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The combined effects of alcohol and cannabis on driving: Impact on crash risk

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ABSTRACT

Background/objectives: Driving under the influence of alcohol or cannabis alone is associated with increased crash risk. This study explores the combined influence of low levels of alcohol (BAC $\leq$ 0.08) and cannabis on crash risk.
Materials and methods: Drivers aged 20 years or older who had been tested for both drugs and alcohol after involvement in a fatal crash in the United States (1991–2008) were examined using a case–control design. Cases were drivers with at least one potentially unsafe driving action (UDA) recorded in relation to the crash (e.g., weaving); controls had none recorded. We examined the prevalence of driving under the influence of alcohol, cannabis, and both agents, for drivers involved in a fatal crash. Adjusted odds ratios of committing an UDA for alcohol alone, THC alone, and their combined effect were computed via logistic regression and adjusted for a number of potential confounders.
Results: Over the past two decades, the prevalence of THC and alcohol in car drivers involved in a fatal crash has increased approximately five-fold from below 2% in 1991 to above 10% in 2008. Each 0.01 BAC unit increased the odds of an UDA by approximately 9–11%. Drivers who were positive for THC alone had 16% increased odds of an UDA. When alcohol and THC were combined the odds of an UDA increased by approximately 8-10% for each 0.01 BAC unit increase over alcohol or THC alone.
Conclusion: Drivers positive for both agents had greater odds of making an error than drivers positive for either alcohol or cannabis only. Further research is needed to better examine the interaction between cannabis concentration levels, alcohol, and driving. This research would support enforcement agencies and public health educators by highlighting the combined effect of cannabis at low BAC levels.
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1. Introduction

Driving while under the influence of alcohol or illicit drugs continues to be a concern in developed countries. This behavior contributes too many motor vehicle crashes. As one example, drink-driving was a factor in almost 30% of Canadian motor vehicle fatalities that occurred in 2003 through 2005 [1]. In the United States, the 2009 National Survey on Drug Use and Health estimated that 30.2 million persons aged 12 years or older had driven under the influence of alcohol at least once during the past year, and 10.5 million persons had driven under the influence of illicit drugs, with young adults aged 21 to 29 years more likely to report these behaviors [2].

Alcohol is the drug detected most frequently in drivers fatally injured in a crash or hospitalized following a crash, while cannabis is one of the most frequently detected illicit drugs [3–6]. Many drivers are found to be under the influence of both alcohol and cannabis [5–13]. For example, Biecheler [8] found that 40% of drivers involved in a fatal crash in France who tested positive for cannabis also had a blood alcohol concentration (BAC) level above the legal limit of 0.05 g/dL, raising questions about their combined effect on drivers.

Alcohol has been consistently shown to have a dose-related effect on driving performance [13,14]. However, the effect of

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cannabis on driving performance is less well established. Research generally shows that recent cannabis use impairs some measures of simulated and on-road driving performance [15–20] and increases the risk of crash involvement [11,21–24] in a dose-related manner [15,25] but others found no statistically significant effect [25–32]. One potential reason for this discrepancy may be that drivers impaired by cannabis are often aware of their impairment and employ behavioral strategies to compensate, such as driving more slowly and increasing their following distance [14–16,20]. It is also possible that THC detection methods may be responsible for this discrepancy. As compared to measuring THC concentration in blood samples, alternative methods such as urine or hair analysis can detect the presence of cannabis metabolites long after ingestion, and presumably long after any impairing effects have dissipated [29]. THC concentration in the blood, on the other hand, is a much more acute measure. In a study conducted by Drummer et al. [33], the authors noted that among 3400 Australian accidents analyzed using blood sampling to test for cannabis consumption, the odds ratio of being responsible for an accident was 3.0(95% CI: 1.19, 7.62)[1] compared to those cases drug-negative. Further, when cases were positive for carboxy-THC a metabolite commonly detected via urine testing the odds of culpability did not differ compared to the drug-negative referent (OR: 0.8; 95% CI: 0.51, 1.28) However THC-only blood positive cases had increased odds of culpability compared to those cases positive for carboxy-THC only (OR: 3.75; 95% CI: 1.34; 10.45). Nonetheless, reviews generally find that only higher doses of cannabis are associated with elevated crash risk and impaired driving skills [25,29]. In a recent meta-analysis of nine culpability or case–control observational studies, acute cannabis consumption was estimated to increase the odds of collision resulting in serious injury or death by 92% (pooled OR: 1.92; 95% CI: 1.35, 2.73) [34].

Although law enforcement efforts in recent years have attempted to decrease driving under the influence of drugs, research suggests that the number of people driving under the influence of cannabis is increasing [5,35–39]. For example, a 10-year study of apprehended drivers in Sweden showed 18% tested positive for delta-9-tetrahydrocannabinol (THC; the main psychoactive chemical compound in cannabis) in 1995, while 29% tested positive in 2004 [37].

The effect on driving of alcohol and cannabis combined appears to be greater than that of either drug alone, with research generally suggesting that the effect is additive [10,14,25,32,40–42] or possibly synergistic [8,9,25,32,43,44], although some research has found no additive effect [11,45,46]. Of particular interest is the combined effect at low doses (i.e., when their BAC is below the legal limit). Research in this area shows inconsistent results. Lamers [45] found that a low dose of alcohol (i.e., producing a BAC of 0.04–0.05 g/dL) combined with a small dose of THC (100 μg/kg) produced no statistically significant difference in the on-road driving proficiency test compared with alcohol-and-drug-free drivers. However, driver visual search frequency at intersections was reduced by 3% ($p = 0.041$) and this effect was most pronounced in female drivers (7% decline in females, 0.3% decline in males). Conversely, Robbe [47] and Robbe and O'Hanlon [48] found that on-road driving performance was severely impaired when low doses of alcohol (BAC of 0.04 g/dL) and THC (100 or 200 μg/kg) were combined, while administering each of these doses alone produced only minor impairment (for the alcohol dose and THC dose of 100 μg/kg) or moderate impairment (for the THC dose of 200 μg/kg).

The present study was conducted to expand on those findings by examining the combined effect of alcohol and THC using fatal motor vehicle crash data. First, we examined the prevalence of driving under low BAC levels, cannabis, and both substances. We hypothesized that alcohol-detection would show a decreasing trend from 1993 through 2008, while cannabis-detection and cannabis combined with alcohol would show increasing trends. Second, we examined the combined effects of low BAC and THC on driving. We hypothesized that the combined effects of alcohol and THC would increase the odds of a driver committing an unsafe driver action compared with alcohol and THC free drivers.

2. Materials and methods

2.1. Data source

Driver crash data were drawn from the Fatality Analysis Reporting System (FARS) compiled by the National Center for Statistics and Analysis of the National Highway Traffic Safety Administration, U.S.A. From this dataset we derived our proxy measure of responsibility (i.e., presence of one or more unsafe driver actions), cannabis and alcohol exposure, and also driver age, sex, medication usage, and driver history. Full details regarding the data source used are published elsewhere [49].

2.2. Inclusion criteria

For inclusion in this study, drivers were required to have a valid blood alcohol content (FARS recorded range: 0 thru 0.94 BAC grams per deciliter) obtained by blood test. Further, all drivers had at least one confirmed blood drug test. We limited our analyses to drivers of passenger vehicles, sport-utility vehicles and light trucks (pick-up trucks) only. Drivers aged less than 20 were excluded as they would not have had sufficient time to acquire a driving history.

2.3. Proxy measure of responsibility

The FARS data source includes several driver-related crash factors. Factors 20–60 are unsafe driver actions (UDAs) that may have contributed to crash initiation [50]. For this study, drivers with at least one UDA recorded were considered to have contributed to the crash; those drivers with no UDAs were considered not to have contributed to crash initiation. As a proxy measure of responsibility, UDAs are preferred over traffic violations as a method of estimating the contribution of each driver involved in a crash given traffic violations can be under-reported due to the requirement of legal proof or given they may not be chargeable offences [50]. Further, the validity of UDAs has been examined using crash-configurations where crash responsibility can be inferred (e.g., head on, rear-end). The driver of the striking vehicle is typically assigned the majority of UDAs [50] and we have also demonstrated this association [51].

2.4. Cannabis, and other drug classification and exposure

Detailed results from drug tests are available from FARS from 1991 onward. This study examines data from 1991 to 2008. Between the years 1991 and 1992, drugs were recorded by group (e.g., Cannabis; Depressants). From 1993 to present (2008) drugs are classified individually (e.g., Hashish; Diazepam) within each drug group. The following THC containing drugs are recorded in FARS: Delta 9 (600); hashish oil (601); hashish (602); marijuana (603); marinol (604); tetrahydrocannabinoid (605); THC (606); cannabinoid, type unknown (695). For each driver, either one (1991 and 1992) or up to three serum analyses were available (1993–2008). Given this change in drug collection, for the primary analysis we only considered drivers who tested positive for one THC drug alone. The FARS database also captures various other

[1] Data were obtained from Drummer et al. [33], Table 1. Odds ratios and 95% confidence intervals were calculated using VassarStats website, located at: http://vassarstats.net/odds2x2.html.

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