** ▪ **Results from empirical studies may be biased if based on sentenced jail times.** Guenzburger & Atkinson, 2014: Actual jail times are on average far shorter than jail sentences. Actual time served is typically less than one day for 1st and 2nd offenders and about 20 days for 3rd time offenders. Ferguson, 2012: Most evaluations cannot distinguish whether jail time was actually served.
Martin, 1993 (USA)	**Jail (two days) and penalties vs. penalties only for DUI – specific effects:** ▪ **Jail (two days) instead of penalties – more recidivism (1st time DUI offenders; *experimental design*).** Introduction of mandatory two-day jail sentence for all first-time DUI offenders. Kind of experimental design: One judge did as intended by the law, the other sentenced only few first-time offenders to jail. Recidivism rates: ▪ No differences in recidivism between «jail» and «no jail» judge ▪ No difference between those sentenced to a fine (large or small) with no jail and those who were given a two-day jail sentence plus a small fine ▪ Conclusion: Jail is not more effective than monetary sanctions.

Jail vs. other sanctions (specific effects) (detailed results)	
Trevena & Weatherburn, 2015 (Australia)	**Jail vs. suspension for any kind of offence – specific effects on reoffending.** ▪ **Jail (up to 12 months) instead of license suspension – no difference in reoffending *(less driving while suspended <u>not</u> taken into account)*.** Matched pairs comparison, jail (up to 12 months) vs. “suspended sentence of two years or less” (unclear what that means). Dependent variable: time to the first new offence. Adjusted for time spent in custody (no adjustment for time with suspended license). ▪ <u>No differences</u> between jail and other sanctions. ▪ Possible explanations (own interpretation, information from original study is lacking): No differences or deterrence effect after jail is as large as the effect of reduced exposure during license suspension.
Villettaz et al., 2006 (**review**)	**Custodial vs. non-custodial sanctions for <u>any kind of offence</u> – specific effects:** ▪ **Jail vs. other sanction – same/more reoffending (*not limited to road traffic related offences; better studies are more favorable for jail*)** Custodial sanctions include jail and other sanctions that imply deprivation of freedom of movement. Non-custodial sanctions include “alternative” sanctions such as community work, , electronic monitoring, financial or suspended custodial sanctions. Sanctions or all kinds of offences are included (***not limited to road traffic related offences***). Compared to non-custodial sanctions, **custodial sanctions (jail)** are: ▪ <u>Favorable for jail in two</u> studies ▪ Neither favorable nor unfavorable in 14 studies ▪ <u>Unfavorable for jail in 11</u> studies. Experimental studies are less unfavorable, i.e. <u>better studies are more favorable to jail</u> sentences than to alternative sanctions.
Weatherburn & Moffatt, 2011 (Australia)	**Effectiveness of high fines for DUI – specific effects:** ▪ **Higher fines – unchanged recidivism.** Relationship between size of fines for drunk driving and recidivism: No relationship was found.
Weinrath & Gartrell, 2001 (Canada)	**Length of <u>imprisonment</u> for DUI – specific effects:** ▪ **Longer imprisonment – less recidivism**. Case control study, controlled for prior DUI convictions, other convictions and treatment for alcohol problems. Longer prison sentences (up to 5-6 months): ▪ <u>Reduced reconviction</u> rates ▪ More effective among drivers with four or more prior DUI convictions than among those with fewer prior DUI convictions. ▪ No further reduction of recidivism for sentence lengths above 6 months.

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