Driving Under the Influence of Cannabis
An Increasing Public Health Concern

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Viewpoint

Driving is a complex task that requires integrity of sensory, motor, and cognitive function. The driving task may be compromised by factors related to the vehicle, the driving environment, and the driver. Driver impairment is a major cause of motor vehicle crashes and commonly results from alcohol intoxication.[1] Cannabis is the most frequently detected illicit drug among drivers involved in motor vehicle crashes, often in combination with alcohol.[2] Evidence from experimental and epidemiological studies indicates that cannabis also impairs driving performance and increases crash risk.[1,2] The prevalence of cannabis use is expected to increase following recent legalization of medical and recreational use in several countries worldwide and the introduction of a legal cannabis industry.[3] As a result, driving under the influence of cannabis has become an increasing public health concern.

Experimental laboratory studies have repeatedly demonstrated that the primary component of cannabis (ie, of Δ^9-tetrahydrocannabinol [THC]) impairs the motor performance (eg, reaction time, tracking) and cognitive function (eg, attention, decision making, impulse

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control, memory) needed for safe driving in a dose-related manner.[1,2] Performance impairments are maximal during the first hour after smoking and decline over 2 to 4 hours after cannabis use.[2]

Standard deviation of lateral position (SDLP), a measure of "weaving" or road tracking control as measured in on-road driving tests in actual traffic, appeared to be one of the most sensitive measures to detect THC-induced driving impairment. A study in 18 participants showed that smoking low (100 µg/kg of THC) and medium (200 µg/kg of THC) doses of cannabis significantly increased SDLP in a dose-related manner. The SDLP further increased when cannabis was combined with a low alcohol dose that produced a blood alcohol concentration (BAC) of 0.04 g/dL.[4]

In addition, the time spent driving outside of the traffic lane increased exponentially with increasing SDLP ($r = 0.94$) and was maximal (1.1%, about 40 seconds during the 1-hour driving test) following combined use of cannabis and alcohol. Mean increments in SDLP associated with cannabis use were equivalent to changes in SDLP previously observed in drivers performing the on-road test with a BAC of 0.05 g/dL, the

level of legal impairment in many European countries. Blood alcohol concentrations at or above this level have been associated with a substantial increase in crash risk.[1] Cannabis in combination with alcohol produced a mean increase in SDLP that was equivalent to that associated with a BAC greater than 0.10 g/dL, which is greater than the level of legal impairment in the United States.

Findings from on-road studies indicating that cannabis alone and combined with alcohol impairs road tracking have been replicated in driving simulator studies,[1,2] supporting their validity and reliability. On-road and driving simulator studies also have shown that cannabis produces dose-related impairments of distance keeping and reaction time that added to those of alcohol when given in combination[1,2] In these studies, drivers were aware of their driving impairment. Consequently, they invested more effort, drove at a greater distance from other vehicles, and slightly adjusted their speed.[1] Yet, drivers were unable to compensate for the adverse effects of cannabis on lateral position because road tracking performance is a highly overlearned, habitual, and automated process that operates outside of conscious control.

Other laboratory studies have explored the possibility that the impairing effects of THC might be substantially reduced after repeated use owing to tolerance but provided little empirical evidence for this assumption. Cognitive and psychomotor impairments were blunted in (some) regular cannabis users but were nevertheless evident across multiple performance domains.[5] An on-road driving study involving 24 participants[6] demonstrated that acute administrations of dronabinol (10 mg and 20 mg), a synthetic THC prescribed to treat anorexia in wasting diseases and emesis in patients with cancer and chronic pain, increased SDLP and reaction time in occasional as well as heavy (daily and near daily) cannabis users. Increments in SDLP were comparable with impairments associated with BACs of 0.08 to 0.10 g/dL in occasional users. The magnitude of driving impairment was generally less among heavy users but still comparable with a BAC of 0.05 g/dL, particularly after the higher dose of THC.

Epidemiological findings on the role of THC in vehicle crashes show that cannabis use among drivers is associated with a moderate (about 1.2- to 2.0-fold) increase in crash risk,[2] less of an effect than might have been predicted from experimental research. Various studies have shown that the combined use of cannabis and alcohol is associated with greater crash risk than the use of either alone.[1] A significant problem with epide-

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miological studies is that (blood) samples for drug screening are often taken 3 to 4 hours after a crash. Concentrations of THC in these samples are usually very low (around 1 ng/mL) and not representative of the event because THC concentrations decline very rapidly after smoking. Moreover, low THC blood concentrations are not necessarily an indication of recent use but may also reflect past use in nonimpaired drivers. Most epidemiological studies therefore have been unable to estimate crash risk of drivers during the acute intoxication phase of cannabis use. Those that did collect blood samples closer to the crash event typically reported higher associations (odds ratios of 2-14) between cannabis use and crash risk at THC concentrations above 5 ng/mL.[7]

Scientific evidence on the association between cannabis use and driving impairment contrasts with public attitudes toward driving under the influence of cannabis. Regular cannabis users often admit to driving under the influence of cannabis and wrongfully believe that cannabis does not affect their driving performance or that they can compensate for cannabis-associated impairment.[2] Consuming cannabis with or without alcohol is a common occurrence that causes substantial risk to intoxicated drivers and road users in general. In a policy brief by the World Health Organization, driving under the influence of cannabis was estimated to be responsible for slightly more than 8700 road traffic deaths worldwide in 2013.[8] This is still far less than the number of deaths due to alcohol-impaired driving in the same year (slightly more than 188 000) but does underscore the importance of developing evidence-based policy and legislation to counteract the safety risks posed by driving under the influence of cannabis.

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