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# Overview of Major Issues Regarding the Impacts of Alcohol and Marijuana on Driving

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AAA Foundation for Traffic Safety

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## Title

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## About the Sponsor

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Founded in 1947, the AAA Foundation in Washington, D.C. is a not-for-profit, publicly supported charitable research and education organization dedicated to saving lives by preventing traffic crashes and reducing injuries when crashes occur. Funding for this report was provided by voluntary contributions from AAA/CAA and their affiliated motor clubs, from individual members, from AAA-affiliated insurance companies, as well as from other organizations or sources.

As part of a project funded by the AAA Foundation for Traffic Safety, this document provides an overview of issues related to marijuana consumption, driving impairment and blood testing as well as the potential impacts of social and legal factors. Comparisons are made to alcohol to provide a point of reference. This overview focuses on the types of marijuana generally available at legal recreational stores and medical dispensaries and not on pharmaceutical grade preparations.

| | Alcohol | Marijuana |
|---|---|---|
| ***Factors affecting blood concentrations*** | | |
| **Form and route of ingestion** | When people drink alcohol, absorption is slower if alcohol is accompanied by other calories and after eating. Alcohol does not have to be digested and enters the blood through diffusion[1]. | Many: Different methods of smoking or vaporizing plant parts (e.g., leaves and buds), resins (hashish), and extracts (hash oil) result in different rates of absorption in the lungs. Oils and extracts can be applied topically and sublingually or infused into "edibles" such as cookies or candies. |
| **Concentration and labeling** | Producers are required to label alcohol by volume or proof (twice the percentage of alcohol by volume). Different forms have different potencies, thus the standard drink sizes have different volumes of liquid, though they contain the same amount of alcohol: 12 oz. regular beer ≈ 5 oz. wine ≈1 shot (1.5 oz.) liquor. | $\Delta^9$-tetrahydrocannabinol (THC) is a cannabinoid in marijuana plants and causes the "high" typically associated with marijuana. Many other cannabinoids are present in marijuana as well. Plants vary widely in the level of THC produced, and concentrations vary among plant parts, resins, and extracts. Illicit and many medical dispensary products are not labeled for concentration of cannabinoids. WA[6] recreational products require concentration labeling, now with a maximum concentration for edibles of 10mg THC per dose and 10 doses per package, while CO rules allow for a 'potency unknown' label if no testing is done[7]. |
| **Metabolism and time since dosage** | The liver continually processes alcohol after absorption, removing it from the blood stream at a fairly constant rate. This allows easy back calculation of blood alcohol concentration (BAC) at a prior point in time since last drink. There is some variation among people depending on metabolism, prior alcohol use, muscle mass, etc.[3,8] In general, the larger a person is the more blood they have and therefore blood alcohol concentration is lower per unit of alcohol consumed. Females will achieve higher peak blood alcohol concentrations for a given dose than males with the same body weight and metabolic rate[32]. Peak breath alcohol concentrations are seen, on average, at approximately 40 minutes after the last drink, with a range from 10 to 91 minutes[1]. | THC blood levels decline exponentially, with wide variability by route[2,3,9–11], potency[2,3,10,11], and user characteristics[2–4,10,12]. Most research is with smoking and often does not account for the concentration of THC. Absorption via lungs is almost instantaneous, with psychoactive effects generally experienced within minutes[2–5]. Some consensus on 2-4 hours of effects after smoking, decreasing quickly after maximum impairment at 20-40 minutes, but higher THC-content smoke has longer-lasting effects[2–5,9] and milder effects have been documented at 6 hours or more post dosage[5,11] with user preferred doses. Slower absorption of oral doses, with onset in 30-120 minutes, particularly in presence of other food, creates a delayed and longer-lasting peak blood level[11,13] that is typically much lower than achieved following smoking. Metabolism and neurological effects of THC may also depend upon the levels of other cannabinoids in the consumed substance[2]. |

| | Alcohol | Marijuana |
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| ***Assessing blood concentration and impairment*** | | |
| **Physiological issues** | Alcohol moves readily throughout the body, so breath or blood levels are reflective of the concentration in the central nervous system (CNS)[3]. | THC is lipophilic, meaning it concentrates in fatty tissue, including the brain, and is less evenly distributed throughout the body than is alcohol. Blood levels therefore may not be reflective of CNS effects. THC itself may be measureable at very low levels in blood days after consumption (typically less than 1 ng/mL in blood), particularly in chronic users[5,11,15]. |
| **Impairment and blood concentration** | These are well correlated within limits, even allowing for tolerance: Subjective effects somewhat precede peak venous BAC levels but BAC levels correspond reasonably well with impairment[3]. Blood concentrations decline linearly. | Peak functional impairment lags peak blood level substantially, decreases at faster rate than effects of alcohol[3,17], with blood concentrations declining exponentially. Impairment remains for 2-4 hours after intake (at least in smoking research) despite blood levels dropping rapidly to low levels[3–5,12]. Following oral ingestion, absorption is slower with much later, and lower, peak blood concentrations, but still substantial impairment[33]. |
| **Main method of testing blood concentration** | Alcohol crosses into the lungs from the blood stream at a generally predictable ratio and can be measured in exhaled breath. The level in the breath is reasonably consistently correlated to the level in the blood[3], resulting in breath analyzers that are accepted measures of BAC. This also facilitates ignition interlocks for prior offenders[14]. Alcohol can also be directly measured from blood. | Currently, the most routine, accurate, and reliable way to measure THC levels is to test a blood sample[3,10,15], which has practical and constitutional implications for road-side testing. As THC metabolizes rapidly, collection must happen soon after driving, ideally within an hour[3]. |
| **Extrapolation to time of incident** | Fairly constant rates of elimination of alcohol from the bloodstream make it possible to estimate, within limits, BAC at any point in time between last drink (allowing for absorption) and the biological test[3] and can be used in court as evidence of estimated BAC at a particular time. A typical statutory requirement is based on BAC within 2 hours of driving, so extrapolation to within 2 hours of the incident/driving is often required. | It is not currently possible to extrapolate backwards with any scientific certainty from a given THC level at the time of a blood test[3]. THC and metabolites can remain in lipid membranes and deposits and be detectible in blood or urine for weeks, with high variability between people[2,3,10,15]. Simply detecting any THC does not therefore indicate impairment; relying upon any detectable THC or the presence of a THC metabolite has been a flaw in prior research on driver culpability in crashes. |
| **Behavioral screening** | The Standard Field Sobriety Test (SFST) is a standardized screener accepted as a potential indicator of impairment[15,18] and justification for biological testing of BAC[18]. | The SFST appears to be less accurate for impairment related to marijuana than alcohol[19]. |

| | Alcohol | Marijuana |
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| ***Factors affecting how acute use impairs driving*** | | |
| **Usual effects on driving-related functions** | Impairs psychomotor functions, pursuit tracking, divided attention, signal detection, hazard perception, reaction time, attention, concentration, and hand-eye coordination. Appears to impair tasks requiring conscious effort more than automatic tasks[3]. Little impairment at low blood levels, depending on skill/task[8]. | Acute use has been shown to moderately diminish virtually every driving-related capacity, generally in a non-linear dose-response fashion: psychomotor functions, cognition, attention, vigilance, tracking, reaction time and coordination[2–4,9,15,20]. Generally regarded to affect automated/routine driving more than that requiring conscious effort [3,12]. Effects depend on dose, absorption, time since peak blood level, history of use, and skill/task[3,13,20]. |
| **Self-perception** | Users tend to underestimate impairment and risk, even at low doses[3,8,12,17]. | Users tend to more accurately estimate or overestimate impairment and employ temporary compensatory defenses that mitigate effects on some skills[3,12,15,17]. |
| **Usual effects on driving behavior** | Tends to increase variation in speed[20], average speed[17,20], steering variability and lateral position[20], and passing attempts and decrease following distance[3]. | Effects on actual driving tend to be lower than those of alcohol, particularly at low doses. Users tend to employ slower speed[3,17,20], less passing[3], and higher following distance[3,9,12,20]. Largest and most consistent effect is on lane position (weaving)[3,12,13,17,20]. Some evidence of greater variation in speed at higher doses[20] and cases of speeding after using marijuana are relatively common[16]. Compensation may be less effective for responding to unexpected events[3,4,15] (e.g., other driver behavior, or an animal running across the road). |
| **Personality** | Effects depend on usual levels of aggression, thrill seeking, and risky driving[21]. Reduces risk aversion among those risk averse, increases impulsivity and aggressive driving among those prone to aggressive driving and reduces inhibitions at higher BAC. | Effects depend on usual levels of aggression, thrill seeking, and risky driving[3,21,22]. Thought to generally lower inhibitions, but may also induce paranoia[11] in susceptible users, and more frequently with some strains of marijuana. |
| **Tolerance** | Heavy drinkers tend to be less sedated at a given BAC due to tolerance[3]. This contributes to them being more likely to underestimate impairment and drive[23]. Heavy drinkers show tolerance, particularly with respect to sensorimotor impairment[8]. | Inconsistent evidence of tolerance effects[2,3]. May shorten time of impairment. Diminishes impairment but not psychological effects[5]. |
| **Experience** | Laws mandating lower BAC limits for inexperienced drivers reflect belief that effects may depend on driver experience[24,25], but evidence of experience effect above minimal levels of experience is mixed[20]. Prior negative experience (crash or arrest) may lower likelihood of driving after drinking[8]. | Effects appear to depend on experience with driving[20] and drug use[3]. Frequent users may be more practiced at compensatory defenses[3] but more likely to assume they can drive safely[26]. |
| **Other drug use** | Users in social settings often only drink alcohol (or perhaps smoke tobacco). Use with other drugs with sedative | Users often also consume alcohol. While research generally suggests additive or even multiplicative effects with alcohol, some studies suggest effects are |

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| | effects (opiates, barbiturates, etc.) may increase risk of crashes[27], but may be more likely at home. Some research suggests chronic (but not concurrent) marijuana use decreases effects of alcohol[3]. | no different than alcohol alone[17]. Alcohol likely reduces compensation skills marijuana users otherwise may employ[2,3]. Some evidence alcohol speeds absorption of THC. Little research on Marijuana with other drugs. |

| | Alcohol | Marijuana |
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| ***Stigma and legal context*** | | |
| **Stigma** | Public health and safety campaigns and high profile driving under the influence (DUI) cases have stigmatized drunk driving, creating a deterrence effect[24,25,28–30]. Thus, *before* they drink, users tend to be worried about either the risks of driving and/or the risks of getting caught. | Less stigma[3,26]. Users are more likely to believe that typical intake of marijuana has a limited effect on driving performance and/or that they can control such an effect[26]. Relaxation of prohibition associated with growing acceptance of use[3,10]. |
| **Consumption setting** | Drinking preceding driving generally done in a social and/or public setting[8], increasing chances of someone stepping in to convince drinker not to drive. | Marijuana use more likely to be at a residence, though this may change with expansion of legal recreational markets. |
| **Serving settings** | Responsibilities of serving establishments not always clear and consistent, but increasing responsibility being placed on bars and restaurants[8,24]. In practice, however, the decision to stop serving someone often comes at a BAC well above what impairs driving. | Legal serving is limited. Most states with medical marijuana laws prohibit public consumption, although enforcement varies widely. In legal recreational markets, some private smoking clubs may allow marijuana, and smoking bars are starting to be established testing the legal waters. Most consumption is therefore most likely at residences. |
| **Serving sizes** | Drinks usually come in fairly standard sizes, although mixed drinks can be of variable potency and sizes. Limited options for buying larger volumes; e.g., can't buy a gallon of vodka in a bar or restaurant. Alcohol concentration levels trigger differing requirements for container size and labeling. | Legal markets have struggled with questions of serving size for edibles; early packages sometimes had several times the THC of an average joint, with little indication of "serving size". WA State now regulates the size of a dose for edibles at 10mg of THC and the maximum number of doses per product at 10 doses for the recreational market[6]. |
| **Young people** | Minimum legal drinking age laws and zero tolerance for underage DUI (and accompanying stigma) limit but don't eliminate DUI among youth, help delay first time of having to choose whether to drive after drinking[24,25,28,31]. | Recent legalization in WA and CO has set minimum age of 21, but typical age of marijuana initiation is 17-18[3], and frequent users, who are at highest risk of drugged driving, likely have been obtaining marijuana illegally. |

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