Cannabis Impaired Driving: An Evaluation of Current Modes of Detection[1]

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De plus en plus préoccupé par la conduite avec facultés affaiblies, le gouvernement canadien a récemment adopté une loi pour contrer le problème. La nouvelle loi force les conducteurs à effectuer une série de tests menés par un agent de police s'il sait/croit que la personne conduit avec facultés affaiblies. L'objectif de cette étude est de présenter un survol d'études scientifiques ayant évalué l'efficacité de trois méthodes permettant de détecter la consommation de cannabis chez les conducteurs. Ces méthodes comprennent : le programme d'évaluation et de classification de drogues (ECD), des appareils de détection dans la salive utilisés sur les lieux et des appareils de détection dans les urines utilisés sur les lieux. Seules les études comprenant des mesures de fiabilité appropriées (c.-à-d. la sensibilité, la spécificité et l'exactitude) font partie de l'étude. Compte tenu de leur fiabilité croissante, les appareils de détection dans la salive semblent montrer les résultats les plus intéressants en matière de détection de la consommation de cannabis chez les conducteurs. Malgré les résultats encourageants, il est nécessaire d'établir un taux maximal d'affaiblissement des facultés causé par le cannabis, semblable au taux d'alcoolémie maximal, avant que ces appareils ne soient valablement utilisés et mis en œuvre.

Mots clés : conduite sous l'influence du cannabis, Programme d'évaluation et de classification des drogues (ECD), expert en reconnaissance de drogues (ERD), conduite avec facultés affaiblies, tests de mesure des facultés affaiblies, tests sur les lieux

Due to the growing concern with motorists driving under the influence of drugs, the Canadian government has recently implemented legislation to tackle this issue. The new legislation compels drivers to submit to a series of tests, by a police officer, if/when a motorist is suspected of drug impairment. The aim of this paper is to present a review of scientific studies that have evaluated the effectiveness of three methods to detect cannabis use in motorists. These methods include the Drug Evaluation and Classification (DEC) Program, on-site oral fluid screening devices, and on-site urine screening devices. Only studies that included appropriate measures of reliability (i.e., sensitivity, specificity, and accuracy) were included in this review. Given their increasing

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reliability, on-site oral fluid devices appear to show the most promise for the detection of cannabis use in motorists. Despite the promising results, however, there is still a need to establish standard levels of impairment for cannabis, like the blood alcohol content (BAC) cut-off levels for alcohol, before these devices can be meaningfully utilized and implemented.

Keywords: cannabis impaired driving, Drug Evaluation and Classification (DEC) Program, drug recognition expert (DRE), impaired driving, impairment testing, on-site testing

Introduction

There is increasing concern about the potential traffic safety risks associated with driving under the influence of drugs (DUID). This concern corresponds with the rising prevalence of drug impaired driving in Canada and other nations (Grotenhermen, Leson, Berghaus, Drummer, Krüger, Longo, Moskowitz, Perrine, Ramaekers, Smiley, and Tunbridge 2007). The Canadian government has recently passed new legislation to strengthen the laws against DUID. On 2 July 2008, Bill C-2 came into force. This legislation amends the impaired driving provision of the Criminal Code, by requiring drivers suspected of being under the influence of drugs to submit to a series of tests to determine impairment. Prior to Bill C-2, drivers suspected of DUID had the right to refuse to be examined for drug impairment. While amendments to the Criminal Code have now taken effect, there is still debate in Canada over (1) at what level drugs impair the functions necessary for safe driving, (2) whether drivers under the influence of drugs are at an increased risk of motor collision and injury, and (3) the effectiveness of the different techniques used to identify drug impairment in motorists (Asbridge 2006).

Cannabis is the second most commonly used intoxicant in Canada, next to alcohol (Adlaf, Begin, and Sawka 2005), and research indicates that the prevalence of driving after consuming cannabis is increasing (Asbridge 2006). Over the past 50 years, evidence has established a direct relationship between increasing levels of blood alcohol concentrations (BAC) and increased risk of motor vehicle accidents (Walsh, Verstraete, Christophersen, Mercier-Guyon, Kintz, Oliver, Moeller, Compton, Sweedler, Potter, and de Gier 2000). As a result, appropriate instruments have been developed to enable police to identify drivers impaired by alcohol and to secure convictions for driving under the influence (DUI). Devices used to estimate BAC from a breath sample, such as the breathalyzer, have become increasingly sophisticated and

reliable and are thus widely accepted by the courts. However, no such limits or devices exist for screening drivers for cannabis impairment. Thus, there is a need to develop a reliable method of determining cannabis impairment in motorists that will stand up in court. This paper will attempt to address the third point in this debate, effectiveness, through a review of scientific studies that have evaluated the following methods, used to detect cannabis impairment in drivers: the Drug Evaluation Classification Program (DEC) / Drug Recognition Expert (DRE), on-site oral fluid screening devices, and on-site urine screening devices.

Methods

A literature search was conducted with regard to the use and evaluation of techniques and devices used to screen on-site for cannabis impairment in motorists. As indicated above, the studies were then broken down into three categories. Only studies which reported the necessary measures of accuracy (sensitivity, specificity, and accuracy), or in which sufficient data was available to calculate these measures, were included in the present review.

Measures of accuracy

The number of cannabis positive cases identified by the given technique or device are known as *true positive* (TP). Factual negative results are classified *true negative* (TN). Discrepancies between the method of detection (i.e., DEC, oral fluid testing device) and the toxicology confirmation results are labelled either *false positive* (FP) if impairment is incorrectly identified or *false negative* (FN) if impairment is missed by the technique. The first measure of accuracy used in this review is sensitivity or the *hit rate*. This measure addresses the likelihood that a driver who has consumed cannabis will be detected by the screening method. Sensitivity is calculated by dividing the number of cannabis impaired cases that the method or device identifies (TP) by the number of cannabis positive cases identified by the toxicology (TP+FN). This measure is important, as tests with high sensitivity minimize the number of false negatives (FN); that is, drivers who have consumed cannabis but who go undetected.

The second measure of accuracy is specificity, which refers to the number of correctly identified cannabis negative cases. Specificity is determined by dividing the number of TN cases by the total number of

drug negative cases identified by the toxicology (TN+FP). Tests with high sensitivity minimize the number of drivers who are incorrectly identified as having consumed cannabis. The final measure used in this review is accuracy. Accuracy represents the proportion of cases that have been correctly identified as either hits or *rejections*. Accuracy is calculated as follows: (TP+TN)/(TP+FP+TN+FN). This measure captures the overall performance of a given procedure (Beirness, Beasley, and LeCavalier 2008).

Results

Drug Evaluation Classification Program / Drug Recognition Expert[2]

The first method of detecting DUID to be examined is the DEC program and the associated DRE police officers. DREs are police officers who have been specially trained and certified to identify drug impairment in suspected motorists. The DREs utilize a procedure that relies on the observation of the suspected driver's socio-behavioural cues, biological and vital signs, and direct questioning (Asbridge 2006). Based on the information gathered, the DRE forms an opinion as to whether the suspected motorist is impaired, and if so, by what class of drug (i.e., CNS depressants, hallucinogens, cannabis). First, the suspected motorist is administered a standardized field sobriety test (SFST), much like the test for alcohol. If the motorist fails the SFST and is deemed by the police officer not to be impaired by alcohol, s/he is evaluated by a DRE. The DRE evaluation can take place either at the roadside or at the police station. If upon examination, the DRE believes the motorist is impaired by a drug, then a bodily fluid sample (i.e., blood) is taken and submitted to a laboratory for toxicology testing. The DEC program, developed in the late 1970s by the Los Angeles Police Department, is currently in use across the United States, as well as in Europe, Australia, and Canada. Included in the recent measures taken to tackle DUID was funding to increase the number of certified DREs in Canada to help enforce the newly strengthened impaired driving laws.

The DRE studies included in this review have been separated into two categories – laboratory studies and field studies (enforcement studies). Both methods have strengths and weaknesses. Laboratory studies involve systematic investigations, conducted in a highly controlled environment, with volunteer research participants who are administered measured doses of cannabis. Field studies, on the other hand, involve the examination of information gathered in enforcement settings, providing a more

realistic research environment. The purpose of both types of studies is to evaluate the ability of DREs to detect signs of drug impairment.

Laboratory studies

Bigelow, Bickel, Roache, Liebson, and Nowowieski 1985

The first laboratory evaluation of the DEC program was conducted by Bigelow et al. (1985) at the John Hopkins University School of Medicine. In this evaluation, 80 volunteers were randomly assigned to one of eight categories of drugs (d-amphetamine, 15 mg; d-amphetamine, 30 mg; marijuana, 12 puffs of 1.3% THC; marijuana, 12 puffs of 2.8% THC; diazepam, 15 mg; diazepam, 30 mg; secobarbital, 300 mg; or a placebo). Each volunteer was then examined by four DREs from the LAPD, for a total of 320 assessments (80 research participants examined by 4 DREs). The DREs were notified that some subjects would receive a placebo (control) and that no subjects would be administered alcohol, PCP, LSD, or any combination of drugs. The results for cannabis, as found by Bigelow et al. (1985) are reported in Table 1. It is evident from the results that the DREs in this study were able to identify research subjects who had been administered cannabis about half the time (48.8%). The DREs were much better at determining that a research subject had not consumed cannabis (92.7%), yielding an accuracy rate of (63.6%). Thus, while the DREs were quite capable of identifying participants who had not been administered cannabis, over half of those who had been were not detected by the DREs.

Table 1: Measures of DEC accuracy – laboratory studies / field studies

Drug: Cannabis	Sensitivity %	Specificity %	Accuracy %
DEC Laboratory Studies – Measures of DEC Accuracy			
Bigelow et al., 1985[a]	48.8	92.7	63.3
Heishman et al., 1996	53.1	61.1	56.0
Heishman et al., 1998	30.4	59.1	39.7
Shinar and Schechtman, 2005	49.0	69.0	41.7
DEC Field Studies – Measures of DEC Accuracy			
Compton, 1986	59.7	86.4	74.6
Preusser et al., 1992	78.4	73.2	75.4
Hardin et al., 1993	93.8	82.6	90.1
Smith et al., 2002	80.5	76.6	79.9
Beirness et al., 2008	79.1	98.2	87.3

[a]It must be noted that the actual number of cannabis cases was relatively small, reducing the reliability of the figures.

Heishman, Singleton, and Crouch 1996

In a subsequent laboratory study, conducted by Heishman et al. (1996), 18 drug-using volunteers were recruited to participate in nine experimental sessions. In each session, the participants received either a placebo, or a high or low dose of ethanol, cocaine, or cannabis. A total of 162 experimental studies were conducted, of which 4 were excluded because cannabis could not be detected in the confirmatory toxicology samples. Twenty-nine certified DREs were recruited to evaluate participants. There was no interview component, as in the actual DEC, but the DREs were informed that the participants might have been administered ethanol, and/or CNS depressants, CNS stimulants, phencyclidine, narcotic analgesic, cannabis, or a placebo. In actuality, with the exception of the placebo, only one drug was administered to the research subjects in each session. The results of the study are presented in Table 1. Again, just over half (53.1%) of the cannabis cases were correctly identified by the DREs, meaning that almost half of those who had consumed cannabis were not detected by the DREs. In this case, the DREs were less able to rule out cannabis consumption in the research subjects.

Heishman, Singleton, and Crouch 1998

A second study by Heishman et al. (1998) evaluated the accuracy of the DEC in identifying four types of drug use. The 12 research participants were administered a dose of a CNS depressant, a CNS stimulant, a narcotic analgesic, or cannabis. In each session, the participants were given either a placebo, a low dose, or a high dose, and each volunteer participated in six sessions. Participants were evaluated by one of 28 certified DREs. As in the previous study, the DREs were not permitted to ask the participants about recent drug use. The results from Heishman et al. (1998) are presented in Table 1. Clearly the sensitivity, that is, the ability of the DRE to correctly identify that a participant had consumed cannabis, was strikingly low (30.4%). The DREs also scored low on the accuracy measure (39.7%), meaning that they either incorrectly identified when cannabis was not present, or rejected cannabis consumption when it was, well over half the time (61.3%). Although it is not reported here, the DREs were better able to identify participants who were dosed with cannabis or the CNS depressant than they were participants who had been administered a CNS stimulant or narcotic analgesic. The results of this study reflect particularly poorly on the ability of the DREs to identify cannabis consumption in motorists.

Shinar and Schechtman 2005

This study re-analysed the data from Heishman et al. (1998) and included DRE opinion about the suspected drug class in cases that had been deemed *not impaired*. The re-analysed data are presented in Table 1. Upon re-analysis, the data shows that the ability of the DREs to correctly identify participants who were administered cannabis is increased to almost half of the time (49%). Although improved, the sensitivity and the accuracy of the DREs remain below 50%. However, the accuracy measure must be considered a conservative estimate (41.7%), as it was not reported in the first study. Accuracy could only be calculated by using the first drug category listed by the DRE (they can list multiple categories). For example, if the DRE had listed both a CNS depressant and cannabis, only cannabis had to be present in the toxicology confirmation for the test to be a match.

Field studies

Compton 1986

The first field evaluation of the DEC program was conducted in the summer of 1985, in Los Angeles, California, by the National Highway Traffic Safety Administration (NHTSA). The study examined adult motorists suspected of being impaired by drugs or a combination of drugs and alcohol. A total of 219 motorists were initially identified, of whom 18 were determined not to be impaired. Of those remaining, 173 (86%) agreed to provide a bodily fluid sample (blood). The suspects first performed a SFST and were then taken to one of two facilities to undergo evaluation by one of 25 DREs who had been chosen for the project. Alcohol breath tests were performed before the DEC examination and a blood sample was taken within two hours of arrest. Cannabis was the third most prevalent drug found in drivers (45%) after PCP (56%) and alcohol (53%). Table 1 presents the measures of accuracy of the DREs to detect cannabis in the suspected drivers. While cannabis was frequently found in the motorists (59.7%), the DREs had trouble detecting its presence in comparison to other drugs: PCP (90.7%), CNS depressants (73.7%), for example. Both the measures of specificity (86.4%) and accuracy (74.6%) were higher in the present study than in any of the laboratory studies presented earlier.

Preusser, Ulmer, and Preusser 1992

One of the largest DEC field study evaluations to date was conducted by Preusser et al. (1992). In this study, the records of 1,842 cases evaluated by DREs, across five US states, were compared with their corresponding toxicology results. A total of 1,711 (92.9%) of the 1,842 cases were deemed by the DREs to be under the influence of drugs, and of these, 1,469 toxicology results were available. From the pool of 1,469, at least one drug was found in 1,236 (84.2%) of cases. Lab tests confirmed the presence of the drug identified by the DRE 64.1% of the time. The results for cannabis are presented in Table 1. As can be seen in the table, the DREs' ability to identify cannabis as the impairing substance (78.4%) was the highest of the five drug classes included (PCP 75.3%; opiates 75.1%; CNS stimulants 57.4%; CNS depressants 68.6%). Measures of specificity (73.2%) and accuracy (75.4%) were also generally higher than those reported in the laboratory studies. The results of this study lend support to the notion that DREs can, in fact, detect cannabis in impaired drivers.

Hardin, Meyer, and Jejuridar 1993

In this field evaluation of the DRE program conducted in Minnesota, DRE judgements were compared with urine samples collected from 76 suspected impaired drivers. Five cases were later removed because the DRE determined that the suspect was not under the influence, leaving 71 cases remaining. Cannabis (68%) was the most commonly detected drug in the sample, followed by narcotic analgesics (14%), CNS stimulants (9%), and CNS depressants (9%). For all categories of drug, the DREs were able to detect drugs present in the motorist 92% of the time and were able to identify the correct substance in 87% of cases. Table 1 presents the measures of accuracy for cannabis. Cannabis was detected most accurately in this study, in comparison to others included in this review, and the results indicate that both the sensitivity and accuracy measures were over 90% (93.8% and 90.1% respectively). Thus, the DREs were able to correctly identify hits or rejections 9 out of every 10 times.

Smith, Hayes, Yolton, Rutledge, and Citek 2002

In the final American evaluation of the DEC procedure, Smith et al. (2002) conducted a re-analysis of DRE reports from the state of Oregon. Seventy cases were selected in which the DREs' opinion matched the drugs or drugs identified in the motorist by toxicology. For all 70 cases,

complete DEC assessment records were available; the cases were representative of the various drug classes, and all were free of alcohol impairment (zero BAC). The drug classes represented were 20 cannabis, 19 CNS stimulants, 14 CNS depressants, and 12 narcotic analgesics. In 5 cases, no drugs were found.

Certain portions of the DEC assessment reports were removed (i.e., toxicology results, confessions) and the cases were sent to 18 DREs for evaluation. Thus, a total of 1,260 judgements were made (70 cases examined by 18 DREs). Measures of accuracy are again presented in Table 1. All measures of accuracy reported in the study were relatively high in comparison to the laboratory studies (sensitivity 80.5%, specificity 76.7%, and accuracy 79.9%). Although the DREs were able to make relatively accurate judgements with only the details of the psychophysical symptoms present (i.e., no interview), the cases were less complex than would commonly be encountered in the field (i.e., no alcohol or poly-drug use). The results provide a good indication of the *reliability*, or inter-rater consistency of DRE judgements.

Beirness, Beasley, and LeCavalier, 2008

The only Canadian study to be included in this review was conducted by Beirness et al. (2008). In this study, the authors examined 1,349 DEC evaluations, representing the entire set of case reports submitted to the national DRE coordinator in Canada. DRE opinions were compared to toxicology results to determine the accuracy of the DREs in identifying the category of drug(s) motorists had consumed. Overall, cannabis was the second most common drug listed in the toxicology reports (38%) after stimulants (47%). The measures of DEC accuracy for cannabis identification are provided in Table 1. The reported findings show much promise for the ability of DREs to correctly identify cannabis use in drivers (sensitivity 79.1%, specificity 98.2%, and accuracy 87.3%). However, the results of this, and the preceding DRE field studies, must be interpreted with caution. Although, on the whole, the field evaluations showed better DRE performance than the laboratory studies, the former may exaggerate the accuracy of the DREs due to an undetermined number of FN cases. There is no way to capture the number of cannabis impaired drivers who were stopped but not suspected of drug use by the police and thus not subjected to the DEC. This issue will be addressed at length at the end of the paper.

On-site oral fluid drug screening devices

Since the beginning of drug testing, there has been an interest in the use of saliva or oral fluid (Verstraete 2005). The use of oral fluid drug screening devices is of particular interest to police and policy makers. This is evident in the number of devices that have recently entered the market and in the vast amount of research documenting and evaluating their use. The ability of the police to supervise oral fluid testing without the intrusion of privacy is particularly important to avoid adulteration of samples taken; the potential for substitution or contamination of oral fluid appears to be minimal (Cirimele, Villain, Mura, Bernard, and Kintz 2006). Saliva is also possibly the only bodily fluid where drug levels correspond with levels found in blood, indicating recent use or impairment (Pehrsson, Gunnar, Engblom, Seppä, Jama, and Lillsunde 2008; Samyn and van Haeren 2000). One problem with studying oral fluid, however, is that some individuals may, at times, be unable to produce enough materials for analysis (Cirimele et al. 2006). This could be particularly true for individuals who have consumed cannabis, as the drug is known to cause dry mouth.

Some of the first attempts to measure drug concentrations in oral fluid were conducted in the early 1980s, and toward the end of the 1990s, on-site oral fluid testing devices began to emerge. Numerous roadside studies have been conducted throughout Europe to test the effectiveness of these devices. Since the beginning of this millennium, both the quantity of devices on the market and the number of studies evaluating them have proliferated (Verstraete 2005). Several of the most recent evaluation studies are reviewed below.

Toennes, Steinmeyer, Maurer, Moeller, and Kauert 2005

In this study Toennes, Steinmeyer et al. (2005) evaluated the effectiveness of a new prototype of the Dräger Drugtest® system to detect the presence of drugs in oral fluid. The study took place between August and November 2001. Oral fluid samples were collected from 177 motorists suspected of DUID, by Saarland state police in Germany. To gather oral fluid, the collection device was swept between the cheek and gum from side to side in the mouth for two minutes. After two minutes the test was performed and the sample was saved for gas chromatography-mass spectrometry (GC-MS) confirmation. A blood sample was also taken approximately an hour later which was also sent for GC-MS analysis. Table 2 presents the results for this device.

Table 2: On-site bodily fluid drug screening devices – Measures of accuracy

Device	Sensitivity %	Specificity %	Accuracy %
On-site oral fluid testing, device accuracy, Tonnes et al., 2005			
Drager DrugTest	91.8	91.3	91.5
On-site oral fluid testing, device accuracy, Laloup et al., 2006			
Drager DrugTest	49.5	100	55.0
On-site oral fluid testing, device accuracy for cannabis compared with oral fluid confirmation, Rosita-2 project, 2006			
Drugwipe	33.8	92.0	73.8
OraLab	73.9	99.3	95.9
OraLine	73.9	25.0	100.0
Oralstat	29.6	94.1	54.5
Oratect	0.0	91.7	75.9
RapiScan	65.0	70.0	67.5
SalivaScreen	33.3	89.5	62.2
Uplink	56.4	89.9	74.3
On-site oral fluid testing, device accuracy for cannabis compared with blood confirmation, Rosita-2 project, 2006			
Drugwipe	45.7	89.1	75.7
OraLab	50.0	100.0	75.0
OraLine	/	100.0	100.0
Oralstat	13.3	85.0	54.3
Oratect	0.0	90.9	52.6
RapiScan	75.0	73.7	74.3
SalivaScreen	28.6	85.7	62.9
Uplink	59.2	89.6	70.5
On-site oral fluid drug screening device, Pehrsson et al., 2008			
Drugwipe	49.5	100	55.0
On-site urine testing, device accuracy, Buchan et al., 1998			
Triage	91.7	99.6	98.3
Abu-Sign	100.0	92.9	94.1
OnTraK	91.5	98.4	97.0
TestTcup	82.9	98.0	95.7

These results indicate that the Dräger Drugtest® system was efficient in detecting recent use of cannabis (sensitivity 91.8%, specificity 91.3% and accuracy 91.5%). In comparison to the DEC procedure, the Dräger Drugtest® system may be more appropriate for roadside drug testing, as it performed strongly in identifying the chemical compound in cannabis that causes impairment.

Laloup, Del Mar Ramirez Fernandez, Wood, De Boeck, Maes, and Samyn 2006

This study also assessed the ability of the Dräger Drugtest® system to screen for the presence of drugs in oral fluid during roadside stops.

Between February 2004 and April 2005, 139 subjects stopped by Belgium police under the suspicion of DUI voluntarily agreed to give oral fluid samples for analysis using the Dräger Drugtest®. Prior to the administration of the test, blood samples were collected from 127 of the subjects to be used for confirmation analysis. Confirmatory liquid chromatography in tandem with mass spectrometry (LC-MS-MS) results in plasma and oral fluid were compared to the Dräger Drugtest® results to assess the accuracy of the device. The results of these tests are presented in Table 2. As can be seen in the table, both the sensitivity (49.5%) and the accuracy (55.0%) of the Dräger Drugtest® were relatively low in this study. This means that the ability of the device to detect cannabis where present, or to provide a negative reading when not present, was low in comparison to other studies. The authors of this study stated that, due to low accuracy, the Dräger Drugtest® system could not be recommended for on-site drug testing.

Raes and Verstraete 2006

The Rosita-2 (Roadside Testing Assessment-2) project, a follow-up to the Rosita project, was conducted in Europe and the United States between 2003 and 2006. The aim of the project was to evaluate the available on-site devices for the detection of drugs in oral fluid. The project was funded by a grant from the Directorate General Transport and Energy of the European Union, and as noted, involved a European-American partnership (6 countries in Europe and 4 American states participated). The following nine devices were evaluated: American Biomedica Oralstat, Branan Medical Oratect, Cozart Bioscience RapiScan (only in the United States), Dräger/Orasure DrugTest/Uplink, Lifepoint Impact, Securetec Drugwipe, Sun Biomedical Oraline, Ultimed Salivascreen, and Varian OraLab. During the study, two of the devices, the Dräger/Orasure DrugTest/Uplink and Lifepoint Impact, were withdrawn from the market.

A total of 2,046 subjects under the suspicion of DUID were solicited for their voluntary participation in the study, and a total of 2,605 evaluations were performed. In each evaluation, two oral fluid samples were taken, one for analysis by the on-site device and the other for confirmation analysis with the *intercept device* (GC-MS). A blood sample was also taken. The on-site tests were performed by a police officer and the results from the device were compared with one of two reference methods (GC-MS or LC-MS-MS). While the full Rosita-2 report contains detailed evaluations from each of the test

locations in Europe and the United States, this review will be limited to the aggregated data for the entire project. The results of the different devices compared with the results of the oral fluid and blood confirmation analysis are presented in Table 2. The results indicate that the cannabis screening devices yielded varying sensitivity rates, ranging from 0% to 75%, and specificity rates ranging from 70% to 100%. The detailed analysis of the cannabis-related data showed that some devices gave a high number of FN results, even where high concentrations of cannabis were found in the toxicology confirmation. The authors note that a more thorough sampling technique may capture more THC, yielding more positive results. Finally, the authors note a high number of device failures with some of the test kits. For example, six of the devices (Varian Oralab; Lifepoint Impact; Branan Oratect, 2nd generation; Sun Oraline; Ultimed Salivascreen; and Branan Oratect, 1st generation) had device failure rates of over 25%, indicating the need for better developed technology.

Pehrsson, Gunnar, Engblom, Seppä, Jama, and Lillsunde 2008

The aim of this study was to evaluate the appropriateness of the Drugwipe 5 and Drugwipe Benzodiazepines on-site oral fluid testing devices for use in roadside drug screening. In total, 266 subjects suspected of DUID by Finnish police officers were tested with the devices, between May 2004 and June 2005. Oral fluid and whole blood samples were taken, in addition to the test samples, for GS-MS laboratory confirmation. Table 2 provides the results of this study with regards to cannabis. The high rate of FP cases in this study (not reported here) was flagged by the authors. In 11 cases, cannabis was detected by the Drugwipe 5 but no THC could be confirmed in oral fluid by GC-MS; in 6 of these, THC was confirmed in the blood sample. The police officers who administered the on-site tests reported that the test line (indicator line) for cannabis was very weak, making the device hard to read and possibly leading to the FP cases just mentioned (the officers found the device hard to read and may have interpreted negative cases as positive). The authors concluded that the ability of the Drugwipe 5 to detect cannabis was unsatisfactory. The main problem, in this regard, was low sensitivity and specificity, leading them to call for the development of a more sensitive and specific antibodies for detecting THC.

The ability of on-site oral drug testing devices to detect pharmacologically active drugs that relate to the pharmacological state of the individual make them the ideal choice for roadside drug screening.

Unfortunately, high rates of device failure and the inconsistency in results render them inappropriate for on-site screening at the present time.

On-site urine drug screening devices

For several years, quick response urine tests have been used to screen for illegal drugs in a variety of settings (i.e., workplace, treatment, and enforcement). Urine testing became particularly popular for use in roadside drug detection but seems to have lost popularity as oral fluid devices become more available and due to several concerns with testing urine. First, urine is not an appropriate bodily fluid to screen for cannabis impaired drivers. The presence of cannabis metabolites in urine does not necessarily indicate impairment because the window of detection is very large, ranging from several days to several weeks. There are also potential health risks associated with the handling of urine samples; police officers run the risk of contracting infections or diseases. Finally, there are privacy concerns related to demanding individuals to provide urine samples, and also concern over upholding the integrity of the samples. While there are several studies that have evaluated on-site urine screening devices (Samyn and van Haeren 2000; Crouch, Hersch, Cook, Frank, Walsh 2002; Toennes, Kauert, Steinmeyer, Moeller 2005), only one of these provided enough data for the present review.

Buchan, Walsh, and Leaverton 1998

This study evaluated the accuracy of four on-site urine test kits designed to detect drugs in suspected DUID cases. Between 16 December 1995 and 17 March 1997, voluntary and legal urine specimens were collected from 305 suspected drug-impaired drivers, in the Tampa Bay area of Florida. A total of 303 of the specimens contained sufficient urine for testing with the following on-site test kits: Triage (Biosite Diagnostics, San Diego, CA); Abu-Sign (Princeton BioMeditech, Princeton, NJ); OnTraK (Roche Diagnostic Systems, Branchburg, NJ); TestTcup (Roche Diagnostic Systems, Branchburg, NJ). Each specimen was reanalysed using GS-MS confirmation. Table 2 provides the results of the four devices. The results for the Abu-Sign kit were clearly quite promising, with 100% sensitivity. However, 18 FNs were recorded for this device, possibly explaining its superior sensitivity rate. The advantages and disadvantages of on-site urine testing were noted at the beginning of this section and will be discussed at length in the discussion to follow.

Discussion

The high variability in effectiveness, both within techniques to detect cannabis impaired driving and between them, leave questions about which approach is the most appropriate for roadside drug screening. Evaluation studies of the DEC are separated into two categories; laboratory studies and field studies, otherwise known as enforcement studies. Laboratory studies involve highly controlled investigations conducted with volunteers who are administered measured doses of specific drugs. Laboratory studies typically only involve the psychophysical assessment component of the DEC procedure and not, for instance, the face to face interaction with the suspect that takes place in the field. Field studies, on the other hand, typically involve an examination of data collected from individuals suspected of drug-impaired driving within an enforcement setting, such as traffic stops.

Overall, the results indicate that laboratory studies do not provide strong support for the accuracy of officers trained in the DEC program in detecting and correctly identifying the particular class(es) of drugs based solely on psychophysical assessment. The detection and identification of the relatively low levels of drugs administered were typically better than chance, while many cases were missed. In the evaluation of the field studies, the research findings indicate more positive results. DREs were able to identify persons intoxicated by drugs and to specify the drug responsible for impairment. In the field studies, the officers' conclusions were not only better than chance, but often highly accurate. However, this accuracy differed by type of drug. There are some key flaws in the accepted methods of evaluating the DEC program. While laboratory studies may be considered to be methodologically stronger than field studies, due to the controlled conditions under which volunteer participants are tested, the highly controlled conditions create an artificial environment that is much different than the field or enforcement settings. Although it is understood that a controlled environment is desirable to minimize the effects of factors outside of those desired for the experiment, the intent of the laboratory studies is to determine the accuracy of a procedure that ultimately will be employed in the field. This point is further strengthened by the fact that, in laboratory studies, the doses of drugs typically administered are lower than those found in drug-impaired drivers and only one drug is administered at a time, whereas most cases of DUID involve poly-drug use.

Finally, while the field evaluations showed better DRE performance than the laboratory studies, the field studies may exaggerate the accuracy of the DREs, due to an undetermined number of FN cases. There is no way to capture the number of cannabis impaired drivers who were stopped but not suspected of drug use by the police and thus not subjected to the DEC. It is this author's opinion that laboratory studies ought to closely mirror the field environment so that the results give a true indication of the validity of the DEC program.

The on-site oral fluid testing devices also show promise for roadside drug testing, and oral fluid testing may be the most appropriate technique for detecting cannabis. Oral fluid is believed to contain only unbound, pharmacologically active drugs, so that the findings in oral fluid relate to the extent of the toxicological state of the individual at the time of testing, whereas drug findings in urine do not; this is especially true of cannabis. Thus, there is a correlation between the presence of drugs, cannabis for instance, in oral fluid and impairment. Oral fluid samples, unlike urine samples, can be also taken under the supervision of a police officer, without the necessity of privacy, which can reduce the chance that the specimen can be tampered with.

Unfortunately, the results of this review show that there is much work left to do before on-site oral fluid devices can be fully implemented in roadside drug screening. The first main issue with the current, on-site oral fluid testing devices is their reliability and accuracy. In the Rosita-2 project for example, some of the devices failed to operate one out of every four times, resulting in a need to perform multiple tests with the same subject. There are also issues of interpreting the readings from some devices. The police officers involved in the Pehrsson et al. (2008) study reported that it was rather difficult to determine whether the Drugwipe 5 was giving a positive reading or not. The low reliability of these devices may be a product of the speed at which they have flooded the market; the speed of science simply could not keep up with the demands to perform on-site tests. Obviously, the development of an on-site screening device for DUID enforcement is a challenge. The tests must be sensitive, specific, and accurate enough to detect cannabis, but must also be reliable and easy to operate. Despite the current difficulties, given their ability to test for recent drug use, oral fluid testing devices show much promise for the future of roadside drug screening.

The lack of recent studies reviewing the usefulness of on-site urine testing devices may be an indication of the inappropriateness of using

these devices to perform roadside drug screening. Not only does urine testing screen for cannabis metabolites that provide no indication of recent use or intoxication, they also pose health risks for the police officers who have to handle the specimen samples and intrude heavily on the privacy of motorists suspected of DUID. Furthermore, there appears to be an increased risk of sample adulteration with regards to on-site urine screening (Walsh, Gier, Christopherson, and Verstraete 2004).

Conclusions

This paper has reviewed studies that have evaluated the various techniques now available to the police to screen for cannabis impaired drivers. This paper was unable to come to a firm conclusion as to which technique is the most appropriate or effective because each has inherent strengths and weaknesses. The different methods of detecting cannabis in saliva and urine have problems with respect to the collection of samples, handling, and transportation as well as the assays used in toxicological analysis. The interpretation of drug levels detected is also a major problem. For example, cannabis metabolites can be detected in urine for days after use, indicating prior exposure and not current levels of intoxication, which reduces the appropriateness of this type test for roadside drug screening. Prevention and deterrent strategies to combat DUID are largely constrained by scientific and technical parameters. The development of strategic initiatives to deal with this problem are further constrained by the significant gaps in what we know about the manner in which cannabis use affects the ability to operate a motor vehicle (Walsh, Verstraete, Christophersen, Mercier-Guyon, Kintz, Oliver, Moeller, Compton, Sweedler, Potter, and de Gier 2000).

If on-site oral fluid tests had higher levels of device reliability, they could be seen as the best technique, given that they have the ability to detect the psychoactive cannabis compounds indicating recent use or impairment and are less subjective than the DEC as performed by police officers. Unfortunately, these devices have not yet achieved an acceptable level of reliability. Therefore, there are still three components of the debate on cannabis and DUID, in general, in Canada and other countries, too. Effort is needed to establish standard levels of impairment for drugs (similar to the 0.08 BAC for alcohol impairment), determine whether drivers under the influence of drugs are an increased traffic safety risk, and to develop a reliable test or technique that accurately screens for the psychoactive chemicals in drugs that may cause driving impairment.

Notes

1 This paper was originally submitted and accepted for publication in 2009. Since then several studies have examined the effectiveness of tests to detect marijuana (*c.f.*, Desrosiers, Lee, Schwope, Milman, Barnes, Gorelick, and Huestis 2012; Downey, King, Papafotiou, Swann, Ogden, Boorman, and Stough 2012; Isalberti, Van Stechelman, Legrand, Van der Linden, and Verstraete 2010; Kintz, Brunet, Muller, Serra, Villain, Cirimele, and Mura 2009; Porath-Waller and Beirness 2010; Verstraete 2012; Wille, Samyn, Ramírez-Fernández, and De Boeck 2010; Yonamine, Sanches, Paranhos, de Almeida, Andreuccetti, and Leyton 2013).

2 For further review of the Drug Evaluation and Classification program, see Beirness, LeCavalier, and Singhal 2007).

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