RESEARCH NOTE: CANNABIS AND DRIVING – RESEARCH NEEDS AND ISSUES FOR TRANSPORTATION POLICY

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This paper summarizes current knowledge regarding the effects of cannabis use on driving. Psychopharmacological evidence has shown that cannabis, unlike alcohol, can be detected several days after consumption. Prevalence data has revealed that cannabis use is increasing, and that as many as 90% of study participants were willing to drive after consuming a typical dose. A review of laboratory studies found that cannabis and alcohol affect different driving tasks. When cannabis and alcohol use were evaluated in simulated and on-road driving situations, drivers were more aware of being intoxicated after using cannabis and thus invoked greater compensatory effort to offset impairment in the driving task. The effect of cannabis use on crash risk has shown that recent use increases crash risk, but not as much as alcohol consumption. This paper concludes that further research is needed before specific transportation policy can be developed for cannabis.

INTRODUCTION

Driver impairment is a significant factor associated with crash risk and an important safety concern. Any transportation policy designed to manage driver impairment must be developed on the foundation of research that identifies sources of impairment that negatively affect driver performance and increase crash risk (Robbe, 1994). Sufficient research has shown that alcohol, driver age, and cellular phone use impair driving performance and enhance crash risk (Dewar, 2002;

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Goodman, Tijerina, Bents & Wierwille, 1999; Moskowitz, 2002). Consequently, transportation policy has imposed legal limits for alcohol and, in some cases, graduated licensing for young drivers and restricted cellular phone use.

Drugs, another source of driver impairment, also warrant attention from policy makers (Kedjidijian, 1995). Cannabis is one of the most commonly consumed recreational drugs and has a long history of being a suspected source of driver impairment (Robbe, 1994). To the extent that there is a clear relationship between cannabis use, driver impairment, and crash risk, transportation policy must be developed to manage cannabis use by drivers (Border & Norton, 1996). Most countries, however, have not developed specific transportation policy for cannabis because much of the available research is inconclusive and some issues have not been adequately addressed.

When considering a rational policy for cannabis use and driving, one can reference the current knowledge regarding the impairment caused by cannabis relative to alcohol. The reason for this is that research has already shown a definitive relationship between blood alcohol concentration (BAC), impairment while driving, and increased crash risk (Moskowitz, 2002). This paper compares the effects of cannabis use and alcohol consumption on driving to provide a relative basis for discussing research needs and issues for transportation policy. Identifying these needs and issues as well as proposing a new direction for research is important for the development of transportation policy aimed at managing cannabis use by drivers.

This paper is organized into five sections to provide a logical examination of the effects of cannabis use on driving. The first section discusses the psychopharmacological properties of cannabis. Next, patterns of cannabis use in the population are described, including what proportion of drivers operate their vehicles after consuming the drug. A review of laboratory research, which summarizes the results of a meta-analytic study on alcohol and cannabis use and driving related tasks, follows. And finally, concluding the literature review is an evaluation of the research on cannabis use and its effect on both driving performance and crash risk.

PSYCHOPHARMACOLOGY OF CANNABIS

Before interpreting the results of empirical studies, one must understand how cannabis affects humans. Herbal cannabis (marijuana) contains more than 60 cannabinoids extracted from different parts of the plant, including the stalk, leaves, flowers, and seeds. Cannabinoids are molecules unique to cannabis with delta-9-tetrahydrocannabinol (9-THC or THC) being the major psychoactive constituent. Other molecules such as 8-THC, cannabinol, and cannabidiol are also important and can have additive or antagonistic effects with THC (Ashton, 2001).

Understanding how cannabis works is particularly important when detecting the drug in drivers. Cannabinoids are lipid soluble and accumulate in fatty tissues for several days after consumption (Ashton, 2001). After four or five days, peak concentrations are reached and the cannabinoids are slowly released back into the body. The half-life of THC in fatty tissue is about seven to eight days, with complete elimination of a single dose taking up to 30 days (Ashton, 2001; Atha, 2000). This means that with repeated consumption, high levels of cannabinoids accumulate in the body, even several days after the last dose is consumed. Consequently, lower detection thresholds will result in positive tests even though no impairment may exist.

There has been considerable debate regarding the best method to detect cannabis in drivers (Atha, 2000; Ward & Dye, 1999). Not only is the collection of blood invasive, but blood is also difficult to store. Urine tests are less invasive than blood sampling, but THC metabolites are present in urine for several days, making the determination of the recency of consumption imprecise. In contrast, saliva sampling is both easy and noninvasive, and recency of use can often be narrowed down to hours. Sweat is also a promising sampling technique since perspiration deposits drug metabolites on the skin. These metabolites are refreshed even after the skin is washed. Although little confirmation of the validity of a sweat test is available, it appears that saliva and sweat may be the most promising measures. Both require further research.

Cannabinoids (like THC) affect the body by interacting with specific endogenous cannabinoid receptors (Devane, Dysarz, Johnson, Melvin & Howlett, 1988). Research that maps the distribution of cannabinoid receptors in the brain has shown that these receptors are localized in the cerebellum, hippocampus, basal ganglia, and cortex (Herkenham et al., 1990). The cerebellum integrates balance and motor information to coordinate movements (see Solowij, 1998 for a review). The hippocampus is involved in learning and memory, while the basal ganglia play an important role in the control of voluntary motor responses. The cortex is important for information processing and mediating other cognitive processes, such as learning, speaking, and problem solving.

Comparison to Alcohol

When an alcoholic beverage is consumed, approximately 20% of the alcohol is absorbed in the stomach and 80% is absorbed in the small intestine (Freudenrich, 2001). After absorption, alcohol enters the bloodstream and dissolves in the water of the blood where it is quickly distributed to body tissues. When alcohol reaches the brain, it affects the cerebral cortex first, followed by the limbic system (hippocampus and septal area), cerebellum, hypothalamus, pituitary gland, and lastly, the medulla, or brain stem. Some of these regions are similar to those affected by cannabis, but alcohol also affects sexual arousal/function and increases urinary output. When BAC is near toxic levels, lower order brain regions are affected, which is often followed by sleepiness, lack of consciousness, coma, or death.

The most important difference between cannabis and alcohol is that alcohol is easier to detect. Alcohol dissolves in water and is distributed evenly throughout the body. Therefore, metabolites do not accumulate in body tissues, and positive test results from blood have a near perfect relationship with alcohol levels in the brain. Because of this, detection of alcohol is more reliable than cannabis detection, and the relationship between BAC, recent consumption, impairment, and crash risk has been easier to establish (Moskowitz, 2002).

Research Needs and Issues for Transportation Policy

With regard to future research, questions remain concerning which cannabinoid to measure and which body fluid is most reliable and cost effective for roadside testing. Research is also needed to ascertain which method best determines the time elapsed since consumption and what time interval defines recent consumption. Information is also lacking on how individual differences in metabolism and tolerance influence detection results, the prediction of impairment, and crash risk. Most important, data is missing on a detected level of cannabinoid(s) that corresponds to an agreed upon value for impairment.

Exposure in the Population

To understand the risk imposed by cannabis, it is necessary to estimate exposure within the population in terms of the percentage of the population consuming cannabis and the inclination of users to drive after consumption. In 1970, 2% to 3% of people in the Netherlands reported having used cannabis; in the 1980s, the percentage grew to 6% to 10%; and in 1991, 12% indicated lifetime use (Korf, 2001). In New South Wales, Australia, a recent national survey (Australian Institute of Health and Welfare [AIHW], 2002) found that 33% of the population tried cannabis and 13% used cannabis in the last year. Data from the United States found that cannabis was the most commonly used illicit drug, with 14.6 million people, or 6.2% of the population, currently using cannabis (Substance Abuse and Mental Health Services Administration [SAMHSA], 2003).

Cannabis is only considered a risk factor for traffic accidents if drivers operate vehicles after consuming the drug. Robbe (1994) found that 30% to 90% of his participants were willing to drive after consuming a typical dose of cannabis. This is consistent with a recent Australian survey in which more than 50% of users drove after consuming cannabis (Lenne, Fry, Dietze, & Rumbold, 2000). A selfadministered questionnaire given to 508 students in grades 10 to 13 in Ontario, Canada, found that 19.7% reported driving within an hour after using cannabis (Adlaf, Mann, & Paglia, 2003).

Comparison to Alcohol

For almost all countries, more people consume alcohol compared to cannabis. In 2002, 51% of Americans 12 years of age or older reported drinking at least once in the past 30 days (SAMHSA, 2003). The proportion of Australians 14 years of age or older who consumed alcohol on a weekly basis in 2001 was 39.5% (AIHW, 2002). Although more people use alcohol, the likelihood that a person will drive after consuming cannabis is greater. For instance, 26.6% of Americans 18 to 25 years of age drove under the influence of alcohol at least once in the past 12 months (SAMHSA, 2003). In Canada during 2003, 15.8% of all drivers (16 years of age and older) indicated they had driven a vehicle within two hours of consuming alcohol sometime during the past 30 days (Beirness, Simpson, & Desmond, 2003). These findings imply that although fewer people consume cannabis compared to alcohol, cannabis users do not perceive consuming cannabis prior to driving to be risky behavior.

Research Needs and Issues for Transportation Policy

One problem interpreting the consumption data for cannabis is that several definitions have been used, including “ever used,” “used last year,” and “used last month.” Also unclear is what operational definition of cannabis use best estimates exposure within a population. Therefore, one should be hesitant when comparing results across studies.

The data on willingness to drive is limited since the information is based on self-report. In addition, the figures for cannabis are difficult to validate because few sources of baseline data exist regarding the prevalence of cannabis use among drivers on the road. A critical research need is to obtain baseline data using an agreed upon threshold for risk and impairment.

Cannabis Use and Laboratory Tasks

Most of the research on cannabis use has been conducted under laboratory conditions. The literature reviews by Robbe (1994), Hall, Solowij, and Lemon (1994), Border and Norton (1996), and Solowij (1998) agreed that the most extensive effect of cannabis is to impair memory and attention. Additional deficits include problems with temporal processing, (complex) reaction times, and dynamic tracking. These conclusions are generally consistent with the psychopharmacological effects of cannabis mentioned above, including problems with attention, memory, motor coordination, and alertness.

A meta-analysis by Krüger and Berghaus (1995) profiled the effects of cannabis and alcohol. They reviewed 197 published studies of alcohol and 60 studies of cannabis. Their analysis showed that 50% of the reported effects were significant at a BAC of 0.073 g/dl and a THC level of 11 ng/ml. This implies that if the legal BAC threshold for alcohol is 0.08 g/dl, the corresponding level of THC that would impair the same percentage of tests would be approximately 11 ng/ml.

COMPARISON TO ALCOHOL

Krüger and Berghaus (1995) also classified the results of each study into eight broad performance categories: encoding and decoding information, tracking, psychomotor tasks, visual functions, reaction time, attention tests, divided attention, and simulated or real driving. For each category, they determined the BAC and level of THC that was needed to impair 50% of the effects in the studies reviewed. Table 1 lists the ranking of performance tests in terms of sensitivity to impairment effects of cannabis and alcohol.

It is clear from Table 1 that alcohol and cannabis have different impairment characteristics. Popular models of driving often separate the task into simultaneous

TABLE 1
RANK ORDER OF TEST SENSITIVITY TO EFFECTS OF CANNABIS AND ALCOHOL (ADAPTED FROM KRÜGER & BERGHAUS, 1995)

Rank	Cannabis	Alcohol
1	Tracking	Driving
2	Psychomotor tasks	En/decoding
3	Attention	Divided attention
4	Divided attention	Visual functions
5	Visual functions	Tracking
6	Driving	Psychomotor tasks
7	En/decoding	Reaction time
8	Reaction time	Attention

activity at strategic, maneuvering, and operational levels of control (Michon, 1985). Alcohol-related problems with encoding and decoding information from memory could affect the choice of route at the strategic level, while impairment of divided attention and visual functioning may result in slower object detection at the maneuver level. In contrast, the effects of cannabis use on tracking are likely to affect lane maintenance ability at the maneuver level. Problems with psychomotor tasks may also affect driver interaction with the steering wheel, brake, and accelerator at the operational level.

RESEARCH NEEDS AND ISSUES FOR TRANSPORTATION POLICY

To date, the association between impairment on the psychological dimensions tested in the laboratory and reduced driving performance or heightened crash risk has not been clearly established. This may be due to the absence of an accepted and valid driving model from which to select appropriate tests. A promising driver model is the American Automobile Association (AAA) Novice Drive Education Curriculum (Lonero et al., 1995). This model emphasizes attention management, visual search, decision making, and risk perception as critical tasks important for safe driving. Another possible resource is a standard test battery for driving that is being developed by researchers in Austria (Schuhfried, 2003). Future studies should use driver models and/or test batteries to identify standardized laboratory tests that relate to core driving skills and show corresponding impairment on driving performance and crash risk.

CANNABIS USE AND DRIVING PERFORMANCE

Several studies have examined cannabis use in driving simulator and on-road situations.[1] The most comprehensive review was done by Smiley in 1986 and then again in 1999. Several trends are evident and can be described by three general performance characteristics:

1. Cannabis increased variability of speed and headway as well as lane position (Attwood, Williams, McBurney, & Frecker, 1981; Ramaekers, Robbe, & O'Hanlon, 2000; Robbe, 1998; Sexton et al., 2000; Smiley, Moskowitz, & Zeidman, 1981; Smiley, Noy, & Tostowaryk, 1987). This was more pronounced under high workload and unexpected conditions, such as curves and wind gusts.
2. Cannabis increased the time needed to overtake another vehicle (Dott, 1972 [as cited in Smiley, 1986]) and delayed responses to both secondary and tracking tasks (Casswell, 1977; Moskowitz, Hulbert, & McGlothlin, 1976; Sexton et al., 2000; Smiley et al., 1981).
3. Cannabis resulted in fewer attempts to overtake another vehicle (Dott, 1972) and larger distances required to pass (Ellingstad et al., 1973 [as cited in Smiley, 1986]). Evidence of increased caution also included slower speeds (Casswell, 1977; Hansteen, Miller, Lonero, Reid, & Jones, 1976; Krueger & Vollrath, 2000; Peck,

Biasotti, Boland, Mallory, & Reeve, 1986; Sexton et al., 2000; Smiley et al., 1981; Stein, Allen, Cook, & Karl, 1983) and larger headways (Robbe, 1998; Smiley et al., 1987).

Comparison to Alcohol

As with cannabis, alcohol use increased variability in lane position and headway (Casswell, 1979; Ramaekers et al., 2000; Smiley et al., 1981; Stein et al., 1983) but caused faster speeds (Casswell, 1977; Krueger & Vollrath, 2000; Peck et al., 1986; Smiley et al., 1987; Stein et al., 1983). Some studies also showed that alcohol use alone and in combination with cannabis affected visual search behavior (Lamers & Ramaekers, 2001; Moskowitz, Ziedman, & Sharma, 1976). Alcohol consumption combined with cannabis use also worsened driver performance relative to use of either substance alone. Lane position and headway variability were more exaggerated (Attwood et al., 1981; Ramaekers et al., 2000; Robbe, 1998) and speeds were faster (Peck et al., 1986).

Both simulator and road studies showed that relative to alcohol use alone, participants who used cannabis alone or in combination with alcohol were more aware of their intoxication. Robbe (1998) found that participants who consumed 100 g/kg of cannabis rated their performance worse and the amount of effort required greater compared to those who consumed alcohol (0.05 BAC). Ramaekers et al. (2000) showed that cannabis use alone and in combination with alcohol consumption increased self-ratings of intoxication and decreased self-ratings of performance. Lamers and Ramaekers (2001) found that cannabis use alone (100 g/kg) and in combination with alcohol consumption resulted in lower ratings of alertness, greater perceptions of effort, and worse ratings of performance.

Research Needs and Issues for Transportation Policy

One of the most critical research needs is the development and adoption of a standard methodology for simulation and road studies. The methodology chosen should include the specification of performance measures that relate to the tests used in laboratory situations and a corresponding driving model. Another important issue is the determination of dosing thresholds and methods for delivering cannabis to study participants. In the absence of a consistent protocol, comparisons are limited because of different doses, inconsistent time intervals between end of consumption and start of a task, incompatible consumption methods, different driving tasks, and varied dependent measures.

Cannabis Use and Crash Risk

Epidemiological studies have been employed to study the effect of cannabis use on crash risk. Crash risk for cannabis use can be determined in a number of ways (see Ward & Dye, 1999). A common method is to compare the prevalence of cannabis in accident-involved drivers to the prevalence of the drug in the nonaccident driving population. An increase in crash risk may be attributed to cannabis use if it is present in more accident-involved cases than in the general driving population.

A review of the epidemiological evidence showed that cannabis is present in approximately 4% to 12% of accident cases (Ward & Dye, 1999). These values are generally consistent with the studies cited by de Gier (1998), who noted rates of detected cannabis in 1.3% of fatally injured drivers in Spain and 12% of injured drivers in France. Data for Victoria, Australia, showed that cannabis was detected in 6.7% of fatal accidents (Gerostamoulos & Drummer, 1993), whereas Canadian figures found that as many as 13% of drivers killed in accidents tested positive for cannabis or its metabolites (Mercer & Jeffery, 1995).

The assessment of crash risk using prevalence rates requires baseline data indicating the frequency of cannabis use among nonaccident involved drivers. Robbe (1994) cited a Canadian study that found 3.7% of fatally injured drivers in Ontario tested positive for cannabis in 1978 and 1979. A roadside survey of drivers in Canada during 1974 is the closest matching baseline data for calculating accident risk (Robbe, 1994). When the prevalence rate of 3.7% is divided by the base rate of 4%, the resulting crash risk for cannabis in fatally injured Canadian drivers is 0.93. This implies cannabis may slightly reduce the risk of being in a fatal accident in Canada. However, this calculation would not be considered valid because the baseline data must apply to a random sample from a comparable population within the same time period as the accident data (Ward & Dye, 1999). Additionally, baseline data is not readily available because, unlike with alcohol, drivers are not normally tested for cannabis unless they are involved in an accident. Therefore, meeting these criteria and matching the baseline data with test results for accident-involved drivers is difficult. So far, no current baseline data exist for cannabis that would be considered valid, and it is not possible to compute a valid crash risk estimate for cannabis based on the prevalence of the drug in accident-involved drivers (Ward & Dye, 1999).

In the absence of valid baseline data, some researchers have considered accident culpability as an alternate measure of crash risk (Robertson & Drummer, 1994). This approach uses odds ratios to analyze whether drivers who tested positive for cannabis are more likely to be responsible (i.e., culpable) for the crash compared to drug-free drivers. Odds ratios that are significantly greater than one indicate a greater risk of being at fault in an accident.

Drummer (1995) used this metric and examined the factors associated with 1,052 fatal accidents in Western Australia between 1990 and 1993. When compared to an age and sex matched drug-free group, drivers with detected levels of cannabis were 0.6 times more likely to be culpable, but the difference was not significant. A more recent South Australian study found comparable results when they calculated culpability indexes for 2,279 nonfatal accidents (Longo, Hunter, Lokan, White, & White, 2000). Drivers who tested positive for cannabis alone were 0.82 times more likely to be culpable compared to drug-free drivers, but again the difference was not statistically significant.

Both Australian studies suggest cannabis may actually reduce the responsibility rate and lower crash risk. Put another way, cannabis consumption either increases driving ability or, more likely, drivers who use cannabis make adjustments in driving style to compensate for any loss of skill (Drummer, 1995). This is consistent with simulator and road studies that show drivers who consumed cannabis slowed down and drove more cautiously (see Ward & Dye, 1999; Smiley, 1999. This compensation could help reduce the probability of being at fault in a motor vehicle accident since drivers have more time to respond and avoid a collision. However, it must be noted that any behavioral compensation may not be sufficient to cope with the reduced safety margin resulting from the impairment of driver functioning and capacity.

A major problem with this inference method is that the prevalence of cannabis in accident-involved drivers is dependent on the method and cannabinoid metabolite used to indicate a positive test. For instance, most urine tests detect THC carboxylic acid (THC-COOH), which is an inactive metabolite. Therefore, positive urine tests only confirm that cannabis has been used, but do not indicate impairment or intoxication at the time of the crash (Atha, 2000).

Swann (2000) used information on THC in blood samples to determine recent consumption of cannabis and evaluated driver culpability for 544 fatalities in Australia. Compared to drug-free drivers, the odds of being culpable were 6.4 for recent cannabis use. Similar results were found by Drummer, Chu and Gerostamoulos (2001) when they analyzed 3,400 Australian accidents and tested for recent cannabis consumption using blood samples. They found that for recent cannabis use, the odds of being culpable in an accident were 3.0. The authors also found that when only positive urine tests were used (i.e., positive for THC-COOH), the odds ratio was only 0.8. This later ratio is consistent with the studies that tested for inactive THC metabolites and implies that the detection method and metabolite used can have an important effect on crash risk.

Another paradigm used to assess crash risk is to use cross-sectional surveys of reported nonfatal accidents that can be related to the presence of risk factors, such as alcohol and cannabis consumption. Such a methodology was employed in a provocative dissertation by Laixuthai (1994). This study used data from two large surveys that were nationally representative of high school students in the United States during 1982 and 1989. Results showed that cannabis use was negatively correlated with nonfatal accidents, but these results can be attributed to changes in the amount of alcohol consumed. More specifically, the decriminalization of cannabis and the subsequent reduction in penalty cost, as well as a reduced purchase price of cannabis, made cannabis more appealing and affordable for young consumers. This resulted in more cannabis use, which substituted for alcohol consumption, leading to less frequent and less heavy drinking. The reduction in the amount of alcohol consumed resulted in fewer nonfatal accidents.

COMPARISON TO ALCOHOL

When compared to alcohol, cannabis is detected far less often in accident-involved drivers. Drummer et al. (2003) cited several studies and found that alcohol was detected in 12.5% to 79% of drivers involved in accidents. With regard to crash risk, a large study conducted by Borkenstein, Crowther, Shumate, Zeil and Zylman (1964) compared BAC in approximately 6,000 accident-involved drivers and 7,600 nonaccident controls. They determined the crash risk for each BAC by comparing the number of accident-involved drivers with detected levels of alcohol at each BAC to the number of nonaccident control drivers with the same BAC. They found that crash risk increased sharply as BAC increased. More specifically, at a BAC of 0.10, drivers were approximately five times more likely to be involved in an accident.

Similar crash risk results were obtained when data for culpable drivers were evaluated. Drummer (1995) found that drivers with detected levels of alcohol were 7.6 times more likely to be culpable. Longo et al. (2000) showed that drivers who tested positive for alcohol were 8.0 times more culpable, and alcohol consumption in combination with cannabis use produced an odds ratio of 5.4. Similar results were also noted by Swann (2000) and Drummer et al. (2003).

RESEARCH NEEDS AND ISSUES FOR TRANSPORTATION POLICY

Prevalence studies of alcohol and cannabis in accident-involved drivers are inconsistent because availability of the substances and pattern of use varies from country to country (de Gier, 1998). Differences in cannabis prevalence rates may also reflect improvements in detection methods and different thresholds used to define a positive case (Ward & Dye, 1999). Cannabis prevalence rates also vary because the drug is often measured only when drivers are stopped under suspicion of impaired or reckless driving (Fell, 1995). Prevalence rates may also diverge because cannabis is often measured only when drivers test negative for alcohol (Ward & Dye, 1999). These limitations suggest the accuracy of the prevalence rates for cannabis in accident-involved drivers is questionable.

Some of the evidence using accident likelihood, culpability, and cross-sectional surveys suggests that unlike with alcohol, cannabis use does not increase crash risk. However, studies of recent cannabis consumption suggest the drug may actually increase the risk of being responsible for a crash. Clearly, the literature is not without its limitations and the independent contribution of cannabis use to accident propensity is plagued by confounding factors and alternative explanations. For instance, cannabis use may be indicative of a more general underlying predisposition toward problem behaviors that increases the incidents of drinking and driving and speeding (Donovan, 1993). Cannabis use may also accompany more general problem behaviors, such as criminal and delinquent behaviors that have been shown to increase accident likelihood (e.g., Junger & Wiegersman, 1995; Marowitz, 1995).

Crash risk for cannabis is also affected by the presence of alcohol. In many epidemiological studies, alcohol was present in 50% to 90% of the positive cannabis cases (Ward & Dye, 1999). Harrison, Backenheimer and Inciardi (1995) cited a National Highway Traffic Safety Administration (NHTSA) study that found cannabis was detected alone in 1.1% of U.S. fatal accidents, in combination with alcohol in 5.1% of accidents, and with some other substance in 0.5% of accidents. Therefore, the combination of cannabis and alcohol in many accident cases precludes conclusions about the effect of either substance alone.

The presence of alcohol is also problematic because of the features of the accidents involved. Mercer and Jeffery (1995) found in their analysis of fatal traffic accidents in British Columbia, Canada, that alcohol use alone and in combination with cannabis were detected more often in younger drivers. Young drivers already have a greater crash risk than the general driving population (Dewar, 2002). Gerostamoulos and Drummer (1993) also reported that wet roads, poor visibility, and the presence of other drugs were identified in 30% of fatal accident cases in which drivers tested positive for cannabis. It is clear from these studies that in many situations the measurement of crash risk for cannabis consumption is confounded by other factors.

CONCLUSION

The overall conclusion from this review is that knowledge regarding the effect of cannabis on driving is strong in some domains, but weak in others. Researchers have done a good job understanding how cannabis affects humans at the psychopharmacological level. This is mostly due to the discovery and subsequent mapping of endogenous cannabis receptors in the brain. However, more research is needed to identify the most reliable and valid detection method for roadside testing. Survey data showed that after alcohol, cannabis is the most commonly consumed drug by drivers and a larger proportion of cannabis users drive after using the drug compared to alcohol users who drive after drinking. This makes cannabis use by drivers an important safety consideration for researchers and policy makers.

Research using laboratory tasks showed that cannabis and alcohol affect driving differently, but the relationship between the tasks used in the laboratory and driving performance needs to be established. Information on cannabis use and driving in both simulator and road studies found that drivers who use cannabis are more aware of their intoxication and compensate by slowing down and adopting a more cautious driving style. However, more research is needed to understand the limits of driver compensation.

The most research is needed in the domain of cannabis and crash risk analysis. Some studies found no relationship between cannabis and increased crash risk, but more current data suggested that recent cannabis use increased crash risk. This finding needs to be replicated in other countries, and the data need to account for possible confounding factors such as driver age and road conditions. In the meantime, a conservative approach should be taken by assuming cannabis is sufficiently impairing to increase crash risk. However, before a specific policy can be developed regarding means of detecting the drug and thresholds for impairment, more research is needed.

NOTE

[1] Contact Nicholas J. Ward at nicw@me.umn.edu for copies of the updated and modified summaries of the simulator and on-road studies reviewed.

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