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Amy Porath-Waller, Ph.D.,[1] Doug Beirness, Ph.D.[1], and Dereece Smither, Ph.D., NHTSA	

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16. Abstract

The objective of this study was to determine which combinations of drug-related signs and symptoms from the Drug Evaluation and Classification (DEC) protocol most efficiently and effectively predict the drug category or combination used by the subject. A sample of 2,261 DEC evaluations conducted on suspected drug-impaired drivers was obtained from 11 States. The sample included cases that involved specific drug categories and two-drug combinations that are commonly encountered by DREs. To assess the signs and symptoms from the DEC evaluation that best predict the drug category or drug combination used by suspected drug-impaired drivers, a series of statistical analyses was conducted. This study also examined how effectively the set of drug-related measures from the DEC procedure could distinguish drug-positive from drug-negative cases for two common drug categories (cannabis and CNS depressants) and the relative importance of clinical, behavioral and observational measures in predicting drug categories responsible for impairment. Thirteen drug-related indicators were found to significantly contribute to the prediction of drug category; 12 indicators contributed significantly to the prediction of drug combinations. Additionally, indicators related to the appearance and physiological response of the eye contributed the most to the prediction of both single drug categories and drug combinations, followed closely by clinical indicators, and performance on the psychophysical tests. A qualitative analysis of cases ruled out for medical reasons revealed that the subjects were older than in other cases, were more likely to have been involved in a crash, and were more likely to report being diabetic. A variety of medical conditions and injuries were considered to have possibly influenced the evaluation or rendered the subject incapable of performing the tests.

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Executive Summary

Background

Alcohol has generally dominated the field of impaired driving, with drug-impaired driving a priority public safety issue. As a result, the research literature on the risks of driving after using drugs has lagged considerably behind that focusing on alcohol. In many respects, drug-impaired driving is a more complex issue than alcohol-impaired driving. For instance, unlike alcohol, drug use among drivers cannot be reliably detected or measured in breath; instead, a toxicological analysis of bodily fluids such as blood, urine, or oral fluid is required. This alone creates an immediate complication for enforcement and adjudication. While a great deal can be learned from the successes in the area of alcohol and driving, drugs and driving is a more complex issue that requires novel approaches to enforcement and adjudication.

As a means to facilitate the detection, identification, and prosecution of drug-impaired drivers, a standardized and systematic approach known as the Drug Evaluation and Classification (DEC) program was developed to assist law enforcement officers in gathering objective information on the clinical and behavioral effects of drug use. Based on scientific and medical knowledge about the known signs and symptoms associated with various drugs, the DEC program is a 12-step procedure developed to assist trained law enforcement officers known as Drug Recognition Experts (DREs) in recognizing and evaluating behaviors and physiological indicators associated with seven different drug categories: central nervous system (CNS) depressants, inhalants, dissociative anesthetics, cannabis, CNS stimulants, hallucinogens, and narcotic analgesics.

The purpose of the DEC procedure is to provide an officer with evidence to determine whether or not the subject is impaired, whether the observed impairment is due to drugs or a medical condition, and which category (or categories) of drugs might be responsible for the impairment. The procedure also provides the evidence to support a request (or demand depending on the legislation in the jurisdiction) for a bodily fluid sample to be tested for the presence of drugs. The process is systematic as it is based on a complete set of observable signs and symptoms that are known to be reliable indicators of drug impairment. The process is also standardized because training requires it is conducted in the same way by every DRE for every subject to the extent possible under the circumstances. The results of the 12-step protocol, when corroborated by toxicological evidence of drug use, provide sufficient evidence of whether to proceed with drug-impaired driving charges.

A DEC evaluation is a comprehensive assessment that generally requires 45 to 60 minutes to complete. The evaluation has more than 100 elements in numerical, narrative, and pictorial form that are documented during the DEC procedure. Some have questioned whether the number of pieces of information collected is unnecessarily large and time-consuming (Schechtman & Shinar, 2005; Shinar & Schechtman, 2005) and that it may be possible to focus the evaluation on a core set of measures without significantly compromising accuracy (Porath-Waller et al., 2009; Porath-Waller & Beirness, 2010). The additional elements of the evaluation contribute to the totality of the evidence and provide further support for the officer's opinion.

The primary objective of this study was to determine which combinations of drug-related signs and symptoms from the DEC protocol can most efficiently and effectively predict the drug category or combination used by the subject. A secondary objective was to conduct a detailed case-by-case review of cases that had been ruled out by the DRE for not being impaired, or due

to a medical condition, to determine any commonalities in the circumstances and characteristics of these cases.

It is important to note that this project was not meant to determine the accuracy of DREs at determining whether or not subjects are impaired, nor their accuracy at predicting specific drug classes. Rather, this project employed a set of previously confirmed DEC cases to determine which among the large number of evaluative elements are best at signaling classification of a drug to a DRE performing an assessment of a subject.

Method

A sample of 2,261 DEC evaluations conducted on suspected drug-impaired drivers in which evaluating officers' opinions were confirmed by toxicological analysis of blood samples was obtained from 11 States geographically distributed across the United States. To be included in the study, each case had to include the Drug Influence Evaluation (DIE) Face Sheet, narrative report, and toxicology report. Included cases also had to involve specific drug categories and two-drug combinations that are commonly encountered by DREs:

- CNS depressants,
- CNS stimulants,
- narcotic analgesics,
- cannabis,
- CNS stimulants with cannabis,
- CNS stimulant with narcotic analgesics,
- CNS stimulants with CNS depressants, and
- cannabis with alcohol.

In addition, a set of cases deemed "rule-outs" for medical and non-medical reasons, such as lack of sufficient evidence of impairment, were collected for a special review to determine commonalities in the circumstances and characteristics of these cases. All the information from the DIE face sheets, narrative reports, and toxicology reports was coded to create a database of measures for statistical analysis.

To assess the signs and symptoms from the DEC evaluation that best predict the drug category or drug combination used by suspected drug-impaired drivers, we conducted a series of multinomial logistic regression analyses. This type of statistical analysis is able to predict an outcome, such as drug category, from a set of measures (e.g., pulse rate, systolic blood pressure, performance on One Leg Stand [OLS] test). This analysis indicates which set of measures best predicts each of the drug categories and also provides an estimate of the overall effectiveness of the statistical test. We conducted one analysis to identify the set of drug-related measures from the DEC evaluation that best predicted the most prevalent drug categories (CNS depressants, CNS stimulants, narcotic analgesics, and cannabis) used by suspected drug-impaired drivers; a second analysis was performed to determine the signs and symptoms that best predict the prevalent two-drug combinations used by suspected drug-impaired drivers: CNS depressants with narcotic analgesics, CNS depressants with CNS stimulants, CNS stimulants with narcotic analgesics, and CNS depressants with cannabis.

We also examined how effectively the set of drug-related measures from the DEC procedure could distinguish drug-positive from drug-negative cases for two common drug categories (cannabis and CNS depressants) by constructing receiver operating characteristic (ROC) curves and determining the relative importance of clinical, behavioral and observational measures in predicting the drug category (or categories) responsible for impairment.

It is important to note that several of the group sizes for the drug categories and combinations were well below the recommended 325 cases per group for statistical analyses. Conducting the analyses using these small groups limits the ability of the statistical test to correctly identify moderately strong relationships between the drug category/combination and the drug-related measures from the DEC procedure. The group size for the rule-out group, which was used as the reference group, was also well below the recommended group size of 325 cases. It was determined that these drug categories and combinations should be included in the final sample.

Results

The average amount of time that lapsed between the arrest of the subject and the start of the evaluation was 52 minutes. Once the evaluation started, it took an average of 54 minutes to complete. The time it took to conduct an evaluation varied significantly according to the drug category or combination involved, with rule-out cases taking significantly less time to complete than those involving a confirmed drug category or drug combination. This difference was attributed to the fact that "rule-out" cases were often incomplete either because the subject could not complete the tasks or the officer discontinued the evaluation for safety reasons.

The findings revealed that 22 drug-related signs and symptoms obtained during the DEC evaluation significantly predicted the correct drug category responsible for the observed impairment of the subject. Based on this set of 22 drug-use indicators, an overall correct classification rate of 86% was obtained across the four drug categories and no-drug cases. This classification rate shows how successful the set of 22 indicators is in correctly predicting the drug categories and confirms the validity of these drug-use indicators. This high level of predictability was confirmed by constructing ROC curves for the CNS depressants and cannabis cases. These ROC curves provide an overall assessment of how well the set of 22 drug-use indicators predicts who did and did not use the category of drug, and the results showed a high level of effectiveness. We also found that the set of drug-related signs and symptoms predicted some of the drug categories such as cannabis better than others such as CNS stimulants. Within the set of 22 signs and symptoms, 13 were found to significantly contribute to the prediction of the drug category:

- being under the care of a doctor or dentist,
- condition of the eyes,
- condition of the eyelids,
- mean pulse rate,
- assessment of horizontal gaze nystagmus (HGN),
- convergence,
- One Leg Stand (OLS test performance,
- eyelid tremors,
- pupil size in darkness,
- reaction to light,

- presence of visible injection sites,
- systolic blood pressure, and
- muscle tone.

With respect to the prediction of the drug combinations, we found that the set of 22 drug-related indicators from the DEC protocol also significantly predicted the combination of drug categories responsible for the observed impairment. An overall classification rate of 75% was obtained for correctly classifying the four drug combinations and rule-out cases—about 10% lower than that obtained in the analysis that predicted a single drug category. The results also revealed that some drug combinations (e.g., CNS depressants with narcotic analgesics) were better predicted than others (e.g., CNS depressants with CNS stimulants). Twelve key drug-related indicators were found to contribute significantly to the prediction of drug combinations:

- condition of the eyes,
- condition of the eyelids,
- mean pulse rate,
- assessment of HGN,
- performance on the Walk and Turn (WAT) Test,
- pupil size in room light and darkness,
- reaction to light,
- rebound dilation,
- presence of visible injection sites,
- muscle tone, and
- estimation of 30 seconds on the Modified Romberg Balance (MRB) test.

It is noteworthy there was overlap between the indicators that significantly predicted drug category and combination, with the following indicators being common to both:

- condition of the eyes,
- condition of the eyelids,
- mean pulse rate,
- assessment of HGN,
- pupil size in darkness,
- reaction to light,
- presence of visible injection sites, and
- muscle tone.

This study also investigated the unique contribution of specific groupings of drug-related signs and symptoms from the DEC evaluations, finding that indicators related to the appearance and physiological response of the eye contributed the most to the prediction of both single drug categories and drug combinations, followed closely by clinical indicators and performance on the psychophysical tests. Interestingly, observations and statements made by the subject contributed the least to the prediction of drug category and were not found to be a statistically significant predictor of drug combinations.

The qualitative analysis of cases ruled out for medical reasons revealed that the subjects assessed in these evaluations were older than in other cases, were more likely to have been involved in a

crash, and were more likely to report being diabetic. A variety of medical conditions and injuries were reported that were considered to have possibly influenced the evaluation or rendered the subject incapable of performing the tests. In cases ruled out for lack of impairment, the officer's judgment was often considered conservative (i.e., there were signs and symptoms of impairment but the evaluating officer deemed them insufficient to warrant charges).

Discussion

The findings from this study suggest that DREs should be careful to review a set of key signs and symptoms when determining the categories of drugs used by suspected drug-impaired drivers. Eight drug-related signs were found to be common in both of the statistical analyses predicting the single-drug categories and two-drug combinations. Drug use indicators related to the appearance and physiological response of the eye were found to contribute the most to the prediction of the drug category/combination responsible for the impairment. These results could help form the basis of a core set of indicators DREs could potentially revisit prior to determining their opinion of drug influence. However, prediction of the drug categories and combinations was not found to be perfect. This points to the need to consider the other indicators from the evaluation and the observational skills of the DRE to assess the totality of drug symptomatology. Focusing attention on the key signs and symptoms identified in this research may enhance the validity, effectiveness and efficiency of drug detection and identification by DREs and may lead to a more effective and efficient DEC program, improved enforcement of drug-impaired driving, and greater acceptance of the DEC program by the courts.

The detailed review of medical rule-out cases revealed a wide variety of medical conditions that could have led to observations that either mimicked drug effects or that could not be distinguished from drug effects. Further investigation of a large sample of medical rule-out cases is warranted to get a better picture of these types of cases. In addition, the performance of these people, whether influenced by drugs, was often that the person should not be driving. Officers need clear direction in these cases as to when the drivers should be referred and/or reported to the departments of motor vehicles for medical review and/or assessment of their fitness to operate vehicles.

Introduction

Background

Alcohol has generally dominated the field of impaired driving, with drug-impaired driving emerging as a priority public safety issue. As a result, the research literature on the risks of driving after using drugs has lagged considerably behind that focusing on alcohol. In many respects, drug-impaired driving is a more complex issue than alcohol-impaired driving. For instance, unlike alcohol, drug use among drivers cannot be reliably detected or measured in breath; instead, a toxicological analysis of bodily fluids such as blood, urine, or oral fluid is required. This creates an immediate complication for enforcement and adjudication. In addition, research investigating the effects of drugs on a driver's ability to safely operate a motor vehicle has shown that various types of substances (and combinations of substances) can have different effects on behavior. Although a great deal can be gleaned from successes in the area of alcohol and driving, drugs and driving is a more complex issue that requires novel approaches to enforcement and adjudication. To deal with some of these complications, the DEC program was developed to assist law enforcement officers in gathering objective information in a standardized manner that facilitates the identification and prosecution of drug-impaired drivers.

Drug Evaluation and Classification Program

The DEC program was developed during the 1970s by the Los Angeles Police Department with the help of toxicologists, physicians, and other experts. Based on scientific and medical knowledge about the known signs and symptoms associated with various drugs, the DEC program is a systematic and standardized 12-step procedure to assist trained law enforcement officers, DREs, in recognizing and evaluating behaviors and physiological indicators associated with seven different drug categories:

- central nervous system (CNS) depressants,
- inhalants,
- dissociative anesthetics,
- cannabis,
- CNS stimulants,
- hallucinogens, and
- narcotic analgesics.

The purpose of the DEC procedure is to provide an officer with necessary evidence to determine whether a subject is impaired, whether the observed impairment is due to drugs or a medical condition, and which category (or categories) of drugs might be responsible for the impairment. The process is systematic because it is based on a complete set of observable signs and symptoms that are known to be reliable indicators of drug impairment. The process is also standardized because it is conducted in the same way by every DRE for every subject, whenever possible. The results of the 12-step protocol, when corroborated by toxicological evidence of drug use, provide sufficient evidence to proceed with drug-impaired driving charges.

Fifty States, the District of Columbia, U.S. territories, and Canada are participating in the DEC program. Other jurisdictions have a small number of trained DREs, including Australia, the United Kingdom, and China (Hong Kong). The program is supported by the National Highway

Traffic Safety Administration and coordinated by the Highway Safety Committee of the International Association of Chiefs of Police (IACP). In 1992 a set of minimum standards were adopted specifying the requirement for certification and re-certification of DREs and DRE instructors, standards for decertification and reinstatement of DREs, and standards for agency participation (IACP, 1999). These international standards were revised in 2018 by the DEC Standards Revision Subcommittee of the Technical Advisory Panel of the IACP Highway Safety Committee. The Technical Advisory Panel stays abreast of scientific developments and from time to time makes recommendations for changes to the DEC protocol where evidence warrants.

DEC Protocol

The 12 steps involved in the DEC protocol are summarized below.

Breath alcohol test: A breath test for alcohol is conducted to determine whether alcohol may be contributing to the subject's impairment. If the subject's breath alcohol concentration is not deemed sufficient to explain the degree or type of impairment, the officer will proceed with a drug influence evaluation.

Interview of the arresting officer: The DRE continues with the investigation by discussing the circumstances of the arrest with the arresting officer.[1] The arresting officer is asked about the subject's observed behavior, appearance and driving pattern, and any observations that might be relevant and valuable are noted. Also pertinent are any statements made by the subject and whether the arresting officer found any other relevant evidence, such as drug paraphernalia.

Preliminary examination: The DRE determines if the subject may be suffering from an injury or some other medical condition not necessarily related to drug use. Accordingly, the DRE asks the subject a series of standard questions relating to the subject's health and recent ingestion of food, alcohol, and drugs, including prescribed medications. The DRE will also begin systematically assessing the subject's behavior and automatic bodily responses for signs of drug-induced behavior. This includes observations of the subject's attitude, coordination, face, speech and breath. The DRE also determines whether the subject's pupils are of equal size and whether the eyes can follow a moving stimulus and track in sync. The DRE also looks for HGN and takes the subject's pulse for the first of three times.

Eye examinations: The DRE examines the subject for HGN, vertical gaze nystagmus, and a lack of ocular convergence.

Divided attention psychophysical tests: To assess the degree and types of psychomotor impairment, the DRE administers the OLS, WAT, MRB, and Finger to Nose (FTN) tests.

Vital signs: The DRE measures the subject's blood pressure, temperature, and pulse rate (second measurement).

Dark room examinations: The DRE estimates a subject's pupil size under three different lighting conditions (room light, near total darkness, and direct light) with a pupilometer to determine whether the pupils are dilated, constricted, or normal. The DRE also assesses how the subject's eyes respond to light (slow, normal, or fast reaction) under conditions of near total darkness. Finally, the subject's nasal and oral cavities are examined for signs of ingestion.

[1] The DRE conducting the drug influence evaluation may not necessarily be the arresting officer.

Examination for muscle tone: The DRE examines the subject's skeletal muscle tone to assess whether the muscles are rigid, flaccid, or normal.

Check for injection sites: The DRE examines the subject for injection sites, which may indicate recent use of certain types of drugs. The DRE also takes the subject's pulse (for the third and final time).

Subject's statements and other observations: The DRE asks a series of questions regarding the subject's drug use.

Opinion of the evaluator: Based on the totality of the evidence and observations noted during the evaluation, the DRE will form an opinion as to whether the subject is impaired by a drug or combination of drugs and the probable category or categories of drugs responsible for the impairment. The DEC Program classifies drugs into seven categories:

- CNS depressants (e.g., benzodiazepines, tranquilizers);
- inhalants (e.g., solvents, aerosols);
- dissociative anesthetics (e.g., ketamine, phencyclidine [PCP];
- cannabis;
- CNS stimulants (e.g., cocaine, amphetamines);
- hallucinogens (e.g., ecstasy, lysergic acid diethylamide [LSD]); and
- narcotic analgesics (e.g., heroin, oxycodone, morphine).

These categories are not based solely on the chemistry or pharmacokinetic properties of substances but rather are based on a commonality of the signs and symptoms that would most likely be observed, that is, the pharmacodynamic properties. Cases can also be ruled out for medical or other reasons.

Toxicological examination: Depending on the legislation in the jurisdiction, the DRE requests or requires the subject to provide a sample of blood, urine, or oral fluid to be sent to the toxicology laboratory for analysis.

All the information collected during the evaluation is documented on a Drug Influence Evaluation (DIE) Face Sheet (Appendix A). The information from the DIE Face Sheet is then summarized in a written report, the Narrative Report (Appendix B).

Previous Research on the DEC Program

A review of existing laboratory and field evaluation studies on the DEC program reported the overall accuracy of DEC evaluations made by trained DREs on impaired drivers to be more than 80% (Beirness et al., 2007). A study of 1,349 DEC evaluations completed by DREs in Canada reported an overall accuracy rate of 95% (Beirness et al., 2009), with some drug classes being more difficult to detect than others. Taken together, these research findings (Beirness et al., 2007, 2009) provide confidence in the use of the DEC procedure to detect persons impaired by substances other than alcohol. However, as encouraging as the results are, they also indicate that the DEC program is not perfect. Beirness and colleagues (2007, 2009) have noted that some drug classes are more difficult to detect accurately than others. For example, the sensitivity of the DEC procedure in detecting CNS depressants was lower than that for other drugs. In addition, drugs used in combination with alcohol or other drugs are more difficult to detect accurately. Most errors fell under the category of false negatives (i.e., cases where the DRE failed to identify

the subject as impaired by a particular drug class but the toxicology analysis revealed the drug to be present). False positives (i.e., cases where the DRE believed a subject was impaired by a drug but the toxicology revealed no drugs were present) were extremely rare. The variable accuracy rates among the different classes of drugs require further investigation and suggest that further work may be necessary to identify and specify the most reliable signs and symptoms of particular drug classes.

Smith, Hayes, Yolton, Rutledge and Citek (2002) investigated the importance of face-to-face interactions with the subject, physical evidence (e.g., presence of drugs or paraphernalia) and confessions/statements made by the subject in DREs' determination of whether a subject is under the influence of a drugs and, if so, which category of drugs are involved. Records from 70 DEC cases from four drug categories (cannabis, narcotic analgesics, CNS stimulants and CNS depressants) and no-drug cases were provided to 18 DREs from Oregon with the statements made by subjects or arresting officers, toxicology results, and descriptions of drugs or paraphernalia found on the subject omitted from the evaluation reports. Using a limited set of information from the DEC evaluations (including the written reports of direct observations and physiological and psychophysical test results), the DREs were asked to determine whether each of the 70 subjects was under the influence of one or more drugs and, if so, what categories of drugs were involved. Overall, the DREs correctly identified positive drug influence in nearly 95% of cases. The findings also revealed that when officers determined that subjects were under the influence of drugs, their accuracy in specifying the drug category was 80.7% for cannabis, 94% for narcotic analgesics, 78.4% for CNS stimulants, 68.6% for CNS depressants, and 65.6% for cases not involving drugs. The investigators concluded that the majority of drug category decisions could be made solely on the basis of recorded observations of the subject and the DEC evaluation results, with face-to-face interactions, physical evidence, and subject statements contributing to the totality of the situation and serving as useful adjuncts to DRE decision-making.

In a re-analysis of data from a previous study that involved having volunteers consume specified quantities and types of drugs, Shinar and Schechtman (2005) evaluated the ability of DREs to detect drug impairment and the impairing drug category solely on the basis of the results from the four psychophysical tests (i.e., MRB, WAT, OLS, and FTN) and limited clinical indicators of drug use (e.g., nystagmus, pupil diameter under different light conditions, pulse rate, blood pressure, temperature). Four drugs—corresponding to four different drug categories—were evaluated in this study: cannabis, CNS depressants (e.g., alprazolam), narcotic analgesics (e.g., codeine) and CNS stimulants (e.g., amphetamine). The results suggested that DREs were forming their opinion about the category of drug consumed based on only one or two pivotal signs or symptoms while ignoring others, even if contradictory to their judgment.

Issue Under Study

Conducting a DEC evaluation is extensive and generally takes approximately 45 to 60 minutes to complete. More than 100 different elements in numerical, narrative, and pictorial form are documented during the procedure, and it concludes with a request/demand for a biological specimen (blood, urine, or oral fluid) to support the DRE's opinion. Some have questioned whether the number of pieces of information collected is unnecessarily large and overly time-consuming (Schechtman & Shinar, 2005; Shinar & Schechtman, 2005). Because the DEC evaluation provides evidence of impairment and drug influence, it is important that the opinion

of the evaluating officer in terms of drug category/categories is as accurate as possible. Therefore, it may prove beneficial and enhance the accuracy of DEC evaluations if, when forming their opinion, DREs first consider elements of the evaluation that are most predictive of various drug categories and use the other elements to capture the totality from all indicators.

Recent research suggests it may be possible to identify a core set of measures from DEC evaluations that can be used to guide opinions about drug category/categories without significantly compromising accuracy (Porath-Waller et al., 2009; Porath-Waller & Beirness, 2010). Using data from 742 completed evaluations from Canada, Porath-Waller and colleagues (2009) reported that DREs can focus on a limited set of key signs and symptoms when determining the category of drug used by a suspected drug-impaired driver without compromising the accuracy of their evaluations. These investigators identified a set of nine signs and symptoms from single-drug category cases that best predicted three classes (CNS stimulants, narcotic analgesics and cannabis) of drugs used by suspected drug-impaired drivers:

- pulse rate,
- condition of the eyes,
- condition of the eyelids,
- lack of convergence,
- hippus,[2]
- rebound dilation,
- reaction to light,
- injection sites, and
- systolic blood pressure.

Based on this set of nine clinical indicators, an overall classification rate of 81% was obtained across the three drug categories. As other indicators are considered by the DRE, the totality of the evaluation would be expected to improve the classification rate.

In a follow-up study to this work, Porath-Waller and Beirness (2010) analyzed the signs and symptoms that were most predictive of common drug combinations (CNS stimulants with cannabis, CNS stimulants with narcotic analgesics, and cannabis with alcohol) from a sample of 819 completed evaluations from Canada. Results showed that 11 clinical indicators significantly enhanced the prediction of drugs used by subjected drug-impaired drivers:

- the condition of the eyes,
- lack of convergence,
- rebound dilation,
- reaction to light,
- presence of visible injection sites,
- assessment of HGN,
- pupil size in darkness,
- performance on the OLS test,
- muscle tone, and
- performance on the WAT test.

[2] Hippus is no longer assessed as part of the DEC evaluation protocol.

One implication from this research is that it may not be necessary for DREs to collect all the information that the evaluation currently demands: It may be possible to limit the evaluation to a core set of measures. Due to the limited cases available to Porath-Waller and colleagues, it was not possible to evaluate the full set of data in the DEC cases.

Project Objectives

The goal of this investigation was to determine—by using a large sample of DEC evaluations conducted on suspected drug-impaired drivers—which combinations of elements of the DEC protocol can most efficiently and effectively identify the drug category/categories used by a subject.

These were the objectives of our study:

1. Obtain a sample of DEC evaluation cases confirmed by toxicological analysis of blood samples;
2. Code the information found on the DIE face sheets, narrative reports, and toxicology reports to create a database of measures for analysis; and
3. Analyze the data to determine the connections between the measures and drug category/combination and determine which combinations of factors offer the best predictive validity in the most efficient and effective manner.

This study expands on the literature in this area by using a large sample size that has broad geographical representation. Another unique feature is it used DEC cases with toxicological confirmation using blood. This research built on previous work by Porath-Waller and colleagues (2009, 2010) by examining all of the information recorded during the DEC evaluations and assessing additional drug categories and combinations. The current investigation's larger sample size permited use of more sophisticated statistical analyses to address a number of important research questions such as the relative importance of clinical, behavioral and observational indicators in predicting the drug category/categories responsible for impairment, and the discrimination between drug-positive and drug-negative cases. To determine any commonalities in the circumstances or characteristics of these cases, this study involved a detailed case-by-case review of cases ruled out by the DRE for not involving drugs or those that were ruled out due to medical reasons.

Method

Power Analysis

A power analysis was conducted using NCSS PASS software[3] to determine the number of complete DEC cases per drug category and drug combination and the number of rule-out ("no drug") cases that would permit a statistically powerful analysis and reduce Type I error (a false positive—testing positive when there is no drug). For the purposes of this study, a complete case consisted of the DIE face sheet, narrative report, and toxicological report. Cases missing any of these components were considered incomplete and were not included.[4]

As the NCSS PASS software does not calculate statistical power for a multinomial logistic regression analysis, we converted our hypotheses to a binary logistic regression model for the purposes of this power analysis. Given that both binary and continuous predictor variables were to be included in the statistical models, power was calculated for both types of predictors. The power analysis based on a binary predictor required a larger sample size compared to that involving a continuous predictor. To provide a conservative estimate of the required number of cases needed to achieve 80 percent power at a .05 significance level, the power analysis was based on a binary predictor. Results from this analysis suggested that a minimum sample of 3,575 cases, with a minimum *n* of 325 for each of the drug categories/combinations be collected to detect an odds ratio (OR) of 2.5. The OR is a measure of the strength of the association between the outcome and predictor variables, with ORs close to 1.0 indicating only weak associations and ORs greater than 3.0 indicating strong positive associations (Sandercock, 1989).

Study Sample of DEC Cases

The sample consisted of 2,534 DEC evaluations conducted on drivers suspected of drug-impaired driving between April 22, 2000, and December 24, 2012. In all cases, the opinion of the evaluating officer was confirmed by toxicological analysis of blood samples.[5] To be included in the study sample, each complete case had to include the DIE face sheet, narrative report, and toxicology report. Additional inclusion criteria included the cases being actual cases resulting from traffic stops (not cases completed as part of training) and that the cases involved particular prevalent drug categories and two-drug combinations (CNS depressants, CNS stimulants, narcotic analgesics, cannabis, CNS stimulants with cannabis, CNS stimulant with narcotic analgesics, CNS stimulants with CNS depressants, and cannabis with alcohol), medical and non-medical rule-outs. In some cases, however, we excluded cases involving drug categories and combinations that did not meet our inclusion criteria (e.g., training cases; cases with no toxicology results; cases with urine samples).

Data was collected from a total of 11 States, ensuring a range of geographic representation in the study sample. Cases in which the toxicology result did not match the opinion of the DRE (*n* = 156) were not included in the final study sample, reducing the sample size to 2,378 cases.

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[3] PASS 11 [Power Analysis & Sample Size] software. NCSS, LC, Kaysville, UT.

4 Note that some of the rule-out cases did not have toxicology reports, but they were still included in the study sample.

[5] Based on the IACP criteria for correct opinion, the opinion of the DRE concerning the drug category or categories responsible for the impairment was deemed confirmed if the toxicological analysis disclosed the presence of at least one drug category named by the DRE.

Table 1 shows the number of cases and percentages in each of the seven drug categories and nine two-drug combinations in the sample.

Table 1. Number of Cases in Each Drug Category and Drug Category Combination

Drug Category/Combination	Number of Cases (%)
Rule-out	53 (2.2%)
Medical rule-out	29 (1.2%)
Alcohol	1 (0.0%)
CNS depressants	432 (18.2%)
CNS stimulants	166 (7.0%)
Hallucinogens	2 (0.1%)
Dissociative anesthetics	11 (0.5%)
Narcotic analgesics	194 (8.2%)
Inhalants	13 (0.5%)
Cannabis	544 (22.9%)
Alcohol and CNS depressants	33 (1.4%)
Alcohol and narcotic analgesics	1 (0.0%)
Alcohol and cannabis	101 (4.2%)
CNS depressants and CNS stimulants	114 (4.8%)
CNS depressants and narcotic analgesics	319 (13.4%)
CNS depressants and cannabis	107 (4.5%)
CNS stimulants and narcotic analgesics	104 (4.4%)
CNS stimulants and cannabis	96 (4.0%)
Narcotic analgesics and cannabis	58 (2.4%)

The results from the power analysis revealed that a minimum of 325 cases for each of the drug categories and combinations would be needed for a statistically powerful analysis. As presented in Table 1, we obtained recommended minimum number of cases for only two drug categories: CNS depressants and cannabis. The number of cases in the CNS stimulants and narcotic analgesic drug categories were only about half of the recommended minimum *n* of 325. In terms of the drug combinations, the number of cases for the combinations of alcohol and cannabis, CNS depressants and narcotic analgesics, CNS depressants and CNS stimulants, CNS depressants and cannabis, and CNS stimulants and narcotic analgesics were all about one-third of the recommended minimum of 325 cases. There were also some drug combinations with cell

sizes lower than 100. It was decided that these drug combinations would not be considered for inclusion in the current study.

The immediate implication associated with these smaller-than-recommended cell sizes is the reduction in statistical power to detect a moderate association (OR) between the outcome and predictor variables. That is, the analysis may reveal, that there is no significant association between a given drug category and drug-related indicator from the DEC evaluation when, in fact, such an association exists.

Due to the low number of rule-out cases in the current sample (n = 53), it was determined that rule-out cases from Canada (n = 127) would be added to the sample so that it could be used as a referent group in the analyses. No statistically significant differences were noted between the rule-out cases obtained from the two jurisdictions, except that the Canadian cases had toxicological confirmation of the results based on urine rather than blood. The DEC evaluations were also conducted during slightly different time periods: Canadian cases occurred from January 12, 1995, to November 27, 2009, whereas the American cases occurred from April 18, 2004, to December 26, 2011. Although the Canadian rule-out cases were collected over a 14-year period (compared to 7 years for the U.S. cases), there is no reason to believe that variability in the DREs' reporting or laboratory protocols may have affected the Canadian cases. The DEC program is a systematic and standardized protocol used throughout North America and there have been no major changes to this protocol over the years. The merging of rule-out cases from Canada and the United States resulted in a combined total of 180 rule-out cases. Despite this merging of cases, the cell size for the referent group was still lower than the recommended 325 cases resulting in reduced statistical power for the analyses.

In consultation with the NHTSA project manager, it was determined that two drug combinations (CNS depressants and cannabis, n = 107, and alcohol and cannabis, n = 101) would be merged to form a single drug combination group of CNS depressants and cannabis, as it was determined that the cases in these two groups were not behaving significantly different from one another. Moreover, the similar pharmacological effects of alcohol and CNS depressants (NHTSA & IACP DRE Program, 2003) justified the merging of these two drug combination groups, which resulted in a cell size of 208 cases—marginally closer in size to the recommended 325 cases from the power analysis.

In summary, the final sample size for analysis consists of 2,261 cases broken down by the following drug categories:

- CNS depressants (n = 432),
- CNS stimulants (n = 166),
- narcotic analgesics (n = 194),
- cannabis (n = 544), and
- rule-out cases (referent group; n = 180).

The drug combinations that were included in the final sample for analysis were:

- CNS depressants and narcotic analgesics (n = 319),
- CNS depressants and CNS stimulants (n = 114),
- CNS stimulants and narcotic analgesics (n = 104), and
- CNS depressants and cannabis (n = 208).

Several of the cell sizes for these drug categories and combinations were well below the recommended cell size of 325 from the power analysis, and as such, their inclusion in the statistical analysis will result in a reduction in statistical power to detect a moderate association (OR) between the outcome and predictor variables. These concerns were collaboratively discussed with the NHTSA project manager, and it was determined that these drug categories and combinations would be included in the final sample size in order to satisfy the requirements of the contract,

While not part of the quantitative analysis, the 29 medical rule-out cases along with the 53 non-medical rule-out cases collected for this study were subjected to a qualitative review to determine the extent to which there were commonalities in the circumstances or characteristics of these cases.

Data Collection Procedure

We made contact with DRE State Coordinators across States to arrange for obtaining data from their States.

Data Coding Procedures

The instrument used to code data in the current study was used previously in other studies involving DEC cases (Porath-Waller et al., 2009; Porath-Waller & Beirness, 2010) and has shown to be reliable, with inter-rater reliability exceeding 86%. For purposes of the current study, some additional variables were coded, including the State where the case was conducted, the names of the drugs identified in the toxicology report as well as the quantity of the drug reported and the units of measurement, the circumstances that led to the arrest of the subject, and the events that resulted in an opinion of a medical rule out being noted. The instrument used in the current study includes 157 codes for the numerical, pictorial and narrative information contained in the DIE face sheet, narrative and toxicology results (Appendix E).

Quality Control Plan for Data Entry

All data entry clerks received at least 2 days of formal data entry training and were closely supervised by the two principal investigators. To ensure quality control with respect to the entry of DEC data into the database, a double entry verification process was implemented, whereby up to 10% of cases were to be entered twice into separate files by different data entry clerks. The two files were then compared to assess the extent of data coding errors. The target was to have a data entry error rate of less than 1%.

On several occasions over the course of the data coding process, the clerks were assigned a set of cases to code and enter that had been previously entered by another clerk. A feature of the data entry program compared the data and provided a list of mismatched codes for each variable. Review of the errors from the first set of 30 cases revealed that text variables were listed as errors if they did not match perfectly in terms of spelling, case or spacing. For some text fields, the limited space provided by the database forced clerks to use abbreviations. As these text errors were of no consequence to the analysis and the interpretation of the text was never in question, it was decided to restrict the comparison to numeric variables only.

The first set of double entry cases revealed an error rate of 1.76%. On review of the specific errors, it was determined that one clerk was reversing the entry of tests done on the right and left side (for example, on the OLS test). This was addressed with the clerk and easily corrected.

In total, 188 cases (8.34%) were entered twice over the course of the study to determine the reliability of data coding and entry. Overall, the error rate was 1.17%. Given the stringent criteria used, one can have a high degree of confidence that the data in the current study are accurate.

Statistical Methods[6]

The data was first screened and cleaned for accuracy and all relevant statistical assumptions were assessed (Tabachnick & Fidell, 2007). Various descriptive statistics (e.g., M, SD, r, Cramer's V) were then calculated to provide a summary of the characteristics of the study sample and inform the main statistical analyses.

Analyses

To assess the prediction of a single drug category or a two-drug combination from the various signs and symptoms measured during the DEC evaluation, we performed multinomial logistic regression analyses. This multivariate analysis allows the prediction of an outcome variable that has more than two categories from a set of predictor variables that may be continuous, discrete, dichotomous, or a mix of these (Tabachnick & Fidell, 2007). This procedure selects the best set of predictors after accounting for the variance of other factors. Logistic regression also permits the calculation of classification rates for the outcome categories in order to provide an estimate of the relative success or effectiveness of the model in correctly predicting the category of drugs used. For all analyses, we report the regression coefficients, chi-square tests, odds ratios and 95 percent confidence intervals. Separate analyses were conducted for the drug categories and the two-drug combinations.

A receiver operating curve (ROC) was then derived from the logistic regression model to obtain an overall assessment of how well the model predicts which subjects have used a particular drug category and those who have not used any drugs (Kleinbaum & Klein, 2010). The area under the ROC curve (AUC) and 95 percent confidence intervals were calculated to provide an overall summary of the model's accuracy. The AUC equals 0.5 when the ROC curve corresponds to random chance and 1.0 for perfect accuracy (Kleinbaum & Klein, 2010). ROC curves could only be performed for the CNS depressants and cannabis drug categories as the cell sizes for the other drug categories and combinations were below the power analysis' recommended minimum of 325 cases.

The drug-related signs and symptoms from the DEC evaluations were then conceptually grouped based on whether they were clinical indicators (e.g., pulse rate, blood pressure, body temperature, muscle tone), performance on psychophysical tests, appearance and physiological response of the eyes, or observations or self-reported statements from the subject. These groups of variables were then entered as blocks into a sequential multinomial logistic regression procedure to determine the relative importance of the four groups of indicators in predicting drug category/combination.

[6] See Appendix F for a summary of Statistical Methods Terms.

Results

Characteristics of the Study Sample

Subject sex: Males comprised 65.9% of the study sample. The distribution of subject sex significantly varied by drug category/combination, X^2 (8, N = 2255) = 244.23, p < .0001. As shown in Table 2, more males than females had used CNS stimulants, narcotic analgesics, cannabis, and CNS depressants in combination with cannabis. In contrast, more females than males had used CNS depressants, CNS depressants in combination with CNS stimulants, CNS depressants in combination with narcotic analgesics, and CNS stimulants in combination with narcotic analgesics. Among the group of rule-out cases, there were more males than females.

Table 2. Number of Cases in Each Drug Category/Combination by Sex

Drug Category/Combination	Males	Females	Total
Rule-out (%)	146 (9.8)	34 (4.4)	180 (8.0)
CNS depressants (%)	205 (13.8)	226 (29.4)	431 (19.1)
CNS stimulants (%)	115 (7.7)	51 (6.6)	166 (7.4)
Narcotic analgesics (%)	132 (8.9)	61 (7.9)	193 (8.6)
Cannabis (%)	459 (30.9)	85 (11.1)	544 (24.1)
CNS depressants with CNS stimulants (%)	60 (4.0)	53 (6.9)	113 (5.0)
CNS depressants with narcotic analgesics (%)	146 (9.8)	171 (22.3)	317 (14.1)
CNS depressants with cannabis (%)	161 (10.8)	47 (6.1)	208 (9.2)
CNS stimulants with narcotic analgesics (%)	63 (4.2)	40 (5.2)	103 (4.6)
Total (%)	1487 (65.9)	768 (34.1)	2255 (100.0)

Note: The rule-out category includes cases from the current sample (n = 53) and Canada (n = 127).

Subject age: The sample ranged in age from 15 to 90 years, with an average age of 33.9 years (SD = 13.3). Subjects from 19 to 24 comprised 26.4% of the study sample, followed closely by the group 25 to 34 years old (24.2%). Subjects from 35 to 44 comprised 17.3% of the study sample; those 45 to 54 years comprised 16.5% of the study sample; and subjects 55 and older and those younger than 19 comprised the smallest proportions of the sample, 8.5% and 7.1%, respectively.

The distribution of subject age varied significantly by drug category/combination, X^2 (40, $N = 2018$) = 666.25, $p < .0001$. As presented in Table 3, younger subjects (15 to 24 years old) had used cannabis more than the other drug categories and combinations. Subjects 25 to 34 years old had used CNS depressants and cannabis more often than the other drug categories and combinations. CNS depressants were also the most common drug category used among subjects 35 to 54 years. Subjects 55 and older had used CNS depressants in combination with narcotic analgesics most often, followed closely by the use of CNS depressants.

Table 3. Number of Cases in Each Drug Category/Combination by Subject Age

Drug Category/Combination	15–18	19–24	25–34	35–44	45–54	55+	Total
Rule-out	10	54	52	31	15	8	170
(%)	(6.9)	(10.2)	(10.7)	(8.9)	(4.5)	(4.7)	(8.4)
CNS depressants	8	40	87	95	94	42	366
(%)	(5.6)	(7.5)	(17.8)	(27.1)	(28.3)	(24.4)	(18.1)
CNS stimulants	3	33	39	40	29	13	157
(%)	(2.1)	(6.2)	(8.0)	(11.4)	(8.7)	(7.6)	(7.8)
Narcotic analgesics	0	31	49	30	39	24	173
(%)	(0)	(5.8)	(10.0)	(8.6)	(11.7)	(14.0)	(8.6)
Cannabis	103	239	87	22	28	9	488
(%)	(71.5)	(44.9)	(17.8)	(6.3)	(8.4)	(5.2)	(24.2)
CNS depressants with CNS stimulants (%)	0 (0)	17 (3.2)	30 (6.1)	21 (6.0)	20 (6.0)	10 (5.8)	98 (4.9)
CNS depressants with narcotic analgesics (%)	2 (1.4)	29 (5.5)	73 (15.0)	74 (21.1)	75 (22.6)	44 (25.6)	297 (14.7)
CNS depressants with cannabis	18	79	48	9	14	7	175
(%)	(12.5)	(14.8)	(9.8)	(2.6)	(4.2)	(4.1)	(8.7)
CNS stimulants with narcotic analgesics	0	10	23	28	18	15	94
(%)	(0)	(1.9)	(4.7)	(8.0)	(5.4)	(8.7)	(4.7)
Total	144	532	488	350	332	172	2,018
(%)	(7.1)	(26.4)	(24.2)	(17.3)	(16.5)	(8.5)	(100.0)

Note: The rule-out category includes cases from the current sample ($n = 53$) and Canada ($n = 127$).

Sickness, injury and disability: When asked if they were sick or injured, 36.2% of subjects responded affirmatively. The distribution of subjects reporting being sick or injured varied significantly by drug category/combination, X^2 (8, N = 2,181) = 152.48, $p < .0001$. As presented in Table 4, the highest proportion of subjects who reported being sick or injured had used CNS depressants followed by CNS depressants in combination with narcotic analgesics.

Table 4. Number of Cases in Each Drug Category/Combination by Subject Reporting Being Sick or Injured

Drug Category/Combination	Not Sick or Injured	Sick or Injured	Total
Rule-out (%)	130 (9.3)	48 (6.1)	178 (8.2)
CNS depressants (%)	230 (16.5)	187 (23.7)	417 (19.1)
CNS stimulants (%)	116 (8.3)	43 (5.4)	159 (7.3)
Narcotic analgesics (%)	104 (7.5)	86 (10.9)	190 (8.7)
Cannabis (%)	409 (29.4)	109 (13.8)	518 (23.8)
CNS depressants with CNS stimulants (%)	68 (4.9)	38 (4.8)	106 (4.9)
CNS depressants with narcotic analgesics (%)	134 (9.6)	177 (22.4)	311 (14.3)
CNS depressants with cannabis (%)	148 (10.6)	57 (7.2)	205 (9.4)
CNS stimulants with narcotic analgesics (%)	52 (3.7)	45 (5.7)	97 (4.4)
Total (%)	1,391 (63.8)	790 (36.2)	2,181 (100.0)

Note: The rule-out category includes cases from the current sample (n = 53) and Canada (n = 127).

About 29% of subjects indicated that they each had a disability or defect, with distribution varying significantly by drug category/combination, X^2 (8, N = 2,175) = 144.04, p < .0001. The highest proportion of those subjects who had reported having a disability or defect had used CNS depressants in combination with narcotics, followed closely by CNS depressants (Table 5).

Table 5. Number of Cases in Each Drug Category/Combination by Subject Reporting Having a Disability or Defect

Drug Category/Combination	No Disability or Defect	Disability or Defect	Total
Rule-out (%)	142 (9.1)	33 (5.3)	175 (8.0)
CNS depressants (%)	285 (18.3)	131 (21.1)	416 (19.1)
CNS stimulants (%)	118 (7.6)	41 (6.6)	159 (7.3)
Narcotic analgesics (%)	112 (7.2)	78 (12.6)	190 (8.7)
Cannabis (%)	435 (28.0)	81 (13.1)	516 (23.7)
CNS depressants with CNS stimulants (%)	74 (4.8)	33 (5.3)	107 (4.9)
CNS depressants with narcotic analgesics (%)	159 (10.2)	151 (24.4)	310 (14.3)
CNS depressants with cannabis (%)	168 (10.8)	36 (5.8)	204 (9.4)
CNS stimulants with narcotic analgesics (%)	62 (4.0)	36 (5.8)	98 (4.5)
Total (%)	1,555 (71.5)	620 (28.5)	2,175 (100.0)

Note: The rule-out category includes cases from the current sample (n = 53) and Canada (n = 127).

Care by a doctor or dentist: About half of the sample (50.7%) indicated they were under the care of doctors or dentists. The distribution of those under the care of a doctor or dentist varied significantly according to drug category/combination, X^2 (8, N = 2,164) = 572.74, $p < .0001$. As presented in Table 6, the highest proportion of subjects who indicated they were under the care of a doctor or dentist had used CNS depressants, followed by a combination of CNS depressants with narcotic analgesics.

Table 6. Number of Cases in Each Drug Category/Combination by Subject Reporting Care by Doctor or Dentist

Drug Category/Combination	No Care	Care	Total
Rule-out (%)	130 (12.2)	43 (3.9)	173 (8.0)
CNS depressants (%)	86 (8.1)	327 (29.8)	413 (19.1)
CNS stimulants (%)	112 (10.5)	46 (4.2)	158 (7.3)
Narcotic analgesics (%)	65 (6.1)	124 (11.3)	189 (8.7)
Cannabis (%)	414 (38.8)	96 (8.8)	510 (23.6)
CNS depressants with CNS stimulants (%)	39 (3.7)	71 (6.5)	110 (5.1)
CNS depressants with narcotic analgesics (%)	56 (5.2)	255 (23.2)	311 (14.4)
CNS depressants with cannabis (%)	121 (11.3)	83 (7.6)	204 (9.4)
CNS stimulants with narcotic analgesics (%)	44 (4.1)	52 (4.7)	96 (4.4)
Total (%)	1,067 (49.3)	1,097 (50.7)	2,164 (100.0)

Note: The rule-out category includes cases from the current sample (n = 53) and Canada (n = 127).

Crash type: The majority of the sample had not been involved in a crash (75.8%). About one-quarter of the drivers were evaluated following crashes: 18.2% were involved in property damage crashes, 3.2% were involved in crashes that resulted in injury, and 0.9% had crashes involving fatalities. The distribution of crash type was found to vary significantly by drug category/combination, X^2 (24, N = 2074) = 214.78, $p < .0001$, with all three types of crashes being more frequent among those subjects who had used CNS depressants (Table 7).

Table 7. Number of Cases in Each Drug Category/Combination by Type of Crash

Drug Category/Combination	None	Fatal	Injury	Property Damage	Total
Rule-out (%)	115 (7.2)	3 (15.0)	5 (7.4)	12 (3.1)	135 (6.5)
CNS depressants (%)	242 (15.1)	5 (25.0)	30 (44.1)	127 (33.0)	404 (19.5)
CNS stimulants (%)	134 (8.4)	2 (10.0)	2 (2.9)	11 (2.9)	149 (7.2)
Narcotic analgesics (%)	126 (7.9)	2 (10.0)	7 (10.3)	49 (12.7)	184 (8.9)
Cannabis (%)	474 (29.6)	1 (5.0)	1 (1.5)	30 (7.8)	506 (24.4)
CNS depressants with CNS stimulants (%)	70 (4.4)	2 (10.0)	3 (4.4)	29 (7.5)	104 (5.0)
CNS depressants with narcotic analgesics (%)	212 (13.2)	3 (15.0)	11 (16.2)	83 (21.6)	309 (14.9)
CNS depressants with cannabis (%)	162 (10.1)	2 (10.0)	7 (10.3)	24 (6.2)	195 (9.4)
CNS stimulants with narcotic analgesics (%)	66 (4.1)	0 (0)	2 (2.9)	20 (5.2)	88 (4.2)
Total (%)	1,601 (77.2)	20 (1.0)	68 (3.3)	385 (18.6)	2,074 (100.0)

Note: The rule-out category includes cases from the current sample (n = 53) and Canada (n = 127).

Day of week: The percentage of evaluations conducted according to the day of week is illustrated in Figure 1. The highest percentage of evaluations were conducted on Saturday (17.0%), followed closely by Friday (16.5%) and Thursday (15.6%).

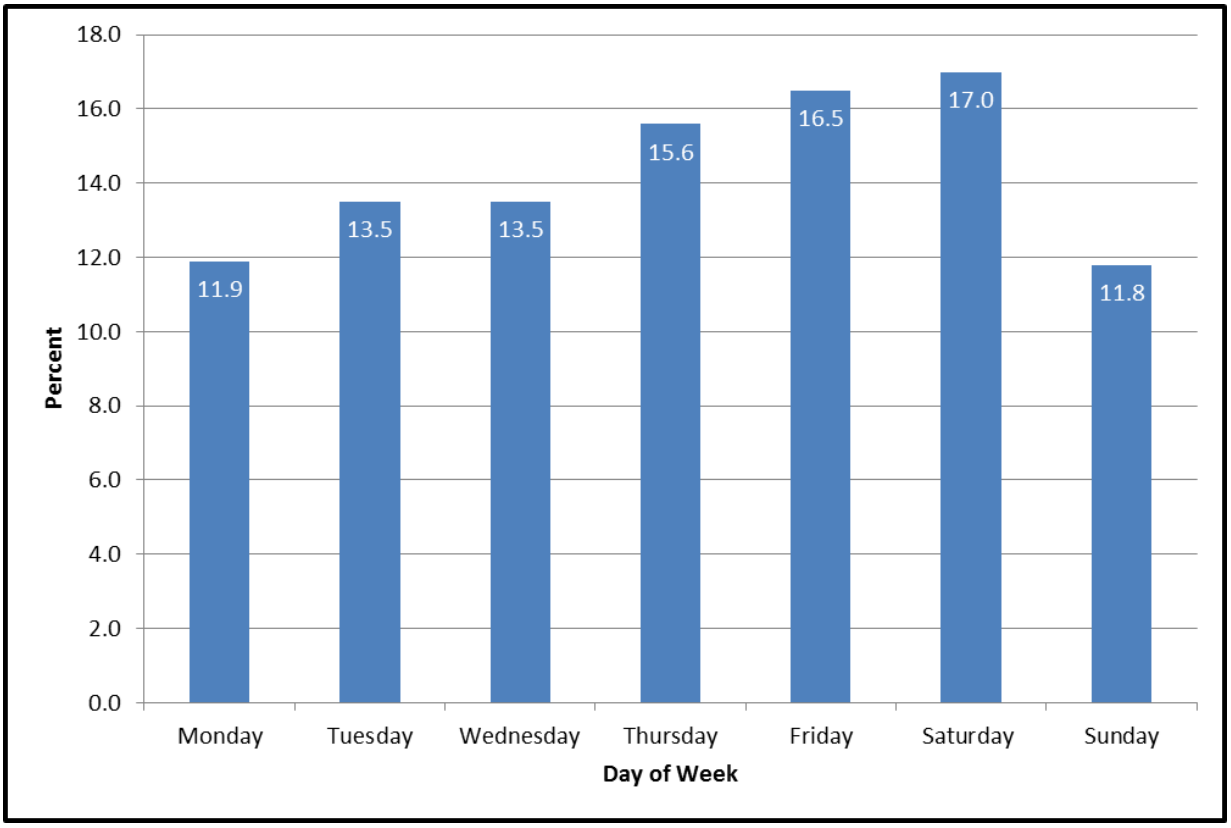

Figure 1. Percentage of Evaluations Conducted by Day of Week

The distribution of the drug category/combination of the DEC evaluations was found to vary significantly according to the day of the week that the evaluation was conducted, X^2 (48, N = 2,239) = 86.18, p = .001. As shown in Table 8, the highest percentage of evaluations conducted from Friday to Sunday involved cannabis. From Monday to Thursday, evaluations involving CNS depressants were the most common, followed closely by those involving cannabis (Table 8).

Table 8. Number of Cases in Each Drug Category/Combination by Day of Week

Drug Category/Combination	Mon.	Tue.	Wed.	Thurs.	Fri.	Sat.	Sun.	Total
Rule-out	29	3.0	29	28	2.5	17	19	177
(%)	(10.9)	(9.9)	(9.6)	(7.9)	(6.8)	(4.5)	(7.2)	(7.9)
CNS depressants	53	63	77	72	69	59	37	430
(%)	(19.9)	(20.9)	(25.4)	(20.4)	(18.7)	(15.5)	(14.0)	(19.2)
CNS stimulants	18	24	20	24	22	31	26	165
(%)	(6.8)	(7.9)	(6.6)	(6.8)	(6.0)	(8.1)	(9.8)	(7.4)
Narcotic analgesics	31	33	23	21	37	27	19	191
(%)	(11.7)	(10.9)	(7.6)	(5.9)	(10.0)	(7.1)	(7.2)	(8.5)
Cannabis	49	61	68	71	105	107	80	541
(%)	(18.4)	(20.2)	(22.4)	(20.1)	(28.5)	(28.1)	(30.2)	(24.2)
CNS depressants with CNS stimulants (%)	16 (6.0)	13 (4.3)	10 (3.3)	17 (4.8)	24 (6.5)	15 (3.9)	17 (6.4)	112 (5.0)
CNS depressants with narcotic analgesics (%)	40 (15)	41 (13.6)	39 (12.9)	62 (17.6)	43 (11.7)	63 (16.5)	27 (10.2)	315 (14.1)
CNS depressants with cannabis (%)	24 (9.0)	22 (7.3)	27 (8.9)	35 (9.9)	28 (7.6)	44 (11.5)	26 (9.8)	206 (9.2)
CNS stimulants with narcotic analgesics (%)	14 (5.3)	6 (2.3)	15 (5.0)	10 (3.3)	23 (6.5)	16 (4.3)	18 (4.7)	102 (4.6)
Total	266	302	303	353	369	381	265	2,239
(%)	(11.9)	(13.5)	(13.5)	(15.8)	(16.5)	(17.0)	(11.8)	(100.0)

Note: The rule-out category includes cases from the current sample (n = 53) and Canada (n = 127).

Month of year: The distribution of evaluations conducted according to the month is illustrated in Figure 2. The highest percentage of evaluations was conducted in March (9.5%), followed closely by June (9.2%) and April (9.0%). The lowest percentage of evaluations was conducted in October (7.0%) followed closely by February (7.2%).

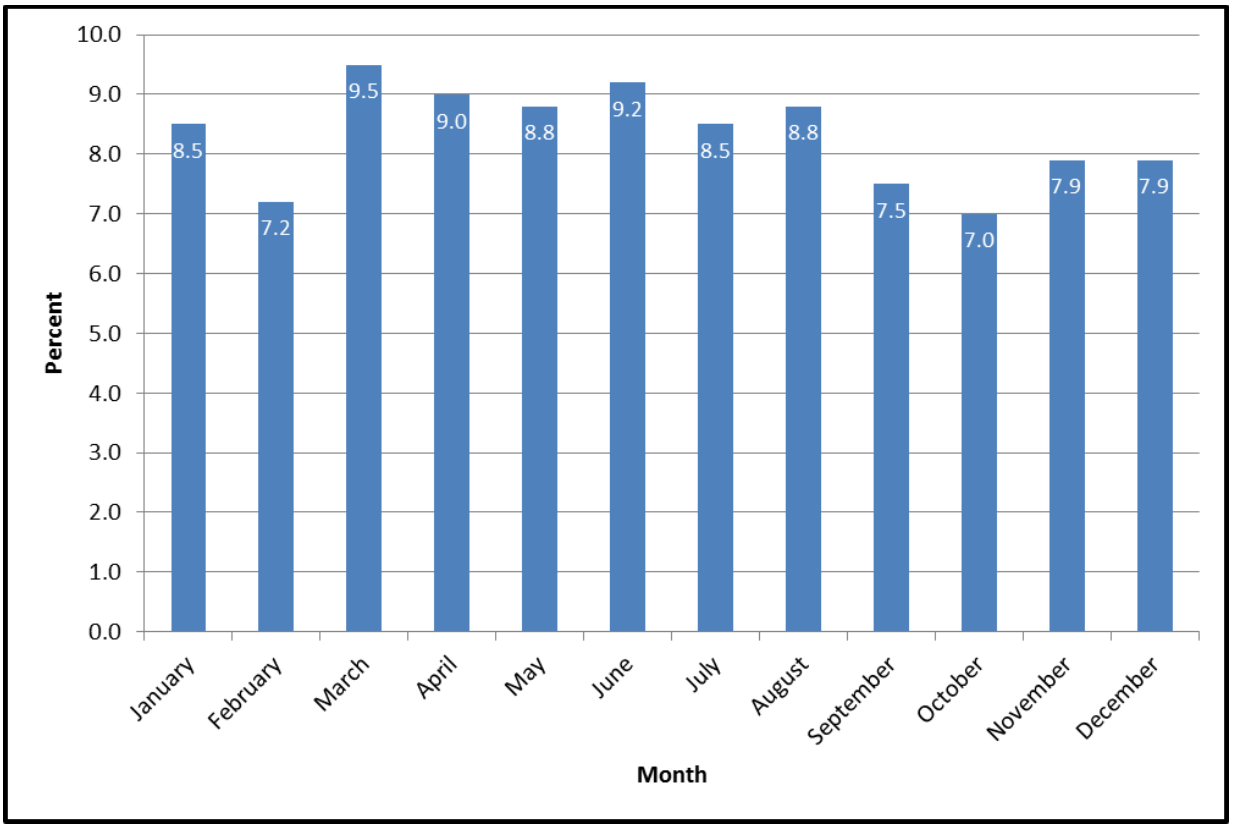

Figure 2. Percentage of Evaluations Conducted by Month of Year

The distribution of the drug category/combination of the DEC evaluations was found to vary significantly according to the month that the evaluation was conducted, X^2 (88, N = 2239) = 157.74, $p < .0001$. In general, evaluations involving cannabis accounted for the highest percentage of evaluations conducted throughout the year, followed closely by evaluations involving CNS depressants. The two exceptions to this pattern were for July and September, when evaluations involving CNS depressants represented the highest percentage of all evaluations conducted (Table 9).

Table 9. Number of Cases in Each Drug Category/Combination by Month

Drug Category/Combination	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Rule-out	17	16	29	9	14	6	6	14	9	13	37	7	177
(%)	(8.9)	(9.9)	(13.6)	(4.5)	(7.1)	(2.9)	(3.1)	(7.1)	(5.4)	(8.3)	(20.8)	(3.9)	(7.9)
CNS depressants	38	27	44	41	31	37	51	36	37	26	26	36	430
(%)	(19.9)	(16.8)	(20.7)	(20.4)	(15.7)	(17.9)	(26.7)	(18.2)	(22.0)	(16.7)	(14.6)	(20.2)	(19.2)
CNS stimulants	8	8	12	16	5	17	13	17	18	12	10	15	165
(%)	(4.2)	(5.0)	(5.6)	(8.0)	(9.6)	(8.2)	(6.8)	(8.6)	(10.7)	(7.7)	(5.6)	(8.4)	(7.4)
Narcotic analgesics	16	15	18	11	15	21	14	26	16	13	14	12	191
(%)	(8.4)	(9.3)	(8.5)	(5.5)	(7.6)	(10.1)	(7.3)	(13.1)	(9.5)	(8.3)	(7.9)	(6.7)	(8.5)
Cannabis	52	35	55	56	46	50	35	48	36	39	41	48	541
(%)	(27.2)	(21.7)	(25.8)	(27.9)	(23.4)	(24.2)	(18.3)	(24.2)	(21.4)	(25.0)	(23.0)	(27.0)	(24.2)
CNS depressants with CNS stimulants (%)	15 (7.9)	7 (4.3)	9 (4.2)	10 (5.0)	10 (5.1)	15 (7.2)	8 (4.2)	7 (3.5)	9 (5.4)	6 (3.8)	13 (7.3)	3 (1.7)	112 (5.0)
CNS depressants with narcotic analgesics	25	33	25	25	30	28	36	31	15	26	20	21	315
(%)	(13.1)	(20.5)	(11.7)	(12.4)	(15.2)	(13.5)	(18.8)	(15.7)	(8.9)	(16.7)	(11.2)	(11.8)	(14.1)
CNS depressants with cannabis (%)	15 (7.9)	13 (8.1)	11 (5.2)	21 (10.4)	20 (10.2)	23 (11.1)	21 (11.0)	10 (5.1)	19 (11.3)	16 (10.3)	11 (6.2)	26 (14.6)	206 (9.2)
CNS stimulants with narcotic analgesics	5	7	10	12	12	10	7	9	9	5	6	10	102
(%)	(2.6)	(4.3)	(4.7)	(6.0)	(6.1)	(4.8)	(3.7)	(4.5)	(5.4)	(3.2)	(3.4)	(5.6)	(4.6)
Total	191	16.1	213	201	197	207	191	198	168	156	178	178	2,239
(%)	(8.5)	(7.2)	(9.5)	(9.0)	(8.8)	(9.2)	(8.5)	(8.8)	(7.5)	(7.0)	(7.9)	(7.9)	(100.0)

Note: The rule-out category includes cases from the current sample (n = 53) and Canada (n = 127).

Time of day: The distribution of evaluations conducted according to the time of day is illustrated in Figure 3. The highest percentage of evaluations was conducted between 18:00 and 24:00 (36.9%), followed by 12:00 to 18:00 (26.5%) and 00:00 to 06:00 (25.3%).

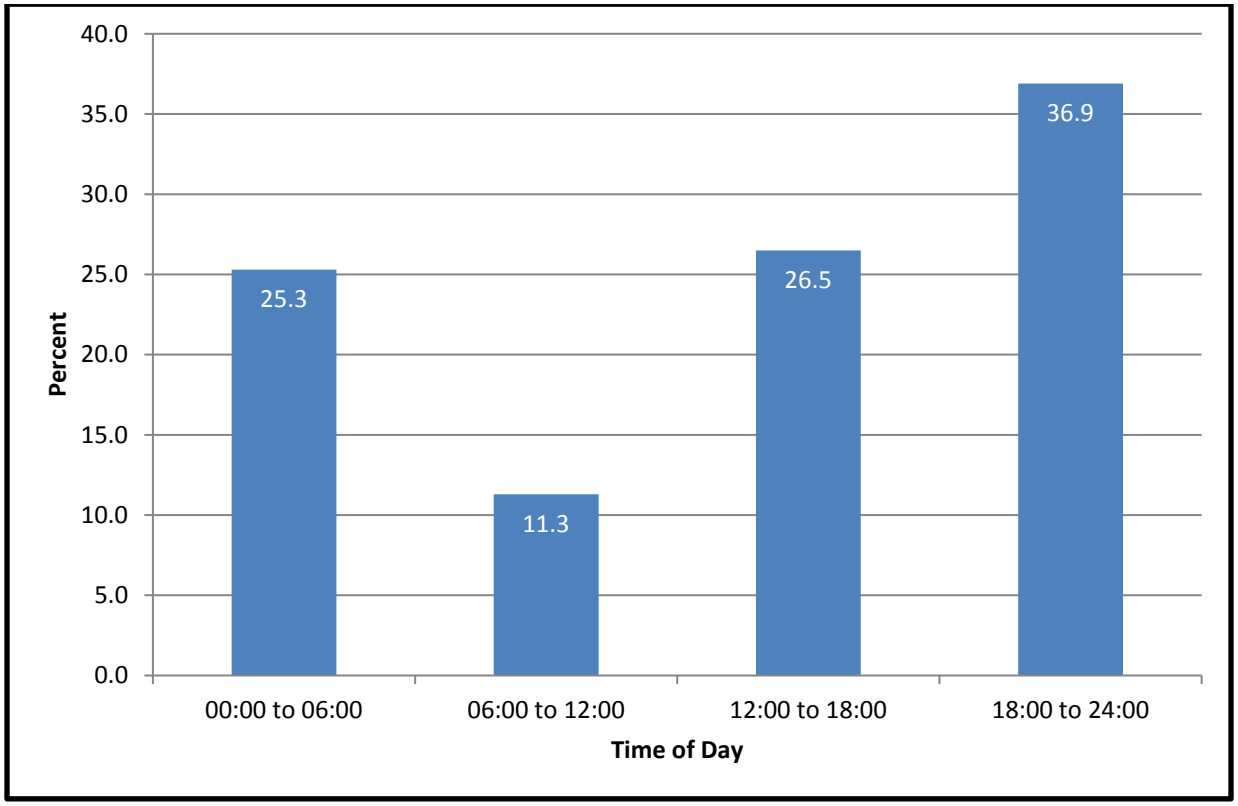

Figure 3. Percentage of Evaluations Conducted by Time of Day

The distribution of the drug category/combination of the DEC evaluations was found to vary significantly according to the time of day that the evaluation was conducted, X^2 (24, N = 1,920) = 238.65, $p < .0001$. Table 10 reveals that among evaluations conducted from 00:00 to 06:00 and 18:00 to 24:00, the highest proportion involved cannabis. Among evaluations conducted from 06:00 to 12:00 and 12:00 to 18:00 the highest proportions involved CNS depressants, followed closely by evaluations involving narcotic analgesics.

Table 10. Number of Cases in Each Drug Category/Combination by Time of Day

Drug Category/Combination	00:00 to 06:00	06:00 to 12:00	12:00 to 18:00	18:00 to 24:00	Total
Rule-out	21	18	40	35	114
(%)	(4.3)	(8.3)	(7.9)	(4.9)	(5.9)
CNS depressants	51	65	137	122	375
(%)	(10.5)	(30.0)	(26.9)	(17.2)	(19.5)
CNS stimulants	55	16	34	41	146
(%)	(11.3)	(7.4)	(6.7)	(5.8)	(7.6)
Narcotic analgesics	35	23	62	54	174
(%)	(7.2)	(10.6)	(12.2)	(7.6)	(9.1)
Cannabis	164	22	60	225	471
(%)	(33.8)	(10.1)	(11.8)	(31.7)	(24.5)
CNS depressants with CNS stimulants	24	13	27	33	97
(%)	(4.9)	(6.0)	(5.3)	(4.7)	(5.1)
CNS depressants with narcotic analgesics	33	36	107	100	276
(%)	(6.8)	(16.6)	(21.0)	(14.1)	(14.4)
CNS depressants with cannabis	75	12	22	65	174
(%)	(15.5)	(5.5)	(4.3)	(9.2)	(9.1)
CNS stimulants with narcotic analgesics	27	12	20	34	93
(%)	(5.6)	(5.5)	(3.9)	(4.8)	(4.8)
Total	485	217	509	709	1,920
(%)	(25.3)	(11.3)	(26.5)	(36.9)	(100.0)

Note: The rule-out category includes cases from the current sample (n = 53) and Canada (n = 127).

Time to conduct DEC evaluations: On average, it took 53.6 minutes (SD = 20.9) to perform a DEC evaluation. The time to complete a DEC evaluation ranged from 7 to 218 minutes. The average amount of time that lapsed between the arrest of the subject and the start of the drug evaluation by the DRE was 52.5 minutes (SD = 41.7) and ranged from zero to 325 minutes.

The time it took to conduct an evaluation varied significantly according to the drug category or combination consumed by the subject (F[8, 1,395] = 6.43, $p < .0001$). Pairwise post-hoc comparisons were conducted using a Bonferonni correction. As is outlined in Table 11, evaluations involving no drugs took significantly less time to conduct compared to those

involving CNS depressants, narcotic analgesics, CNS depressants in combination with CNS stimulants, CNS depressants in combination with narcotic analgesics or CNS stimulants in combination with narcotic analgesics. In addition, evaluations of subjects who had used cannabis took significantly less time to conduct than those of subjects who had used CNS depressants or a combination of CNS depressants and narcotic analgesics.

Table 11. Average Time to Conduct DEC Evaluations According to Drug Category/Combination

Drug Category/Combination	M	SD
Rule out	46.8	19.8
CNS depressants	56.7*∞	22.2
Narcotic analgesics	55.6†	18.4
Cannabis	49.6	19.1
CNS depressants with CNS stimulants	56.1‡	19.9
CNS depressants with narcotic analgesics	57.6^ξ	21.7
CNS stimulants with narcotic analgesics	60.2≠	33.1

*Indicates difference between CNS depressants and rule-out categories is statistically significant, $p < .0001$.
†Indicates difference between narcotic analgesics and rule-out categories is statistically significant, $p < .05$.
‡Indicates difference between CNS depressants with CNS stimulants combination and rule-out category is statistically significant, $p < .05$.
^Indicates difference between CNS depressants with narcotic analgesics combination and rule-out category is statistically significant, $p < .0001$.
≠Indicates difference between CNS stimulants with narcotic analgesics combination and rule-out category is statistically significant, $p < .01$.
∞Indicates difference between CNS depressants and cannabis categories is statistically significant, $p = .001$.
ξIndicates difference between CNS depressants with narcotic analgesic combination and cannabis category is statistically significant, $p = .001$.

Prediction of Drug Category From Drug-Related Signs and Symptoms Among DEC Evaluations

Bivariate Results

As a preliminary analysis to inform the multinomial logistic regression analyses predicting the drug category from the drug-related signs and symptoms assessed during the DEC evaluations, the bivariate associations between the various DEC indicators and drug categories were examined (Table 12). The categorization of the drug-related signs and symptoms were based on DEC standards; the exception was the total sway and estimation of 30 seconds on the MRB test.

For the categorization of total sway, we examined the frequency distributions for the amount of sway (in inches) noted front-to-back and side-to-side, observing a cut-off in the distributions at two inches. We then summed the two measures to produce a total measure of sway on the MRB test (<2 inches, 2+ inches). For the estimation of 30 seconds, we adopted the general practice used by DREs (Richman, 2010) that an accurate estimate falls within the range of 25 to 35 seconds. Any estimates below 25 seconds were considered fast, whereas any estimates above 35 seconds were considered slow.

As indicated by the values of the chi-square statistics, most of the signs and symptoms assessed during the DEC evaluation were significantly correlated with drug category. Inspection of the Cramer's V measures for these significant chi-square statistics provides an indication of the strength of the association between the signs and symptoms and the drug category. The signs and symptoms most strongly associated with drug category were being under the care of a doctor or dentist, condition of the eyes, assessment of HGN, rebound dilation, reaction to light, muscle tone, and pupil size in room light and darkness.

Table 12. Bivariate Associations Between Drug Category and Signs and Symptoms Among DEC Evaluations

Signs and Symptoms	N	Cramer's V	X^2
Sick or injured (yes, no)	1,462	.23	78.88***
Diabetic or epileptic (yes, no)	1,456	.11	16.19**
Disability or defects (yes, no)	1,456	.21	62.85***
Care of doctor or dentist (yes, no)	1,443	.54	414.21***
Taking of medication (yes, no)	1,449	.37	200.06***
Condition of the eyes (normal, reddening of the conjunctiva, bloodshot, watery, combination of previous categories)	1,498	.25	353.42***
Tracking (yes, no)	1,335	.06	4.04
Pupil size (equal, not equal)	1,496	.04	2.85
Ability to follow stimulus (yes, no)	1,498	.11	17.41*
Eyelids (normal, droopy)	1,484	.43	269.66***
Assessment of horizontal gaze nystagmus (not impaired, impaired)	1,406	.77	835.05***
Vertical gaze nystagmus (yes, no)	1,453	.48	329.46***
Convergence (present, absent)	1,467	.36	184.99***
Rebound dilation (yes, no)	1,448	.50	365.59***
Reaction to light (little to none, slow, normal)	1,462	.62	1,117.14***
Visible injections (none, old/fresh)	1,494	.30	136.39***

Signs and Symptoms	N	Cramer's V	X^2
Muscle tone (near normal, flaccid, rigid)	1,485	.47	655.67***
Average pulse rate (low, normal, high)	1,454	.30	252.30***
Body temperature (low, normal, high)	1,457	.21	126.78***
Systolic blood pressure (low, normal, high)	1,486	.27	221.73***
Diastolic blood pressure (low, normal, high)	1,486	.20	115.05***
Pupil size in room light (constricted, normal, dilated)	1,494	.42	516.70***
Pupil size in darkness (constricted, normal, dilated)	1,458	.54	862.56***
Pupil size in direct light (constricted, normal, dilated)	1,468	.33	316.27***
Performance on One Leg Stand Test (not impaired, impaired)	1,511	.43	273.90***
Performance on WAT test (not impaired, impaired)	1,511	.45	308.45***
Presence of eyelid tremors (yes, no)	1,395	.46	295.20***
Presence of leg tremors (yes, no)	1,366	.26	92.15***
Presence of body tremors (yes, no)	1,237	.20	47.76***
Number of hits on Finger to Nose Test	1,423	.08†**	—
Use of finger pad during Finger to Nose Test (yes, no)	1,404	.05	3.78
Completion of MRB test (not completed, completed)	1,513	.14	29.98***
Total sway on MRB test (<2 inches, 2+ inches)	1,432	.32	148.88***
Estimate of 30 seconds on MRB test (accurate, slow, fast)	1,472	.16	72.67***

Note: The categorization of signs and symptoms was based on DEC standards.
†This is a point-biserial correlation, which is a correlation between a dichotomous and a quantitative variable.
*$p < .05$. **$p < .01$. ***$p < .0001$.

Multivariate Results

A multinomial logistic analysis was performed on the set of DEC cases to determine the prediction of drug category (CNS depressants, CNS stimulants, narcotic analgesics and cannabis)

from the drug-related signs and symptoms assessed during an evaluation. Signs and symptoms that were included in the final model were:

- Subject was sick or injured (yes, no);
- Subject was under the care of a doctor or dentist (yes, no);
- Subject was taking any medication (yes, no);
- Condition of the eyes (normal, bloodshot, watery, reddening of the conjunctiva, combination of these);
- Ability to follow a stimulus (yes, no);
- Condition of eyelids (normal, droopy);
- Mean pulse rate (low, normal, high);
- Assessment of HGN (not impaired, impaired);
- Convergence (present, absent);
- Performance on the OLS test (not impaired, impaired).
- Leg tremors (yes, no);
- Eyelid tremors (yes, no);
- Performance on the WAT test (not impaired, impaired);
- Pupil size in room light (constricted, normal, dilated);
- Pupil size in darkness (constricted, normal, dilated);
- Pupil size in direct light (constricted, normal, dilated);
- Reaction to light (little to none, slow, normal/quick);
- Visible injection sites (none, old/fresh);
- Systolic blood pressure (low, normal, high);
- Body temperature (low, normal, high);
- Muscle tone (near normal, flaccid, rigid); and
- Total sway during the MRB test (<2 inches, 2+ inches

Signs and symptoms that were not statistically significant at the bivariate level were excluded from the final model (i.e., tracking, pupil size, use of finger pad during FTN test). A number of drug-related signs and symptoms were also excluded from the final model because their initial inclusion violated the statistical assumption of adequacy of expected frequencies (i.e., being diabetic or epileptic, having a disability or defect, rebound dilation, vertical gaze nystagmus, body tremors, completion of the MRB test and estimate of 30 seconds on the MRB test). That is, more than 20% of cells had an expected frequency of less than five. When this assumption is violated, statistical power is attenuated and it restricts the goodness-of-fit criteria used to evaluate the model (Tabachnick & Fidell, 2007). Finally, the number of hits on the FTN test, a continuous variable, was found to violate the statistical assumption of linearity in the logit. When this assumption is violated, the analysis is not appropriate and may mislead the results (Tabachnick & Fidell, 2007). In an attempt to establish a linear relationship between the logit and this continuous variable, a logarithmic transformation was performed; unfortunately, this transformation did not make that relationship linear. As a result, this variable was excluded from the final model.

Results from the overall multinomial logistic regression test indicated that the set of 22 signs and symptoms obtained from the DEC evaluation significantly distinguished the four drug categories (CNS depressants, CNS stimulants, narcotic analgesics and cannabis) from the rule-out or rather

no-drug cases, $\chi 2$ (132, $N = 1516$) = 2,081.55, $p < .0001$. Overall, the correct classification rate for the four drug categories and no-drug cases was 86.3%—that is, more than four-fifths of all cases were correctly classified based on the inclusion of the set of 22 drug-related indicators in the overall multinomial logistic regression model. Based on the set of 22 signs and symptoms from the overall model, the classification rate was 89.8% for CNS depressants, 74.0% for CNS stimulants, 89.2% for narcotic analgesics, 91.3% for cannabis and 64.9% for the no-drug cases.

Table 13 shows the unique contribution of the individual predictors (from the set of 22 drug-related signs and symptoms) to the overall multinomial logistic regression model by comparing models with and without each predictor. Using a Bonferonni correction ($p < .0022$) to control for Type I error, 13 signs and symptoms significantly contributed to the prediction of the drug category, including *being under the care of a doctor or dentist, the condition of the eyes and eyelids, mean pulse rate, assessment of HGN, convergence, performance on the OLS test, eyelid tremors, pupil size in darkness, reaction to light, presence of visible injection sites, systolic blood pressure,* and *muscle tone.*

Table 13. Contribution of Signs and Symptoms in Predicting Drug Category among DEC Evaluations

Signs and Symptoms	χ^2 to Remove	df
Being sick or injured	9.53	4
Under care of doctor or dentist	48.25*	4
Use of medication	11.80	4
Condition of the eyes	83.02*	16
Ability to follow stimulus	12.29	4
Eyelids	28.29*	4
Mean pulse rate	41.51*	8
Assessment of horizontal gaze nystagmus	190.32*	4
Convergence	50.48*	4
Performance on the OLS test	29.97*	4
Leg tremors	7.63	4
Eyelid tremors	26.18*	4
Performance on the WAT test	14.80	4
Pupil size in room light	19.47	8
Pupil size in darkness	35.41*	8
Pupil size in direct light	20.08	8
Reaction to light	85.13*	8
Presence of visible injection sites	21.62*	4

Signs and Symptoms	χ^2 to Remove	df
Systolic blood pressure	25.18*	8
Body temperature	20.72	8
Muscle tone	37.24*	8
Total sway on MRB t	10.23	4

*$p < .0022$.

As a follow-up to the overall multinomial logistic regression analysis, a binary logistic regression analysis was conducted to determine the specific signs and symptoms that distinguished the CNS depressant drug category from the no-drug category (i.e., the reference group). Table 14 presents the regression coefficients, chi-square tests, odds ratios and 95 percent confidence intervals for the signs and symptoms for the CNS depressant drug category as compared to no-drug cases. Using a Bonferonni correction ($p < .0022$) to control for Type I error, the signs and symptoms that reliably distinguished the CNS depressants cases from the no-drug cases were *being under the care of a doctor or dentist, assessment of HGN, performance on the OLS test,* and *reaction to light*.

The odds ratios (ORs) indicate whether there is an increased or decreased likelihood of the signs and symptoms being associated with the CNS depressant drug category as compared to the no-drug category; ORs greater than one reflect an increased likelihood whereas ORs less than one reflect a decreased likelihood (in some instances, the ORs have been flipped to avoid stating double negatives and ease interpretation for the reader). Results indicated that subjects who used CNS depressants were more likely to be under the care of a doctor or dentist, exhibit impaired assessment of HGN, demonstrate impaired performance on the OLS test, and have a slow reaction to light as compared to those who had not used drugs.

Table 14. Prediction of Drug Category From Signs and Symptoms Among DEC Evaluations: CNS Depressants vs. No-Drug Cases

Signs and Symptoms	B	SE	Wald χ^2 Test	OR	95% CI for OR
Being sick or injured	.44	.49	.82	1.55	.60, 4.03
Being under care of doctor or dentist	-1.78	.53	11.31*	.17	.06, .48
Using medication	-1.83	.66	7.61	.16	.04, .59
Condition of the eyes					
• Reddening of the conjunctiva vs. normal	-.79	.93	.72	.46	.07, 2.80
• Bloodshot vs. normal	.08	.63	.02	1.08	.31, 3.75
• Watery vs. normal	1.55	1.11	1.93	4.69	.53, 41.38
• Combination vs. normal	-.23	.63	.13	.80	.23, 2.72
Not able vs. able to follow stimulus	.32	1.26	.06	1.37	.12, 16.18
Droopy vs. normal eyelids	1.30	.50	6.69	3.66	1.37, 9.78
Low vs. normal mean pulse rate	5.06	3.40	2.22	157.42	.20, 221.42
High vs. normal mean pulse rate	1.12	.49	5.14	3.05	1.16, 8.00
Not impaired vs. impaired assessment of horizontal gaze nystagmus	-2.85	.56	26.12*	.06	.02, .17
Lack of convergence vs. convergence	.18	.54	.11	1.20	.42, 3.46
Not impaired vs. impaired performance on OLS test	-2.19	.59	13.97*	.11	.04, .35
Absence vs. presence of leg tremors	-.36	.62	.34	.70	.21, 2.35
Absence vs. presence of eye tremors	.05	.47	.01	1.05	.42, 2.63
Not impaired vs. impaired performance on WAT test	-2.23	.67	11.24	.11	.03, .40
Constricted vs. normal pupil size in room light	-1.48	2.27	.43	.23	.003, 19.27
Dilated vs. normal pupil size in room light	.51	.53	.93	1.66	.59, 4.68

Signs and Symptoms	B	SE	Wald χ^2 Test	OR	95% CI for OR
Constricted vs. normal pupil size in darkness	.77	1.06	.53	2.17	.27, 17.34
Dilated vs. normal pupil size in darkness	.60	.79	.57	1.82	.38, 8.58
Constricted vs. normal pupil size in direct light	-21.31	.0001	.02	.006	.006, 5.58
Dilated vs. normal pupil size in direct light	.42	.64	.42	1.52	.43, 5.32
Little to no vs. normal reaction to light	-1.86	1.32	2.00	.16	.01, 2.05
Slow vs. normal reaction to light	2.80	.60	21.68*	16.42	5.06, 53.33
Lack vs. presence of visible injection sites	.32	.66	.24	1.38	.38, 5.08
Low vs. normal systolic blood pressure	1.78	.62	8.30	5.90	1.76, 19.75
High vs. normal systolic blood pressure	.97	.54	3.22	2.63	.92, 7.56
Low vs. normal mean body temperature	1.53	.53	8.43	4.61	1.64, 12.94
High vs. normal mean body temperature	-.68	1.30	.28	.51	.04, 6.49
Flaccid vs. normal muscle tone	1.40	.62	5.15	4.07	1.21, 13.69
Rigid vs. normal muscle tone	.33	.69	.23	1.39	.36, 5.30
Minimal sway vs. sway on MRB test	-1.06	.46	5.32	.35	.14, .85

*$p < .0022$.

A binary logistic regression analysis was also conducted to determine which signs and symptoms from the overall model distinguished the CNS stimulant drug category from the no-drug category (i.e., the reference group). The regression coefficients, chi-square tests, odds ratios and 95 percent confidence intervals for the signs and symptoms for the CNS stimulant drug category compared to the no-drug category are displayed in Table 15. Findings revealed that suspected drug-impaired drivers who consumed CNS stimulants were more likely than those who did not consume any drugs to have a higher-than-normal mean pulse rate, demonstrate impaired performance on the OLS test, have a slow reaction to light and rigid muscle tone.

Table 15. Prediction of Drug Category From Signs and Symptoms Among DEC Evaluations: CNS Stimulants vs. No-Drug Cases

Signs and Symptoms	B	SE	Wald $\chi 2$ Test	OR	95% CI for OR
Being sick or injured	.68	.50	1.90	1.98	.75, 5.22
Being under care of doctor or dentist	-.13	.56	.05	.88	.30, 2.61
Using medication	-.49	.51	.94	.61	.23, 1.66
Condition of the eyes					
• Reddening of the conjunctiva vs. normal	-2.32	1.46	2.52	.10	.01, 1.73
• Bloodshot vs. normal	1.00	.66	2.27	2.71	.74, 9.92
• Watery vs. normal	2.41	1.14	4.49	11.09	1.20, 102.70
• Combination vs. normal	1.22	.64	3.63	3.40	.97, 11.98
Not able vs. able to follow stimulus	2.09	1.19	3.08	8.08	.78, 83.25
Droopy vs. normal eyelids	-.07	.51	.02	.93	.34, 2.53
Low vs. normal mean pulse rate	-11.35	7.80	.0001	.001	.0000, 5.60
High vs. normal mean pulse rate	2.39	.51	22.04*	10.90	4.02, 29.54
Not impaired vs. impaired assessment of horizontal gaze nystagmus	1.21	.65	3.42	3.35	.93, 12.08
Lack of convergence vs. convergence	-1.31	.49	7.17	.27	.10, .70
Not impaired vs. impaired performance on OLS test	-2.77	.58	22.44*	.06	.02, .20
Absence vs. presence of leg tremors	-.50	.57	.78	.61	.20, 1.85
Absence vs. presence of eye tremors	-.57	.47	1.43	.57	.22, 1.44
Not impaired vs. impaired performance on WAT test	-1.09	.57	3.67	.34	.11, 1.03
Constricted vs. normal pupil size in room light	.77	2.19	.12	2.16	.03, 156.46
Dilated vs. normal pupil size in room light	.69	.54	1.62	1.99	.69, 5.75

Signs and Symptoms	B	SE	Wald $\chi 2$ Test	OR	95% CI for OR
Constricted vs. normal pupil size in darkness	1.28	1.04	1.52	3.60	.47, 27.53
Dilated vs. normal pupil size in darkness	.45	.77	.33	1.56	.35, 7.06
Constricted vs. normal pupil size in direct light	-4.52	2.90	2.44	.01	.004, 3.18
Dilated vs. normal pupil size in direct light	1.43	.66	4.77	4.19	1.16, 15.13
Little to no vs. normal reaction to light	-.37	1.21	.10	.69	.06, 7.35
Slow vs. normal reaction to light	3.14	.60	27.08*	22.99	7.06, 74.85
Lack vs. presence of visible injection sites	-1.23	.64	3.67	.29	.08, 1.03
Low vs. normal systolic blood pressure	.83	.65	1.59	2.28	.63, 8.21
High vs. normal systolic blood pressure	1.09	.53	4.30	2.98	1.06, 8.38
Low vs. normal mean body temperature	1.19	.54	4.89	3.29	1.15, 9.44
High vs. normal mean body temperature	-.20	1.08	.03	.82	.10, 6.80
Flaccid vs. normal muscle tone	1.22	.67	3.37	3.40	.92, 12.55
Rigid vs. normal muscle tone	1.95	.60	10.55*	7.05	2.17, 22.93
Minimal sway vs. sway on MRB test	-1.04	.45	5.30	.35	.15, .86

*$p < .0022$.

The signs and symptoms from the overall model that distinguished the narcotic analgesics drug category from the no-drug category were also investigated in a follow-up binary logistic regression analysis. The regression coefficients, chi-square tests, odds ratios and 95 percent confidence intervals for the signs and symptoms for the narcotic analgesic category compared to the no-drug category are displayed in Table 16. Findings revealed that subjects who consumed narcotic analgesics were more likely than those who did not consume any drugs to be under the care of a doctor or dentist and have droopy eyelids, constricted pupils in darkness and a slow reaction to light.

Table 16. Prediction of Drug Category From Signs and Symptoms Amon DEC Evaluations: Narcotic Analgesics vs. No-Drug Cases

Signs and Symptoms	B	SE	Wald $\chi 2$ Test	OR	95% CI for OR
Being sick or injured	.17	1.93	0.6	1.19	.30, 4.67
Being under care of doctor or dentist	-2.68	.78	11.76*	.07	.02, .32
Using medication	-.89	.93	.92	.41	.07, 2.53
Condition of the eyes					
• Reddening of the conjunctiva vs. normal	-.52	1.50	.12	.60	.03, 11.24
• Bloodshot vs. normal	.65	.93	.48	1.91	.31, 11.92
• Watery vs. normal	2.99	1.37	4.78	19.93	1.36, 292.67
• Combination vs. normal	1.23	.95	1.67	3.41	.53, 21.87
Not able vs. able to follow stimulus	-2.18	1.78	1.51	.11	.003, 3.68
Droopy vs. normal eyelids	2.66	.78	11.55*	14.29	3.08, 66.26
Low vs. normal mean pulse rate	5.09	3.50	2.12	162.25	.17, 534.17
High vs. normal mean pulse rate	-.44	.77	.33	.64	.14, 2.89
Not impaired vs. impaired assessment of horizontal gaze nystagmus	2.27	1.02	4.93	9.71	1.31, 72.20
Lack of convergence vs. convergence	-.012	.76	.0002	.99	.22, 4.36
Not impaired vs. impaired performance on OLS test	-2.23	1.02	4.80	.11	.02, .79
Absence vs. presence of leg tremors	-.78	.84	.85	.46	.09, 2.39
Absence vs. presence of eye tremors	.75	.72	1.09	2.11	.52, 8.62
Not impaired vs. impaired performance on WAT test	-.07	.98	.01	.93	.14, 6.33
Constricted vs. normal pupil size in room light	2.60	1.88	1.91	13.47	.34, 539.60
Dilated vs. normal pupil size in room light	-15.30	103.55	.0002	.0002	0, 1.21

Signs and Symptoms	B	SE	Wald $\chi 2$ Test	OR	95% CI for OR
Constricted vs. normal pupil size in darkness	3.92	1.07	13.58*	50.61	6.28, 407.93
Dilated vs. normal pupil size in darkness	-14.77	169.93	.0008	.0002	0, 2.30
Constricted vs. normal pupil size in direct light	-4.41	2.02	4.77	.01	.0002, .64
Dilated vs. normal pupil size in direct light	-3.76	2.45	2.36	.02	.0002, 2.82
Little to no vs. normal reaction to light	2.19	1.22	3.22	8.93	.82, 97.53
Slow vs. normal reaction to light	2.59	.80	10.52*	13.30	2.78, 63.51
Lack vs. presence of visible injection sites	-.90	.76	1.40	.41	.09, 1.81
Low vs. normal systolic blood pressure	.62	.79	.62	1.86	.40, 8.72
High vs. normal systolic blood pressure	-1.44	.86	2.77	.24	.04, 1.29
Low vs. normal mean body temperature	.69	.67	1.04	1.99	.53, 7.43
High vs. normal mean body temperature	-.61	1.99	.09	.55	.01, 26.72
Flaccid vs. normal muscle tone	1.28	.83	2.40	3.59	.71, 18.14
Rigid vs. normal muscle tone	-1.85	1.76	1.10	.16	.01, 4.99
Minimal sway vs. sway on MRB test	-1.70	.70	5.87	.18	.05, .72

*$p < .0022$.

To investigate those signs and symptoms from the overall model that distinguished cannabis from the no-drug category (i.e., the reference group), a final binary logistic regression analysis was conducted. The regression coefficients, chi-square tests, odds ratios and 95 percent confidence intervals for the signs and symptoms for the cannabis drug category compared to the no-drug category are displayed in Table 17. Findings revealed that compared to subjects who had not used drugs, those who consumed cannabis were more likely to have reddening of the conjunctiva, bloodshot eyes, a combination of eye conditions, a higher than normal mean pulse rate, a lack of convergence, impaired performance on the OLS test and eyelid tremors.

Table 17. Prediction of Drug Category From Signs and Symptoms Amon DEC Evaluations: Cannabis vs. No-Drug Cases

Signs and Symptoms	B	SE	Wald $\chi 2$ Test	OR	95% CI for OR
Being sick or injured	1.13	.41	7.23	3.11	1.40, 6.92
Being under care of doctor or dentist	.51	.45	1.29	1.67	.69, 4.02
Using medication	-1.04	.40	6.76	.35	.16, .77
Condition of the eyes					
• Reddening of the conjunctiva vs. normal	2.92	.71	16.86*	18.62	4.61, 75.22
• Bloodshot vs. normal	2.74	.59	21.32*	15.54	4.85, 49.78
• Watery vs. normal	2.94	1.06	7.70	18.94	2.37, 151.25
• Combination vs. normal	3.13	.58	28.73*	22.94	7.30, 72.11
Not able vs. able to follow stimulus	-.25	1.04	.06	.78	.10, 5.98
Droopy vs. normal eyelids	1.08	.40	7.17	2.94	1.34, 6.48
Low vs. normal mean pulse rate	2.70	2.38	1.28*	14.83	.14, 157.81
High vs. normal mean pulse rate	1.55	.39	15.60*	4.73	2.19, 10.23
Not impaired vs. impaired assessment of horizontal gaze nystagmus	1.09	.51	4.56	2.97	1.09, 8.08
Lack of convergence vs. convergence	1.28	.40	10.36*	3.58	1.65, 7.78
Not impaired vs. impaired performance on OLS test	-1.22	.40	9.46*	.30	.14, .64
Absence vs. presence of leg tremors	-1.04	.44	5.45	.36	.15, .85
Absence vs. presence of eyelid tremors	-1.34	.37	13.04*	.26	.13, .54
Not impaired vs. impaired performance on WAT test	-.52	.39	1.77	.59	.27, 1.28
Constricted vs. normal pupil size in room light	.50	2.15	.05	1.64	.02, 111.19
Dilated vs. normal pupil size in room light	.80	.42	3.60	2.22	.97, 5.06
Constricted vs. normal pupil size in darkness	-.48	.91	.28	.62	.11, 3.66

Signs and Symptoms	B	SE	Wald $\chi 2$ Test	OR	95% CI for OR
Dilated vs. normal pupil size in darkness	.59	.62	.90	1.81	.53, 6.12
Constricted vs. normal pupil size in direct light	-21.15	84.60	.0001	.0006	.0001, 95.10
Dilated vs. normal pupil size in direct light	1.00	.55	3.30	2.73	.92, 8.05
Little to no vs. normal reaction to light	-1.52	1.19	1.62	.22	.02, 2.27
Slow vs. normal reaction to light	.99	.52	3.55	2.68	.96, 7.45
Lack vs. presence of visible injection sites	1.00	.61	2.73	2.73	.83, 8.97
Low vs. normal systolic blood pressure	.09	.50	.03	1.09	.41, 2.89
High vs. normal systolic blood pressure	.45	.41	1.21	1.57	.71, 3.48
Low vs. normal mean body temperature	.01	.46	.0001	1.01	.41, 2.48
High vs. normal mean body temperature	-.84	.82	1.04	.43	.09, 2.17
Flaccid vs. normal muscle tone	.24	.58	.17	1.27	.41, 3.95
Rigid vs. normal muscle tone	.01	.55	.0001	1.01	.34, 2.93
Minimal sway vs. sway on MRB test	-.93	.36	6.69	.40	.20, .80

$^{*}p < .0022$.

ROC Curves

By utilizing the logistic regression analyses described above, the predicted probabilities were obtained for predicting subjects impaired by CNS depressants. Using the results from this analysis, a ROC curve was constructed and the Area Under the Curve (AUC) and 95 percent confidence intervals were calculated. A ROC curve is a plot of sensitivity (or true positive rate) by 1-specificity (or false positive rate) values that allows for an overall assessment of how well the model predicts those who have used the drug category and those who did not use drugs. Figure 4 displays the ROC curve for the accuracy of the model in classifying subjects who were impaired by CNS depressants. The diagonal line provides a reference point for what the ROC curve would look like if the AUC was equal to 0.5 and the model's performance was equal to random chance. When the AUC is greater than 0.5, this indicates that the model's performance is

better than random chance; when the AUC is less than 0.5, this indicates that the model is performing worse than chance (Kleinbaum & Klein, 2010).

The AUC for CNS depressants was found to be .996 (95% CI; .99 - 1.0; p < .0001), which, according to Kleinbaum and Klein's (2010) guidelines, indicates excellent performance by the model.

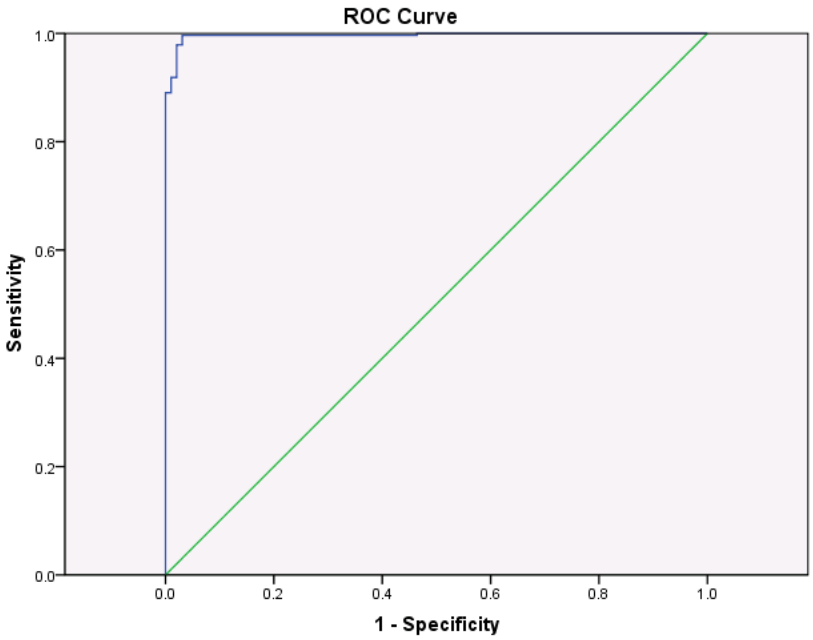

Figure 4. ROC Curve for Classifying Subjects Impaired by CNS Depressants

A ROC curve was also constructed to determine the accuracy of the logistic regression model in classifying subjects impaired by cannabis (Figure 5). The results revealed that the AUC was .956 (95% CI; .94 to .98, $p < .0001$), which is indicative of excellent discriminatory performance by the model (Kleinbaum & Klein, 2010).

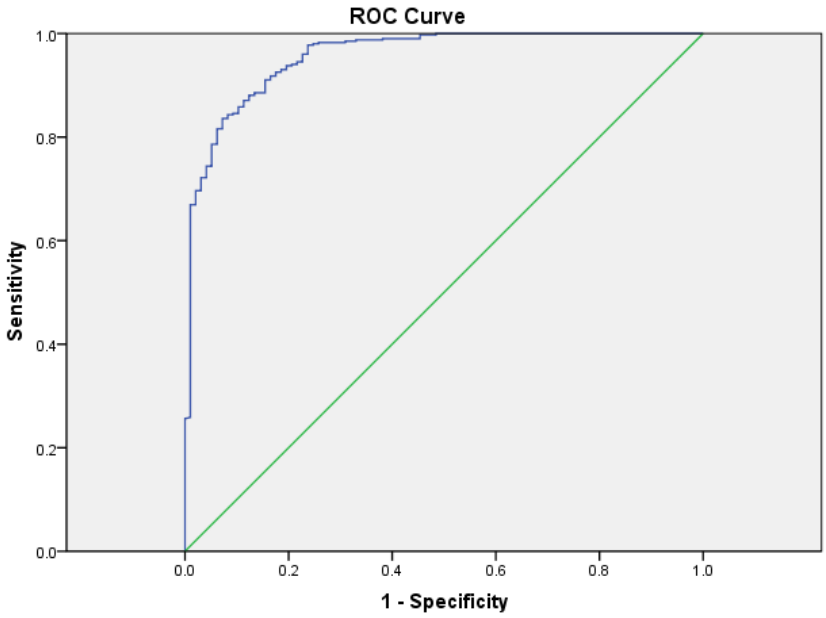

Figure 5. ROC Curve for Classifying Subjects Impaired by Cannabis

There was not a sufficient number of cases to construct a ROC curve for other individual drugs.

Prediction of Drug Category from Groupings of Drug-related Signs and Symptoms Among DEC Evaluations

The set of 22 signs and symptoms from the overall multivariate logistic regression that significantly distinguished the four drug categories (CNS depressants, CNS stimulants, narcotic analgesics and cannabis) from the no-drug cases were grouped into four conceptual blocks:

1. Clinical indicators (i.e., *systolic blood pressure, body temperature, mean pulse rate, muscle tone*);
2. Performance on the psychophysical tests (i.e., *performance on the WAT test and OLS test, and total sway during the MRB test*);
3. Appearance and physiological response of the eyes (i.e., *assessment of HGN; convergence; reaction to light; ability to follow stimulus; and pupil size in room light, darkness and direct light*); and
4. Observations and self-reported statements from the subject (i.e., *under care of doctor/dentist, being sick or injured, use of medication, visible injection sites and leg tremors*).

A sequential multinomial logistic regression analysis was then performed to assess the prediction of drug category from each of these four blocks and to determine their unique contribution to the model. The order in which the blocks were entered into the regression model was based on the objectivity of the signs and symptoms measurement (i.e., clinical indicators, psychophysical

tests, condition of the eyes, and observations and statements by the subject) because, to the best of our knowledge, there is no previous work or theory to guide such a decision.

Findings revealed that all four blocks of drug-related signs and symptoms significantly distinguished the four drug categories from the no-drug cases, and Table 18 presents their unique contribution to the model. As indicated by the chi-square statistics, the block of drug-related signs and symptoms related to the appearance and physiological response of the eyes was found to contribute the most to the model, followed closely by the set of clinical indicators. The set of observations and statements made by the subject were found to contribute the least to the prediction of drug category, yet was still statistically significant.

Table 18. Contribution of Groupings of Signs and Symptoms in Predicting Drug Category Among DEC Evaluations

Groups of Signs and Symptoms	χ^2	df
Clinical indicators	889.45*	32
Performance on psychophysical tests	250.22*	12
Appearance and physiological response of the eyes	998.87*	68
Observations and statements by the subject	56.99*	20
Full model	2,081.55*	132

*$p < .0001$.

Prediction of Drug Combinations From Drug-Related Signs and Symptoms Among DEC Evaluations

Bivariate Results

As a preliminary analysis to inform the multinomial logistic regression analyses that—from the drug-related signs and symptoms assessed during the DEC evaluations—predict drug combinations, the bivariate associations between the various DEC indicators and drug combinations were examined (see Table 19). As indicated by the values of the chi-square (χ^2) statistics, most of the signs and symptoms assessed during the DEC evaluation were significantly correlated with drug combination. Inspection of the Cramer's V measures for these significant chi-square statistics indicates the strength of the association between the signs and symptoms and the drug combination. The signs and symptoms that were most strongly associated with drug combination were:

- eyelids,
- assessment of HGN,
- reaction to light,
- visible injection sites,
- muscle tone,
- pupil size in darkness, and
- performance on the OLS and WAT tests.

Table 19. Bivariate Associations Between Drug Combination and Signs and Symptoms Among DEC Evaluations

Signs and Symptoms	N	Cramer's V	$\chi 2$
Sick or injured (yes, no)	897	.27	64.25***
Diabetic or epileptic (yes, no)	839	.07	4.00
Disability or defects (yes, no)	894	.29	73.62***
Care of doctor or dentist (yes, no)	894	.44	176.47***
Taking of medication (yes, no)	892	.45	183.59***
Condition of the eyes (normal, reddening of the conjunctiva, bloodshot, watery, combination of previous categories)	911	.23	187.01***
Tracking (yes, no)	785	.11	8.74
Pupil size (equal, not equal)	913	.02	.23
Ability to follow stimulus (yes, no)	915	.08	5.16
Eyelids (normal, droopy)	907	.49	221.40***
Horizontal gaze nystagmus (not impaired, impaired)	864	.61	320.19***
Vertical gaze nystagmus (yes, no)	889	.29	76.65***
Convergence (present, absent)	899	.29	72.79***
Rebound dilation (yes, no)	880	.36	115.61***
Reaction to light (little to none, slow, normal)	885	.45	361.42***
Visible injections (none, old/fresh)	912	.21	39.19***
Muscle tone (near normal, flaccid, rigid)	908	.39	279.22***
Average pulse rate (low, normal, high)	893	.24	99.65***
Body temperature (low, normal, high)	883	.17	52.74***
Systolic blood pressure (low, normal, high)	910	.22	86.52***
Diastolic blood pressure (low, normal, high)	910	.16	48.86***
Pupil size in room light (constricted, normal, dilated)	914	.30	163.84***
Pupil size in darkness (constricted, normal, dilated)	898	.38	259.32***
Pupil size in direct light (constricted, normal, dilated)	899	.29	149.20***

Signs and Symptoms	N	Cramer's V	$\chi 2$
Performance on OLS test (not impaired, impaired)	915	.49	219.49***
Performance on WAT test (not impaired, impaired)	922	.51	239.26***
Presence of eyelid tremors (yes, no)	840	.32	86.45***
Presence of leg tremors (yes, no)	832	.19	29.60***
Presence of body tremors (yes, no)	733	.13	12.34*
Number of hits on Finger to Nose Test	865	.31†***	—
Use of finger pad during Finger to Nose Test (yes, no)	864	.10	8.93
Completion of MRB test (not completed, completed)	923	.09	7.29
Total sway on MRB test (<2 inches, 2+ inches)	870	.41	148.79***
Estimate of 30 seconds on MRB test (accurate, slow, fast)	901	.22	85.34***

Note: Categorization of the signs and symptoms was based on DEC standards.
†This is a point-biserial correlation, which is a correlation between a dichotomous and a quantitative variable.
*$p < .05$. **$p < .01$. ***$p < .0001$.

Multivariate Results

A multinomial logistic analysis was then performed on the set of DEC cases to determine the prediction of drug combinations (CNS depressants and CNS stimulants, CNS depressants and narcotic analgesics, CNS depressants and cannabis, and CNS stimulants and narcotic analgesics) from the drug-related signs and symptoms assessed during an evaluation.

Signs and symptoms that were included in the final model included:

- Subject was sick or injured (yes, no);
- Subject was under the care of a doctor or dentist (yes, no);
- Subject was taking any medication (yes, no);
- Condition of the eyes (normal, bloodshot, watery, reddening of the conjunctiva, combination of these);
- Condition of eyelids (normal, droopy);
- Mean pulse rate (low, normal, high);
- Assessment of HGN (not impaired, impaired);
- Vertical gaze nystagmus (present, absent);
- Convergence (present, absent);
- Rebound dilation (yes, no);

- Performance on the OLS test (not impaired, impaired).
- Leg tremors (yes, no);
- Eyelid tremors (yes, no);
- Performance on the WAT test (not impaired, impaired);
- Pupil size in room light (constricted, normal, dilated);
- Pupil size in darkness (constricted, normal, dilated);
- Reaction to light (little to none, slow, normal/quick);
- Visible injection sites (none, old/fresh);
- Systolic blood pressure (low, normal, high);
- Body temperature (low, normal, high);
- Muscle tone (near normal, flaccid, rigid); and
- Estimation of 30 seconds on the MRB test (accurate, slow, fast).

Most of these signs and symptoms were also included in the previous analysis predicting drug category. Indicators that were included in the previous analysis predicting drug category but not the current analysis predicting drug combination include the ability to follow stimulus, pupil size in direct light, and total sway during MRB test. In contrast, rebound dilation, vertical gaze nystagmus, and the estimation of 30 seconds on the MRB test were all new indicators added to the current model predicting drug combination but were not included in the previous analysis predicting drug category.

Signs and symptoms that were not statistically significant at the bivariate level (i.e., being diabetic or epileptic, tracking, pupil size, ability to follow stimulus, use of finger pad during FTN test and completion of the MRB test) were excluded from the final model. A number of drug-related signs and symptoms were also excluded from the final model because their initial inclusion violated the statistical assumption of adequacy of expected frequencies (i.e., having a disability or defect, body tremors, pupil size in direct light, and total sway on the MRB test). Finally, the continuous variable number of hits on the FTN test violated the statistical assumption of linearity in the logit. A logarithmic transformation was performed on this variable to try and establish a linear relationship between it and its logit; however, this was not successful. Accordingly, this variable was excluded from the final model.

Results from the overall multinomial logistic regression test indicated that the set of 22 signs and symptoms obtained from the DEC evaluation significantly distinguished the four drug combinations (CNS depressants and CNS stimulants, CNS depressants and narcotic analgesics, CNS depressants and cannabis, and CNS stimulants and narcotic analgesics) from the no-drug cases, $\chi 2$ (132, $N = 925$) = 1,045.10, $p < .0001$. The overall correct classification rate for the four drug combinations and no-drug cases was 75.3%—that is, approximately three-quarters of all cases were correctly classified based on the inclusion of the set of 22 drug-related indicators in the overall multinomial logistic regression model. Based on the set of 22 signs and symptoms from the overall model, the classification rate was 41.7% for CNS depressants and CNS stimulants, 86.2% for CNS depressants and narcotic analgesics, 75.5% for CNS depressants and cannabis, 59.1% for CNS stimulants and narcotic analgesics, and 86.7% for the no-drug cases.

Table 20 shows the unique contribution of the individual predictors (from the set of 22 drug-related signs and symptoms) to the overall multinomial logistic regression model by comparing models with and without each predictor. Using a Bonferonni correction ($p < .0022$) to control for Type I error, 12 signs and symptoms significantly contributed to the prediction of the drug

combination, including the *condition of the eyes, condition of the eyelids, mean pulse rate, assessment of HGN, rebound dilation, performance on the WAT test, pupil size in room light and darkness, reaction to light, presence of visible injection sites, muscle tone* and *the estimation of 30 seconds on the MRB test* (Table 20).

Table 20. Contribution of Signs and Symptoms in Predicting Drug Combination Among DEC Evaluations

Signs and Symptoms	$\chi 2$ to Remove	df
Being sick or injured	11.17	4
Under care of doctor or dentist	10.24	4
Use of medication	9.48	4
Condition of the eyes	62.16*	16
Eyelids	18.39*	4
Mean pulse rate	27.06*	8
Assessment of horizontal gaze nystagmus	67.43*	4
Vertical gaze nystagmus	7.54	4
Convergence	5.20	4
Rebound dilation	31.29*	4
Performance on the OLS test	7.63	4
Leg tremors	5.91	4
Eyelid tremors	5.46	4
Performance on the WAT test	19.38*	4
Pupil size in room light	26.67*	8
Pupil size in darkness	26.42*	8
Reaction to light	64.05*	8
Presence of visible injection sites	20.15*	4
Systolic blood pressure	7.33	8
Body temperature	18.47	8
Muscle tone	38.09*	8
Estimation of 30 seconds on MRB test	29.44*	8

*$p < .0022$.

As a follow-up to the overall multinomial logistic regression analysis, a binary logistic regression analysis was conducted to determine the specific signs and symptoms that distinguished the CNS depressant and CNS stimulant combination from the no-drug category (the reference group). Table 21 presents the regression coefficients, chi-square tests, odds ratios and 95 percent confidence intervals for the signs and symptoms of the CNS depressant and CNS stimulant combination as compared to no-drug cases. Using a Bonferonni correction ($p < .0022$) to control for Type I error, the signs and symptoms that reliably separate the CNS depressants and CNS stimulant combination from the no-drug cases include *assessment of HGN, reaction to light, mean pulse rate* and *performance on the WAT test*. The findings showed that subjects who used a combination of CNS depressants and CNS stimulants were more likely to exhibit HGN, have a slow reaction to light and a higher than normal mean pulse rate and demonstrate impaired performance on the WAT test as compared to those subjects who had not used drugs.

Table 21. Prediction of Drug Combination From Signs and Symptoms Among DEC Evaluations: CNS Depressants and CNS Stimulants Versus No-Drug Cases

Signs and Symptoms	B	SE	Wald χ^2 Test	OR	95% CI for OR
Being sick or injured	.87	.62	1.99	2.38	.71, 7.96
Being under care of doctor or dentist	-.47	.60	.61	.63	.19, 2.04
Using medication	-2.18	.79	7.54	.11	.02, .54
Condition of the eyes					
• Reddening of the conjunctiva vs. normal	1.59	1.13	1.99	4.90	.54, 44.56
• Bloodshot vs. normal	1.99	.79	6.32	7.32	1.55, 34.52
• Watery vs. normal	3.78	1.40	7.29	43.70	2.82, 677.93
• Combination vs. normal	1.54	.80	3.73	4.67	.98, 22.28
Droopy vs. normal eyelids	.96	.59	2.71	2.62	.83, 8.25
Not impaired vs. impaired assessment of horizontal gaze nystagmus	-3.18	.70	20.76*	.04	.01, .16
Absence vs. presence of vertical gaze nystagmus	-1.68	1.53	1.21	.19	.01, 3.72
Lack of convergence vs. convergence	.01	.66	.0001	1.01	.28, 3.66
Absence vs. presence of rebound dilation	-.27	.76	.12	.77	.17, 3.37
Little to no vs. normal reaction to light	.19	1.27	.02	1.21	.10, 14.59

Signs and Symptoms	B	SE	Wald χ^2 Test	OR	95% CI for OR
Slow vs. normal reaction to light	3.49	.74	22.40*	32.74	7.72, 138.86
Lack vs. presence of visible injection sites	-1.74	.83	4.34	.18	.03, .90
Flaccid vs. normal muscle tone	-.39	.73	.29	.68	.16, 2.81
Rigid vs. normal muscle tone	2.03	.86	5.56	7.61	1.41, 41.05
Low vs. normal mean pulse rate	-16.06	.0001	.0002	.00001	.00001, .001
High vs. normal mean pulse rate	1.99	.60	11.09*	7.29	2.27, 23.46
Low vs. normal mean body temperature	.27	.70	.15	1.31	.33, 5.13
High vs. normal mean body temperature	-.69	1.31	.28	.50	.04, 6.53
Low vs. normal systolic blood pressure	.76	.73	1.09	2.13	.51, 8.85
High vs. normal systolic blood pressure	.27	.64	.17	1.31	.37, 4.58
Constricted vs. normal pupil size in room light	-19.29	.0001	.0001	.0004	.0001, .004
Dilated vs. normal pupil size in room light	1.15	.67	2.91	3.14	.84, 11.71
Constricted vs. normal pupil size in darkness	.17	1.16	.02	1.19	.12, 11.56
Dilated vs. normal pupil size in darkness	1.07	.99	1.17	2.92	.42, 20.33
Not impaired vs. impaired performance on OLS test	-1.46	.75	3.78	.23	.05, 1.01
Not impaired vs. impaired performance on WAT test	-3.18	.89	12.76*	.04	.01, .24
Absence vs. presence of eyelid tremors	.02	.59	.001	1.02	.32, 3.21
Absence vs. presence of leg tremors	-.53	.73	.53	.59	.14, 2.46
Slow estimation of 30 seconds vs. accurate estimation on MRB test	.08	.75	.01	1.08	.25, 4.70
Fast estimation of 30 seconds vs. accurate estimation on MRB test	.74	.64	1.33	2.10	.60, 7.40

*$p < .0022$.

A binary logistic regression analysis was also conducted to determine which signs and symptoms from the overall model distinguished the CNS depressant and narcotic analgesic combination from the no-drug category (i.e., the reference group). The regression coefficients, chi-square tests, odds ratios and 95 percent confidence intervals for this analysis appear in Table 22. The results from this analysis revealed that suspected drug-impaired drivers who consumed CNS depressants in combination with narcotic analgesics were more likely than those who did not consume any drugs to have droopy eyelids, exhibit HGN, have a slow reaction to light and demonstrate impaired performance on the WAT test.

Table 22. Prediction of Drug Combination From Signs and Symptoms Among DEC Evaluations: CNS Depressants and Narcotic Analgesics Versus No-Drug Cases

Signs and Symptoms	B	SE	Wald χ^2 Test	OR	95% CI for OR
Being sick or injured	.21	.57	.13	1.23	.40, 3.78
Being under care of doctor or dentist	-1.37	.58	5.63	.25	.08, .79
Using medication	-1.78	.80	4.95	.17	.04, .81
Condition of the eyes					
• Reddening of the conjunctiva vs. normal	-2.31	1.31	3.12	.10	.01, 1.29
• Bloodshot vs. normal	.89	.71	1.56	2.44	.60, 9.89
• Watery vs. normal	3.47	1.36	6.54	31.99	2.25, 455.44
• Combination vs. normal	.68	.73	.86	1.97	.47, 8.32
Droopy vs. normal eyelids	2.10	.58	13.35*	8.18	2.65, 25.25
Not impaired vs. impaired assessment of horizontal gaze nystagmus	-2.10	.62	11.40*	1.23	.04, .42
Absence vs. presence of vertical gaze nystagmus	-2.34	1.51	2.40	.10	.01, 1.86
Lack of convergence vs. convergence	-.31	.62	.26	.73	.22, 2.45
Absence vs. presence of rebound dilation	.95	.82	1.35	2.58	.52, 12.77
Little to no vs. normal reaction to light	1.90	1.04	3.35	6.69	.88, 51.12
Slow vs. normal reaction to light	3.05	.71	18.33*	21.06	5.22, 84.99
Lack vs. presence of visible injection sites	-.76	.79	.94	.47	.10, 2.19

Signs and Symptoms	B	SE	Wald χ^2 Test	OR	95% CI for OR
Flaccid vs. normal muscle tone	.001	.66	.0001	1.00	.27, 3.78
Rigid vs. normal muscle tone	-.31	.95	.11	.73	.12, 4.67
Low vs. normal mean pulse rate	4.14	2.47	2.81	62.53	.50, 178.96
High vs. normal mean pulse rate	1.26	.56	5.06	3.52	1.18, 10.51
Low vs. normal mean body temperature	.84	.65	1.69	2.32	.65, 8.28
High vs. normal mean body temperature	-2.38	1.44	2.74	.09	.01, 1.55
Low vs. normal systolic blood pressure	1.21	.68	3.17	3.35	.89, 12.67
High vs. normal systolic blood pressure	-.11	.63	.03	.90	.26, 3.06
Constricted vs. normal pupil size in room light	-.80	1.52	.27	.45	.02, 8.92
Dilated vs. normal pupil size in room light	-.77	.70	1.22	.46	.12, 1.82
Constricted vs. normal pupil size in darkness	1.66	1.03	2.63	5.28	.71, 39.53
Dilated vs. normal pupil size in darkness	-.10	1.31	.01	.91	.07, 11.79
Not impaired vs. impaired performance on OLS test	-1.37	.75	3.38	.25	.06, 1.10
Not impaired vs. impaired performance on WAT test	-3.06	.89	11.78*	.05	.01, .27
Absence vs. presence of eyelid tremors	.17	.56	.09	1.19	.40, 3.57
Absence vs. presence of leg tremors	-.91	.72	1.63	.40	.10, 1.63
Slow estimation of 30 seconds vs. accurate estimation on MRB test	.68	.70	.95	1.97	.51, 7.71
Fast estimation of 30 seconds vs. accurate estimation on MRB test	.08	.63	.02	1.08	.32, 3.70

*$p < .0022$.

The signs and symptoms from the overall model that distinguished the CNS depressants and cannabis combination from the no-drug category (the reference group) were also investigated in a follow-up binary logistic regression analysis. The regression coefficients, chi-square tests, odds ratios and 95 percent confidence intervals for this analysis are displayed in Table 23. Findings indicated that subjects who consumed a combination of CNS depressants and cannabis were more likely to have a combination of eye conditions (i.e., reddening of the conjunctiva, bloodshot or watery eyes), presence of HGN, and impaired performance on the WAT test compared to those who had not used drugs.

Table 23. Prediction of Drug Combination From Signs and Symptoms Among DEC Evaluations: CNS Depressants and Cannabis Versus No-Drug Cases

Signs and Symptoms	B	SE	Wald χ^2 Test	OR	95% CI for OR
Being sick or injured	1.20	.56	4.63	3.32	1.11, 9.88
Being under care of doctor or dentist	-.27	.54	.25	.77	.27, 2.20
Using medication	-.97	.60	2.63	.38	.12, 1.22
Condition of the eyes					
• Reddening of the conjunctiva vs. normal	2.50	.89	7.85	12.17	2.12, 69.86
• Bloodshot vs. normal	2.10	.71	8.88	8.20	2.06, 32.74
• Watery vs. normal	2.65	1.42	3.47	14.08	.87, 227.54
• Combination vs. normal	2.75	.72	14.65*	15.67	3.83, 64.11
Droopy vs. normal eyelids	.91	.53	2.96	2.49	.88, 7.03
Not impaired vs. impaired assessment of horizontal gaze nystagmus	-2.16	.57	14.37*	.12	.04, .35
Absence vs. presence of vertical gaze nystagmus	-1.79	1.49	1.44	.17	.01, 3.10
Lack of convergence vs. convergence	.53	.57	.88	1.70	.56, 5.16
Absence vs. presence of rebound dilation	-1.25	.66	3.58	.29	.08, 1.05
Little to no vs. normal reaction to light	-.64	1.22	.27	.53	.05, 5.77
Slow vs. normal reaction to light	2.40	.66	12.45	10.98	2.90, 41.56
Lack vs. presence of visible injection sites	.13	.84	.02	1.13	.22, 5.87

Signs and Symptoms	B	SE	Wald χ^2 Test	OR	95% CI for OR
Flaccid vs. normal muscle tone	-.88	.68	1.71	.41	.11, 1.55
Rigid vs. normal muscle tone	.06	.81	.01	1.06	.22, 5.16
Low vs. normal mean pulse rate	3.06	2.42	1.59	21.28	.18, 245.93
High vs. normal mean pulse rate	1.45	.52	7.64	4.25	1.52, 11.88
Low vs. normal mean body temperature	.83	.63	1.73	2.29	.67, 7.86
High vs. normal mean body temperature	-3.03	1.24	5.98	.05	.004, .55
Low vs. normal systolic blood pressure	.79	.65	1.46	2.20	.61, 7.85
High vs. normal systolic blood pressure	.19	.56	.12	1.21	.41, 3.62
Constricted vs. normal pupil size in room light	-19.40	87.44	.001	.0004	.0001, 22.52
Dilated vs. normal pupil size in room light	.85	.60	1.99	2.34	.72, 7.62
Constricted vs. normal pupil size in darkness	.19	1.08	.03	1.21	.15, 10.11
Dilated vs. normal pupil size in darkness	2.17	.85	6.57	8.75	1.67, 45.98
Not impaired vs. impaired performance on OLS test	-1.60	.61	7.00	.20	.06, .66
Not impaired vs. impaired performance on WAT test	-2.18	.66	10.91*	.11	.03, .41
Absence vs. presence of eyelid tremors	-.58	.52	1.25	.56	.20, 1.55
Absence vs. presence of leg tremors	-1.15	.64	3.30	.32	.09, 1.10
Slow estimation of 30 seconds vs. accurate estimation on MRB test	-.07	.67	.01	.93	.25, 3.47
Fast estimation of 30 seconds vs. accurate estimation on MRB test	.57	.57	.98	1.76	.57, 5.44

*$p < .0022$

To investigate the signs and symptoms from the overall model that distinguished the CNS stimulant and narcotic analgesic combination from the no-drug category (the reference group), a final binary logistic regression analysis was conducted. The regression coefficients, chi-square tests, odds ratios and 95 percent confidence intervals for the signs and symptoms for the CNS stimulant and narcotic analgesic combination compared to the no-drug category are displayed in Table 24. The results showed that subjects who had used a combination of CNS stimulants and narcotic analgesics were more likely to exhibit a slow or little to no reaction to light and a high mean pulse rate compared to those who had not used drugs. There was not a sufficient number of cases to construct a ROC curve for combinations of drugs.

Table 24. Prediction of Drug Combination From Signs and Symptoms Among DEC Evaluations: CNS Stimulants and Narcotic Analgesics Versus No-Drug Cases

Signs and Symptoms	B	SE	Wald χ^2 Test	OR	95% CI for OR
Being sick or injured	-.03	.62	.003	.97	.29, 3.27
Being under care of doctor or dentist	-.97	.63	2.41	.38	.11, 1.29
Using medication	-.82	.81	1.02	.44	.09, 2.15
Condition of the eyes					
Reddening of the conjunctiva vs. normal	1.06	1.21	.77	2.89	.27, 30.96
Bloodshot vs. normal	1.49	.83	3.25	4.45	.88, 22.52
Watery vs. normal	3.43	1.38	6.17	30.81	2.06, 460.38
Combination vs. normal	1.78	.81	4.81	5.90	1.21, 28.82
Droopy vs. normal eyelids	1.77	.64	7.73	5.87	1.69, 20.43
Not impaired vs. impaired assessment of horizontal gaze nystagmus	.38	.72	.28	1.46	.35, 6.05
Absence vs. presence of vertical gaze nystagmus	-.45	1.86	.06	.64	.02, 24.59
Lack of convergence vs. convergence	-.66	.67	.97	.52	.14, 1.92
Absence vs. presence of rebound dilation	2.65	1.36	3.78	14.12	.98, 203.55
Little to no vs. normal reaction to light	3.26	1.03	9.95*	26.00	3.44, 196.82
Slow vs. normal reaction to light	4.29	.79	29.26*	73.14	15.44, 346.45
Lack vs. presence of visible injection sites	-1.95	.80	5.99	.14	.03, .68

Signs and Symptoms	B	SE	Wald χ^2 Test	OR	95% CI for OR
Flaccid vs. normal muscle tone	-.61	.76	.64	.54	.12, 2.43
Rigid vs. normal muscle tone	1.62	.88	3.43	5.08	.91, 28.34
Low vs. normal mean pulse rate	5.41	2.44	4.92	222.90	1.88, 456.22
High vs. normal mean pulse rate	1.98	.62	10.19*	7.21	2.14, 24.25
Low vs. normal mean body temperature	1.14	.73	2.49	3.14	.76, 13.00
High vs. normal mean body temperature	-1.79	1.52	1.40	.17	.01, 3.26
Low vs. normal systolic blood pressure	1.13	.75	2.26	3.09	.71, 13.41
High vs. normal systolic blood pressure	.57	.68	.70	1.77	.47, 6.69
Constricted vs. normal pupil size in room light	-.04	1.55	.001	.97	.05, 20.20
Dilated vs. normal pupil size in room light	-.34	.81	.17	.72	.15, 3.51
Constricted vs. normal pupil size in darkness	1.05	1.06	1.00	2.87	.36, 22.72
Dilated vs. normal pupil size in darkness	1.81	1.16	2.44	6.14	.63, 59.88
Not impaired vs. impaired performance on OLS test	-1.05	.80	1.71	.35	.07, 1.68
Not impaired vs. impaired performance on WAT test	-2.19	.90	5.95	.11	.02, .65
Absence vs. presence of eyelid tremors	-.23	.61	.14	.80	.24, 2.63
Absence vs. presence of leg tremors	-.12	.85	.02	.89	.17, 4.67
Slow estimation of 30 seconds vs. accurate estimation on MRB test	-.49	.84	.33	.62	.12, 3.20
Fast estimation of 30 seconds vs. accurate estimation on MRB test	1.30	.66	3.85	3.66	1.00, 13.38

*$p < .0022$

There was not a sufficient number of cases to construct a ROC curve for combinations of drugs.

Prediction of Drug Combination From Groupings of Drug-Related Signs and Symptoms Among DEC Evaluations

The set of 22 signs and symptoms from the overall multivariate logistic regression test that significantly distinguished the four drug combinations (CNS depressants and CNS stimulants, CNS depressants and narcotic analgesics, CNS depressants and cannabis, and CNS stimulants and narcotic analgesics) from the no-drug cases were grouped into four blocks:

1. Clinical indicators (i.e., *systolic blood pressure, body temperature, mean pulse rate and muscle tone*);
2. Performance on the psychophysical tests (i.e., *performance on the WAT and OLS tests, and the estimation of 30 seconds during the MRB test*);
3. Appearance and physiological response of the eyes (i.e., *condition of the eyes and eyelids, assessment of HGN, vertical gaze nystagmus, convergence, reaction to light, rebound dilation, and pupil size in room light and darkness*); and
4. Observations and self-reported statements from the subject (i.e., *under care of doctor/dentist, being sick or injured, use of medication, visible injection sites and leg tremors*).

A sequential multinomial logistic regression analysis was then performed to assess the prediction of drug combination from each of these four blocks to determine their unique contribution to the model. The order in which the blocks were entered into the regression model was based on the objectivity of the signs and symptoms measurement (i.e., clinical indicators, psychophysical tests, eyes, and observations and statements by the subject).

The results showed that three of four blocks of drug-related signs and symptoms significantly distinguished the four drug combinations from the no-drug cases, including the clinical indicators, performance on the psychophysical tests, and the appearance and physiological response of the eyes. The unique contribution of the four sets of predictors to the model is shown in Table 25, and inspection of the chi-square statistics reveals that the drug-related signs and symptoms related to the appearance and physiological response of the eyes were found to contribute the most to the model, followed closely by the set of clinical indicators. Performance on the psychophysical tests contributed the least to the prediction of drug combination.

Table 25. Contribution of Groupings of Signs and Symptoms in Predicting Drug Combination Among DEC Evaluations

Groups of Signs and Symptoms	χ^2	df
Clinical indicators	423.80*	32
Performance on psychophysical tests	174.32*	16
Appearance and physiological response of the eyes	451.88*	64
Observations and statements by the subject	4.90	20
Full model	1,045.10*	132

*$p < .0001$

Review of Medical and Non-Medical Rule-Out DEC Evaluations

A total of 82 cases collected for this study were deemed to be rule-outs—that is, cases for which no opinion of drug impairment was made, either because the evaluating officer did not deem the signs and symptoms sufficient to consider the person impaired or because there were medical reasons that prevented the completion of the evaluation or could explain the clinical and behavioral symptoms observed. Of the 82 cases, 29 were considered medical rule-outs and 53 were ruled out for non-medical reasons, such as being not impaired. Some of these cases were missing toxicology reports, either because a blood sample was not requested, the subject refused, or a sample was collected but not sent for analysis.

An in-depth review of all rule-out cases was undertaken to document the reasons for the rule out and to determine the extent to which there might be commonalities among these cases. (Note that the 127 rule-out cases from Canada were not included in this review). With the exception of four cases where a DEC evaluation was conducted as part of the investigation of a fatal crash, all rule-out cases were identified by the arresting officer as a result of suspected impaired driving behavior, or as the result of the officer observing signs and symptoms of impairment during interactions with the driver following a traffic violation or crash. In many cases, the officer found little or no evidence of alcohol use and followed up with a DEC evaluation.

Table 26 shows the age and sex of the medical rule-out cases, non-medical rule-outs cases and regular drug cases along with several of the variables from the initial interview with the arresting officer and the subject. It should be noted that the difference in sample sizes among the medical rule-out (n = 29), non-medical rule-out (n = 53) and regular drug cases (n = 2,296) are large and serve to limit the power of the analyses. Hence, the analyses are presented as a guideline only and are not definitive.

The median age of medical rule-out cases was 49 years, considerably older than the median age of 31 years seen in the other cases. Approximately 1 in 5 of the medical rule-out cases (18.8%) were more than 55 years old. Only 8.8% of the other cases were older than 55. One-quarter of medical rule-outs were females compared to 34% among other cases.

Table 26. Comparison of Medical and Non-Medical Rule-Out Cases With Other Drug Cases

Attribute	Medical Rule-Out Cases	Rule-Out Cases	Regular Drug Cases	Significance
Age Mean Median	 46.5 49	 35.3 32	 33.9 31	 F=12.6, df=2, p <.001
Sex (% female)	24.1	22.6	34.1	χ^2=4.24, df=2, p = .12
Crash involvement (%)	42.9	26.5	22.9	χ^2=5.01, df=2, p = .08
Sick or injured (%)	31.0	44.2	36.9	χ^2=1.6, df=2, p = .45

Attribute	Medical Rule-Out Cases	Rule-Out Cases	Regular Drug Cases	Significance
Diabetic/epileptic (%)	17.2	14.0	6.0	χ^2=11.2, df=2, p = .004
Insulin use (%)	6.9	8.2	2.0	χ^2=11.1, df=2, p = .004
Disability/defects (%)	17.2	28.6	28.4	χ^2=,1.77 df=2, p = .41
Care of doctor or dentist (%)	58.6	39.6	52.0	χ^2=3.45, df=2, p = .18
Taking medication (%)	82.1	72.0	84.9	χ^2=6.36, df=2, p = .04

Crash involvement was highest among medical rule-out cases (42.9%). Many of these evaluations were conducted at a hospital when the subject was waiting to be assessed by medical personnel.

Among medical and non-medical rule-out cases, there was a relatively high prevalence of subjects who reported being diabetic (17.2% and 14.0%, respectively). Only 6% of regular drug cases reported being diabetic. (Note that 10.5% of the American population is diabetic; CDC, 2020).

A comprehensive review of each case—including the DIE face sheet, the narrative and toxicology reports, and any other additional information supplied—revealed a variety of situations and circumstances that resulted in the officer's decision to rule the case out, or situations in which medical conditions were an overriding factor in the evaluation.

As noted previously, a substantial proportion of medical rule-out cases were involved in a crash, with many of the evaluations conducted in hospital while the person was awaiting medical treatment for injuries sustained in the crash. Not surprisingly, it was not uncommon for these evaluations to be incomplete. This was often a consequence of the person being unable to perform the psychophysical portions of the evaluation due to head trauma or injury to the lower limbs.

Subjects of medical rule-outs were also considerably older than most other suspected drug-impaired drivers. These people were typically stopped for traffic violations or because they were exhibiting driving behavior characteristic of impaired drivers (e.g., weaving, crossing the center line, driving unusually slowly) or were involved in minor crashes. One person had run into a parked vehicle and another was stopped driving the wrong way on the freeway.

As might be expected, medical issues were not uncommon among this group. Some were experiencing symptoms of acute illness such as colds/flu or severe allergies. These drivers typically reported using one or more over-the-counter medications to help alleviate symptoms. In two instances, it was noted the drivers were considerably overweight, making it difficult to complete the psychophysical tests. Other cases presented chronic health issues such as heart

problems, back pain, limb injuries or previous head trauma. In a few cases involving older drivers, the officer noted confusion and unusual statements and behaviors, possibly indicative of dementia. Mental health issues (e.g., depression, severe anxiety, schizophrenia) were also reported among the medical rule-out cases. All subjects reported taking prescription medications for these conditions; however, it was unusual for the toxicology reports to indicate the presence of these substances. Previous or ongoing treatment for drug abuse was noted in several cases. Other conditions noted were inner ear problems, previous stroke, resting nystagmus in one eye, possible heart attack and a history of blackouts. These latter two cases were taken to the emergency room for medical assessment.

The toxicology reports on medical rule-out cases did not necessarily show these people to be drug-free: prescription medications were not uncommon and cannabis was also detected in some cases. In the other group of rule-out cases (non-medical), the officer judged the subject as not impaired or that there was insufficient evidence to form an opinion about the category of drugs involved. In all but two of these cases,[7] the subject had been arrested for suspected impaired driving as a result of observed or reported poor driving behavior. Several cases had relatively low blood alcohol concentrations (BACs) at roadside and exhibited symptoms of impairment inconsistent with the BAC.

These cases involved a judgment on the part of the evaluating officer. Very few cases showed no signs or symptoms of drug use or impairment. For whatever reason, the officer determined that his or her observations made during the evaluations were not sufficient to proceed with impaired driving charges. In many of these cases, this judgment could be considered conservative—that is, the signs and symptoms of impairment were evident. Some evaluations showed several cues on the psychophysical tests but inconsistent evidence on the clinical indicators or vice versa. No explanations for the opinions were offered in the narrative. In many cases, where a toxicology report was available, cannabis was often the drug involved. In States with zero-tolerance laws, it was sometimes noted that the driver was cited for operating a vehicle with a detectable amount of a prohibited substance, even if they were deemed not impaired.

[7] In two cases, the drivers were evaluated as part of a routine crash investigation.

Discussion

The overall objective of this study was to determine which combinations of elements of the DEC protocol offer the best predictive validity in the most efficient and effective manner. We collected from 11 States a large sample of DEC cases conducted on suspected drug-impaired drivers and confirmed by toxicological analysis of blood samples. Through a series of multivariate statistical models, we statistically identified the set of drug-related measures from the DEC evaluation that best predicted the most prevalent drug categories (CNS depressants, CNS stimulants, narcotic analgesics and cannabis) and two-drug combinations (CNS depressants with narcotic analgesics, CNS depressants with CNS stimulants, CNS stimulants with narcotic analgesics, and CNS depressants with cannabis) used by suspected drug-impaired drivers. We also examined the discrimination between drug-positive and drug-negative cases for two common drug categories (cannabis and CNS depressants) and determined the relative importance of clinical, behavioral and observational measures in predicting the drug category/categories responsible for impairment.

This project was not intended to determine the accuracy of DREs (i.e., their ability to determine whether subjects were impaired, nor their ability to decide which drugs the subjects were using at time of arrest. Rather, this project employed a set of previously confirmed DEC cases to identify which among the large number of evaluative elements the DREs collected were best at signaling impairment to the DREs performing assessments of the subjects.

A secondary objective of this investigation was to conduct a detailed case-by-case review of those cases that were ruled out by the DRE for not involving drugs or those that were ruled out due to medical conditions. The purpose of this review was to determine any commonalities in the circumstances or characteristics of these cases.

Findings

Conducting a DEC evaluation is extensive; this study showed that it takes a DRE an average of 54 minutes to complete an evaluation. The time it took to conduct an evaluation was found to vary significantly according to the drug category or combination involved, with rule-out cases taking significantly less time to complete than those involving CNS depressants, narcotic analgesics, CNS depressants in combination with CNS stimulants, and CNS depressants in combination with narcotic analgesics. Evaluations of subjects who had used cannabis were also found to take significantly less time than those involving CNS depressants or a combination of CNS depressants and narcotic analgesics. It is not clear why these specific drug categories and combinations are taking more time to complete than others. However, it is worth noting that several classes of psychoactive prescription drugs (e.g., opioids, sedatives/tranquilizers, stimulants) fall into these categories. This study also noted that the average amount of time that lapsed between the arrest of the subject and the start of the evaluation was 52 minutes. This finding has important implications for the detection of drug categories that have short-term effects (e.g., CNS stimulants, inhalants) and a limited time for toxicological detection in blood.

Findings also revealed that the highest percentage of DEC evaluations was conducted on Saturdays (17%), followed closely by Fridays (16.5%) and Thursdays (15.6%). The lowest percentage of evaluations was conducted on Sundays (11.8%), followed closely by Monday (11.9%). Examination of the distribution of drug category/combination of cases indicated that the

highest percentage of evaluations conducted from Friday to Sunday involved cannabis, whereas those involving CNS depressants were more common from Monday to Thursday.

In examining the distribution of DEC evaluations conducted by month, the highest percentage was conducted in March (9.5%), followed closely by June (9.2%) and April (9%). The lowest percentage of evaluations was conducted in October (7.0%), followed closely by February (7.2%). Evaluations involving cannabis accounted for the highest percentage of evaluations throughout the year, followed by CNS depressants. However, there were two exceptions to this pattern: During July and September, evaluations involving CNS depressants represented the highest percentage of all DEC evaluations conducted.

The study also examined the distribution of DEC evaluations conducted according to the time of day and found that the highest percentage was conducted between 18:00 and 24:00 (36.9%), followed by 12:00 to 18:00 (26.5%), and 00:00 to 06:00 (25.3%). When examining the distribution of evaluations conducted by time of day, findings indicated that evaluations involving cannabis represented the highest proportion of evaluations conducted from 00:00 to 06:00 and 18:00 to 24:00. Evaluations involving CNS depressants accounted for the highest proportion of evaluations conducted from 06:00 to 12:00 and 12:00 to 18:00.

Prediction of Drug Category and Combination From Drug-Related Signs and Symptoms

Findings revealed that a statistical model that included 22 drug-related signs and symptoms obtained during the DEC evaluation significantly predicted the correct drug category associated with the impairment experienced by the subject. Based on this set of 22 indicators, an overall classification rate of 86% was obtained across the four drug categories and no-drug cases, reflecting the success of the model in correctly predicting the drug categories and attesting to the validity of these indicators of drug use. This high level of predictability was confirmed by constructing ROC curves for the CNS depressants and cannabis cases. The ROC curves provide an overall assessment of how well the model predicts those who used the drug category and those who did not; the results demonstrated a high level of performance by the model. Classification was found to be better for some categories (e.g., cannabis) than others (e.g., CNS stimulants). Of the 22 signs and symptoms, 13 were found to significantly contribute to the prediction of the model: being under the care of a doctor or dentist, the condition of the eyes, condition of the eyelids, mean pulse rate, assessment of HGN, convergence, performance on the OLS test, eyelid tremors, pupil size in darkness, reaction to light, presence of visible injection sites, systolic blood pressure and muscle tone.

These results are consistent with those previously obtained by Porath-Waller and colleagues (2009). In their study, nine drug-related signs and symptoms were found to significantly predict three classes of drugs (CNS stimulants, narcotic analgesics and cannabis) with an overall classification rate of 81%. Considerable overlap can be observed with respect to the particular signs and symptoms that significantly predicted drug category in that study and the current work. Specifically, eight indicators were common to the models used in both studies, including the condition of the eyes, condition of the eyelids, mean pulse rate, convergence, reaction to light, pressure of visible injection sites and systolic blood pressure. In contrast to the study conducted by Porath-Waller and colleagues, however, the present investigation obtained a relatively higher

rate of correct classification of cases, which is likely the result of the greater number of drug-related indicators that were included in the prediction model.

With respect to the prediction of drug combinations, we similarly found that a separate statistical model with a set of 22 indicators from the DEC evaluation significantly predicted the combination of drug categories responsible for the subject's impairment. An overall classification rate of 75% was obtained for correctly classifying the four drug combinations and rule-out cases—about 10% lower than that obtained from the statistical model used to predict drug category. This result, however, is consistent with enforcement practice in the field as well as previous research which has documented that drugs used in combination with alcohol or other drugs are more difficult to detect accurately (Beirness et al., 2007, 2009; Porath-Waller & Beirness, 2010). The results also revealed that classification was better for some drug combinations (e.g., 86.2% for CNS depressants with narcotic analgesics) than others (e.g., 41.7% for CNS depressants with CNS stimulants and 59.1% for CNS stimulants with narcotic analgesics). It is worth noting that the two drug combinations with the lower classification rates involved drug categories that have opposite drug effects (CNS Depressants + CNS Stimulants and CNS Stimulants + Narcotic Analgesics), which may account for the lower rate of classification (41.7% and 59.1%, respectively. Twelve key drug-related indicators were found to significantly contribute to the prediction of drug combination including:

- condition of the eyes and eyelids,
- mean pulse rate,
- assessment of HGN,
- performance on the WAT test,
- pupil size in room light and darkness,
- reaction to light, rebound dilation,
- presence of visible injection sites,
- muscle tone, and
- the estimation of 30 seconds on the MRB test.

It is noteworthy that there was overlap between the indicators that significantly predicted drug category and combination. Indicators that were common to both prediction models included condition of the eyes and eyelids, mean pulse rate, assessment of HGN, pupil size in darkness, reaction to light, presence of visible injection sites, and muscle tone (see Table 27).

Table 27. Signs and Symptoms Predictive of Drug Category and Drug Combination Among DEC Evaluations

Signs and Symptoms	Predictive of Drug Category	Predictive of Drug Combination
Being under care of doctor or dentist	✓	
Condition of the eyes	✓	✓
Condition of eyelids	✓	✓
Mean pulse rate	✓	✓

Signs and Symptoms	Predictive of Drug Category	Predictive of Drug Combination
Assessment of HGN	✓	✓
Convergence	✓	
Performance on OLS test	✓	
Performance on WAT test		✓
Eyelid tremors	✓	
Pupil size in room light		✓
Pupil size in darkness	✓	✓
Reaction to light	✓	✓
Rebound dilation		✓
Presence of visible injection sites	✓	✓
Systolic blood pressure	✓	
Muscle tone	✓	✓
Estimation of 30 seconds on MRB test		✓

The results obtained in the current study are consistent with the pattern of results reported by Porath-Waller and Beirness (2010) in their analysis of the most predictive drug-related indicators of three prevalent drug combinations. Two of the drug combinations assessed in their work were also evaluated in the present investigation: CNS stimulants with narcotic analgesics, and alcohol[8] with cannabis. In their study, Porath-Waller and Beirness reported that 11 indicators significantly enhanced the prediction of the combinations of drugs used by suspected drug-impaired drivers, including:

- the condition of the eyes,
- convergence,
- rebound dilation,
- reaction to light,
- presence of injection sites,
- assessment of HGN,
- pupil size in darkness,
- performance on the OLS and WAT tests, and
- muscle tone.

All but two of these indicators (convergence and performance on the OLS test) were statistically significant in the current study. The results from the study conducted by Porath-Waller and Beirness also reported that approximately three-quarters of all cases were correctly classified

[8] Recall that the CNS depressant cases were merged with the alcohol cases in the current study.

using their model, and this overall classification rate is identical to that which was obtained in the present study.

The present work also investigated the unique contribution of specific groupings of drug-related signs and symptoms from the DEC evaluation and found that indicators related to the appearance and physiological response of the eyes contributed the most to the prediction of both drug category and combinations, followed closely by clinical indicators and performance on the psychophysical tests. Interestingly, observations and statements made by the subject contributed the least to the prediction of drug category and were not found to be a statistically significant predictor of drug combination. To the best of our knowledge, this is the first analysis that has assessed the relative contribution of groupings of signs and symptoms from the DEC evaluation.

Taken together, the findings from the current investigation indicate that DREs revisit a set of key signs and symptoms to help determine the categories of drugs used by suspected drug-impaired drivers to facilitate the interpretation of the evidence and enhance the effectiveness and efficiency of their evaluations. Eight drug-related signs were found to be common to both models used to predict the single-drug and two-drug combinations, with indicators related to the appearance and physiological response of the eye contributing the most to the model. These results could help form the basis of a core set of indicators that DREs could consult to form their opinion of drug influence. However, because classification based on the two full statistical models was not found to be perfect, it points to the need for DREs to conduct the full evaluation, utilizing all the indicators and observations to assess the totality of drug symptomatology. It is also worth noting that the findings from this research confirm what is known about the pharmacological effects of the drug categories that were studied. This speaks to the validity of the findings observed in the current study, despite the reduced power associated with the statistical analyses as discussed previously.

Review of Rule-Out and Medical Rule-Out Cases

An in-depth review of medical rule-out cases revealed that these tended to involve older male drivers, many of whom were evaluated following involvement in crashes. The self-reported incidence of diabetes (17.2%) was also more than double that among other cases (6.0%). The American Diabetes Association reports the prevalence of diabetes in the general population to be (8.3%) (CDC, 2011). This suggests that even though the complications associated with diabetes may not necessarily be the direct cause of poor performance on the evaluation, it may be an indicator of the presence of other/related medical conditions that affect driving performance. Hence, diabetes should be a flag alerting DREs to the possibility of medical factors that may not necessarily be related to drug use.

Involvement in a crash is a key factor in medical rule-out cases because potential head and/or limb injuries can prevent subjects from performing psychophysical tests or affect their performance on the tests. To the extent possible, the DEC evaluation should be completed including the collection of a blood sample to provide additional evidence of possible drug impairment. At the very least, clinical indicators and the condition of the eyes should be used to determine if there is any indication of drug use, which may then prompt a demand for a blood sample. In the present study, it was evident that even though the case was deemed a “rule-out” for medical reasons, the toxicology report did not necessarily show that these people were drug-free.

The other group of rule-out cases (non-medical) involved those where the officer judged the subject as not impaired or that there was insufficient evidence to form an opinion about the category of drugs involved. In many of these cases, it appeared that the officers were being conservative in their judgment, electing to deem the person "not impaired" rather than proceed with a case that may have had little chance of success in court.

These rule-out cases beg the question: Why were these drivers arrested if the extent of impairment and drug effects observed during the evaluation was not sufficient to proceed with charges? It may be that the impairment observed on the road or at roadside by the arresting officer had diminished as drug levels waned in the time between driving and the evaluation. This could be addressed by measures to reduce the time from arrest to evaluation or for the introduction of roadside drug-screening procedures. It could also be that other factors such as fatigue and/or distraction may have contributed to the observed driving behavior and the DEC procedure served to rule out drugs as the cause of the impairment. This type of situation speaks to the validity of the DEC procedure and impartiality of the process.

Implications for the DEC Program

The results from this research have important implications for the DEC program and DREs conducting drug influence evaluations on suspected drug-impaired drivers. The findings indicate that DREs should revisit a set of key signs and symptoms to help determine the categories of drugs used by suspected drug-impaired drivers to facilitate the interpretation of the evidence and enhance the effectiveness and efficiency of their evaluations. This does not suggest that these are the only indicators that should be assessed. However, it does indicate that the key indicators should be reviewed and all other signs, symptoms and observations be brought into the process to capture the totality of the case.

The findings from this study can also be integrated into DEC program training by emphasizing the set of critical indicators of drug use. DEC program training may also need to focus more on effectively and efficiently identifying combinations of drugs used by suspected drug-impaired drivers. The overall classification rate of 75% for the four drug combinations was slightly lower than that obtained for the four single-drug cases (86%). Moreover, a high degree of variability was observed with respect to the classification of combinations with some combinations being easier to classify (i.e., 86.2% for CNS depressants with narcotic analgesics) than others (i.e., 41.7% for CNS depressants with CNS stimulants and 59.1% for CNS stimulants with narcotic analgesics). Given that polydrug use is relatively common among drug users, it is essential that DREs be able to accurately detect the particular classes of drugs that are used by suspected drug-impaired drivers who may have used multiple substances.

The results from this study has the potential to help develop an automated system (e.g., a program or app) that would assist DREs in determining, on a case-by-case basis, the category (or categories) of drugs most likely to be responsible for the observations and symptoms recorded in the evaluation. The data from the DIE face sheet would be entered into a computer program, an algorithm would weigh the various components of the evaluation according to their respective contribution and assess the probability of the case being representative of a particular class (or classes) of drugs. The development of such a system would not replace the DEC program, but would rather provide a tool to support DREs and contribute to the effectiveness and efficiency of the DEC program.

Future Directions for Research and Practice

The detailed review of medical rule-outs revealed a wide variety of medical conditions that could have led to observations that either mimicked drug effects or that could not be distinguished from drug effects. Further investigation of a large sample of medical rule-out cases is warranted to get a better picture of these types of cases. In addition, the performance of these people, whether or not influenced by drugs, was often such that the person should not be driving. Officers need clear direction in these cases as to when the drivers should be referred and/or reported to the Department of Motor Vehicles for assessment of their fitness to operate vehicles.

Throughout the data collection process in this study, we noted various inconsistencies in the organization and storage of DEC cases across the 11 States from which we received data. Some common issues we encountered included the DIE face sheets and narrative and toxicological reports not being stored together, inconsistencies in how the data is stored (e.g., paper vs. electronic copies), and the limited number of rule-out cases that were submitted to DRE State Coordinators. Such inconsistencies can hinder future research efforts aimed at evaluating and strengthening the DEC program. More importantly, however, a valuable educational opportunity is missed when feedback and all case documents are not returned to the DRE for his or her review. It may be valuable for States to review their existing procedures for organizing and storing DEC cases to maximize research and education opportunities.

DRE State Coordinators could be encouraged to systematically and routinely monitor evaluations to document the types of drugs and drug categories commonly encountered. This information can be used to keep all patrol officers informed as to the types of substances they might encounter and alert them to the symptoms of these substances that may be observable during a traffic stop.

The elapsed time between the arrest of the subject at roadside and the collection of the blood sample following the DEC evaluation was almost two hours – a sufficient length of time for considerable metabolism of many drugs. In some cases, the drug levels may have decreased to the point where they are no longer detectable in the sample. In the case of CNS stimulants, the subject may be into the elimination phase of the drug and be displaying symptoms more typically associated with CNS depressants. These types of situations can present significant challenges to the prosecution of these cases. Hence, research could explore alternative approaches such as collecting the blood sample earlier in the DEC protocol or introducing the collection of oral fluid as the sample medium for toxicology.

Limitations

A number of potential limitations should be considered when interpreting the study's finding including the selection of cases, variability in application of the DEC protocol, laboratory procedures, sample size, and the inability to determine accuracy.

Case Selection. The sample of DEC cases used in the present study was not randomly selected and was not representative of all cases conducted in the United States. The cases were selected for inclusion in the study based on several selection criteria, including confirmation by toxicological analysis of blood, actual cases vs. training cases, cases involving particular drug categories and combinations, and States identified in consultation with IACP and the NHTSA Regional Administrators, for participation in the study. Also, cases included in the final sample

were subject to various forms of selection bias (e.g., exemplary cases were submitted by exemplary officers) In addition to asking particular States to contribute cases to the study, it is highly unlikely that the States randomly selected the cases that they contributed.

*DEC Protocol Availability. T*he data used in the current study were collected over a 12-year period. Though it is important to note, we do not have any reason to believe that variability in the DREs' reporting or laboratory protocols may have affected the current findings. The DEC program is a systematic and standardized protocol used throughout North America and there have been no major changes to this protocol over the years.

Laboratory procedures. While laboratories may have improved their drug screening and detection procedures over this time, there is still variability across labs in terms equipment and thresholds, among other things. Even so, there have been significant improvements in the extent to which lower levels of drugs are detected. In addition, we learned there was variability in the drug panels used across the different laboratories doing the toxicological screening. The extent to which this variability has affected the results derived in the current work is not clear. Laboratories conducting toxicological analyses of samples for DEC cases should be encouraged to develop standardized procedures, protocols, and limits of detection and quantification to ensure consistency in detection and reporting of substances in blood samples.

Sample size. Another important limitation of the present study relates to the smaller than recommended cell sizes that were used for several of the analyses, which reduced the statistical power to detect a moderate association between the outcome and predictor variables. Thus, it is possible that this investigation failed to identify one or more significant associations between given drug categories and drug-related indicators from the DEC evaluation. However, we can have a great deal of confidence in the observed findings as they emerged in spite of the reduced statistical power. Moreover, these results are consistent with those from previous research in this area (Porath-Waller et al., 2009; Porath-Waller & Beirness, 2010), which lends credence to their validity.

This study is also limited by certain categories of drugs (e.g., hallucinogens, inhalants, dissociative anesthetics) and combinations of drugs were not investigated due to insufficient sample sizes. This result is not unexpected following a review of the epidemiological data for these classes of substances. Data from the 2012 National Survey on Drug Use and Health (NSDUH) in the United States (SAMHSA, 2013) revealed that the past-year prevalence of hallucinogens is low (1.7%). The prevalence of phencyclidine (PCP, a dissociative anesthetic) is also quite low (0.0% past-year prevalence and 2.4% lifetime prevalence reported in 2011; SAMHSA, 2012), and this substance is also rarely found among drivers. The use of ketamine—another dissociative anesthetic drug—by drivers is also rare (0.8%; Lacey et al., 2009), and most laboratories do not even test for this substance. Moreover, the experimental literature indicates that the effects of ketamine are so profound that most users would be unable to drive a motor vehicle following its consumption. In terms of inhalants, the results of the 2012 NSDUH also reported a low past-year prevalence rate (0.7%; SAMHSA, 2013), with use generally more common among youth 12 to 17 years old, many of whom are too young to drive (2.6%). The effects of inhalants are often short term but can be debilitating for drivers.

With respect to the drug combinations, we were also limited by the availability of DEC cases and were only able to examine four prevalent drug combinations in the current work: CNS depressants with narcotic analgesics, CNS depressants with CNS stimulants, CNS stimulants

with narcotic analgesics, and CNS depressants with cannabis. Two of the drug combinations examined in the present study (CNS depressants with CNS stimulants and CNS depressants with narcotic analgesics) were not previously assessed in Porath-Waller and Beirness' (2010) analysis of the most predictive drug-related indicators of drug combinations. As such, the current work is the first to have explored the signs and symptoms from the DEC evaluation that are most predictive of these two drug combinations. In reviewing the cell sizes for these two drug combinations in an existing database of DEC evaluations conducted in Canada, the number of cases for the combination of CNS depressants with CNS stimulants (n = 105) and CNS depressants with narcotic analgesics (n = 58) were found to be too low to permit a statistically powerful cross-validation of results.

The relatively small number of non-impaired cases available as a referent group for analysis in this study also limits the generalizability of the findings. It is also worth noting that during the course of this study, we learned that cases deemed "not impaired" are not always asked to provide samples for toxicological testing. In addition, these evaluations are not always retained or filed. This rendered it difficult to create a comparison group of cases for analysis. The present investigation used a sample of 180 rule-out cases to use as the referent group. We know from the qualitative review of the 53 non-impaired rule-out cases from the United States that not all of these people were drug-free or necessarily free of all signs of impairment. This creates a less than ideal situation that renders it more difficult to detect differences between this group and the cases in the various drug categories, thereby creating a more conservative test. Nevertheless, a larger sample of confirmed drug-free evaluations would provide greater power and enhance the validity of the findings.

Another potential limitation of the present study relates to the scoring used to determine impairment due to drugs on the WAT and OLS tests and for the assessment of HGN. In the absence of any published scoring criteria for determining impairment due to drugs on these tests, we adopted the scoring used for determining impairment due to alcohol (Stuster & Burns, 1998). This research has demonstrated that 88% of people who present four or more clues (between both eyes) on the HGN test will have likely have a BAC of .08 g/dL or greater. On the OLS test, 83% of individuals who exhibit two or more indicators in the performance of this test have a BAC of .080 g/dL or greater. Finally, Stuster and Burns (1998) showed that 79% of people who exhibit two or more indicators in the performance of the WAT test will have BACs of .08 g/dL or greater. A recent study conducted by Porath-Waller and Beirness (in press), however, examined the validity of using Stuster and Burns' scoring for the HGN, OLS, and WAT tests of the Standardized Field Sobriety Test (SFST) in detecting drug impairment using data recorded during DEC evaluations. The findings revealed that CNS depressants, CNS stimulants, narcotic analgesics and cannabis were all significantly associated with impairment on the SFST, providing preliminary support for the use of HGN, OLS, and WAT to identify drug-related impairment.

Finally, the current work did not conduct an accuracy analysis of the DEC evaluations. While the study had originally intended to examine the accuracy of the DEC evaluations by assessing the extent to which the DRE's opinion of the drug categories was confirmed by the results of the toxicological analysis, it was determined in collaboration with the NHTSA project manager that this was no longer appropriate to conduct given that the cases for this study were selected for inclusion based on established inclusion criteria. A valid assessment of DEC accuracy would require a random selection of cases.

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Appendix A: Sample Drug Influence Evaluation Face Sheet—Cannabis Example

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DRUG INFLUENCE EVALUATION

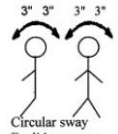
Evaluator: Officer Robert Hayes, Albany P.D.	DRE #: 6606	Rolling Log #: 12-09-025	**Session XXI-#2**
Recorder/Witness: Sgt. Greg Plummer, Oregon State Police	Crash: ☒ None ☐ Fatal ☐ Injury ☐ Property		Case # 12-09-12885
Arrestee's Name (Last, First, Middle): Peltier, Charles E.	Date of Birth: 5/16/70	Sex: M	Race: W
Arresting Officer (Name, ID#): Sr. Trooper Steve Webster, Oregon State Police #4220			
Date Examined / Time /Location: 09/21/12 2325 Linn Co. Jail	Breath Results: Results: 0.00	Test Refused ☐ Instrument #: 2124	Chemical Test: Urine ☒ Blood ☐ Test or tests refused ☐
Miranda Warning Given: Given By: Tpr. Webster	☒ Yes ☐ No	What have you eaten today? When? Hot dog 3 hours ago	What have you been drinking? How much? Beer "I had one"
Time of last drink? 2 hours ago			
Time now/ Actual: Midnight/11:30 pm	When did you last sleep? How long: Last night About 5 hrs. ago	Are you sick or injured? ☐ Yes ☒ No	Are you diabetic or epileptic? ☐ Yes ☒ No
Do you take insulin? ☐ Yes ☒ No "I don't take anything."	Do you have any physical defects? ☐ Yes ☒ No	Are you under the care of a doctor or dentist? ☐ Yes ☒ No	
Are you taking any medication or drugs? ☐ Yes ☒ No "Nothing man."	Attitude: Impatient, anxious	Coordination: Poor, disoriented	
Speech: Slow, slurred	Breath Odor: Normal	Face: Normal	
Corrective Lenses: ☒ None ☐ Glasses ☐ Contacts, if so ☐ Hard ☐ Soft	Eyes: ☐ Reddened Conjunctiva ☐ Normal ☒ Bloodshot ☐ Watery	Blindness: ☒ None ☐ Left ☐ Right	Tracking: ☒ Equal ☐ Unequal
Pupil Size: ☒ Equal ☐ Unequal (explain)	Vertical Nystagmus ☐ Yes ☒ No	Able to follow stimulus ☒ Yes ☐ No	Eyelids ☒ Normal ☐ Droopy

Pulse and time	HGN	Left Eye	Right Eye
1. 104 / 2338	Lack of Smooth Pursuit	No	No
2. 102 / 2345	Maximum Deviation	No	No
3. 100 / 2358	Angle of Onset	None	None

Convergence

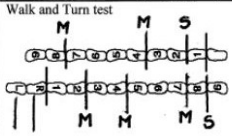
34 ONE LEG STAND 30

Modified Romberg Balance



Circular sway
Eyelid tremors

Walk and Turn test



Walked slowly Leg tremors

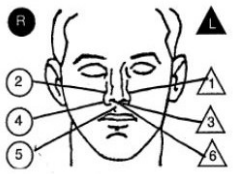
	1st Nine	2nd Nine
Cannot keep balance	✓✓	
Starts too soon		
Stops walking	✓	✓
Misses heel-toe	✓✓✓	✓✓
Steps off line		
Raises arms	✓✓	✓✓✓
Actual steps taken	9	9

L	R	
☑	☑	Sways while balancing
☑	☑	Uses arms to balance
☐	☑	Hopping
☑	☐	Puts foot down

Leg tremors

Internal clock: 35 estimated as 30 seconds	Describe Turn: Lost balance, stepped to the right	Cannot do test (explain): N/A
Type of footwear: Lace-up boots		

Draw lines to spots touched



Eyelid tremors

PUPIL SIZE	Room light 2.5 – 5.0	Darkness 5.0 – 8.5	Direct 2.0 – 4.5
Left Eye	6.5	8.0	6.0 – 7.5
Right Eye	6.5	8.0	6.0 – 7.5

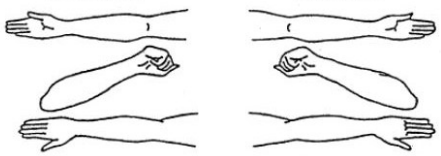
Nasal area: Clear

Oral cavity: Green coating on back of tongue

REBOUND DILATION ☒ Yes ☐ No

REACTION TO LIGHT: Slow

RIGHT ARM LEFT ARM



Nothing observed

Blood pressure: 148/100	Temperature: 98.4

Muscle tone: ☒ Normal ☐ Flaccid ☐ Rigid

Comments:

What drugs or medications have you been using? "I told you, just a beer"	How much? N/A	Time of use? N/A	Where were the drugs used? (Location) N/A
Date / Time of arrest: 09/21/12 2210	Time DRE was notified: 2250	Evaluation start time: 2325	Evaluation completion time: 0030 09/22/12
Precinct/Station:			
Officer's Signature:	DRE #: 6606	Reviewed/approved by / date:	

Opinion of Evaluator: ☐ Rule Out ☐ Alcohol ☐ CNS Stimulant ☐ Dissociative Anesthetic ☐ Inhalant ☐ Medical ☐ CNS Depressant ☐ Hallucinogen ☐ Narcotic Analgesic ■ Cannabis

HS 172 R5/13

Appendix B: Sample Narrative Report—Cannabis Example

DRUG INFLUENCE EVALUATION NARRATIVE

Suspect: Peltier, Charles E.

1. **LOCATION:** The evaluation was conducted in the interview room at the Linn County Jail.

2. **WITNESSES:** The evaluation was witnessed and recorded by Sgt. Greg Plummer of the Oregon State Police.

3. **BREATH ALCOHOL TEST:** Peltier's breath test was a 0.00%.

4. **NOTIFICATION AND INTERVIEW OF THE ARRESTING OFFICER:** I was dispatched to contact Sr. Trooper Webster at the Linn County Jail for a drug evaluation. Senior Trooper Webster advised he had arrested Peltier for DUI after he attempted to elude officers on I-5 south of Salem. The suspect was detained with the use of spike strips. The suspect had poor balance and coordination and after performing poorly on the SFST's he was arrested for DUI.

5. **INITIAL OBSERVATION OF SUSPECT:** I first observed the suspect in the interview room at the jail. He seemed impatient and anxious. He had poor coordination and balance and his speech was slow and slurred.

6. **MEDICAL PROBLEMS AND TREATMENT:** None noted or stated.

7. **PSYCHOPHYSICAL TESTS:** Modified Romberg Balance: Suspect had an approximate 3" circular sway and estimated 30 seconds in 35 seconds. Walk & Turn: Suspect lost his balance during the instructions stage, missed heel to toe three times on the first nine steps and twice on the second nine steps. He stopped twice while walking and raised his arms for balance. One Leg Stand: Suspect swayed while balancing, used his arms for balance, put his foot down once, hopped once and had leg tremors. Finger to Nose: Suspect missed the tip of his nose on four of the six attempts and exhibited eyelid tremors.

8. **CLINICAL INDICATORS:** Suspect had a Lack of Convergence and Rebound Dilation. His pupils were dilated in room light and in direct light. His pulse and blood pressure were elevated and above the DRE average ranges.

9. **SIGNS OF INGESTION:** The suspect had a green coating on his tongue.

10. **SUSPECT'S STATEMENTS:** Suspect admitted drinking a beer earlier and laughed when asked about other drug use.

11. **DRE'S OPINION:** In my opinion Peltier is under the influence of **Cannabis** and unable to operate a vehicle safely.

12. **TOXICOLOGICAL SAMPLE:** The suspect provided a urine sample.

13. **MISCELLANEOUS:** Suspect was also charged with Attempting to Elude. R5/13

HS 172 R5/13

Appendix C: Project Summary for International Association of Chiefs of Police

Project Overview

The Office of Behavioral Safety Research is currently funding a research project to collect and code all the information from a large sample of DEC cases that have resulted from traffic stops to determine which combinations of psychophysical tests and clinical indicators provide the most efficient and effective means to predict the toxicology-confirmed results of the evaluation. The specific objectives of this study are to:

a) gather a sample of DEC evaluation cases confirmed by toxicological analysis of blood samples;
b) code the information from the DEC cases and create a database of measures from the sample; and
c) analyze the data to determine connections between the measures and drug class confirmed by blood samples and determine which combination of factors offers the best predictive validity in the most efficient and effective manner.

The NHTSA project manager is Dr. Dereece Smither. The co-principal investigators of this research study are Drs. Amy Porath-Waller and Douglas Beirness from the Canadian Centre on Substance Abuse (CCSA).

Requests for DEC Cases

This project will require a sample of 4,000 DEC cases total, across the selected States, including the DIE face sheet, narrative, and toxicology result. In an effort to minimize the workload associated with this request, the two principal investigators for this project will travel to the selected States to obtain the data and/or make photocopies of the DEC cases. In order to maintain confidentiality throughout this study, any personally identifiable information contained in the DEC cases will not be coded for inclusion in the study. All of the DEC cases and identities of the Drug Recognition Experts (DREs) will be kept confidential and no DREs will be singled out. The selected States can opt to provide the DEC cases directly to the study investigators. In appreciation of their assistance with this request, CCSA will provide the participating States with a State-specific summary of the data collected for the project.

We are not yet ready to send out requests for data. At present, we need your input to determine a preliminary list of States to provide to the NHTSA Regional Administrators.

Appendix D: Project Summary for DRE State Coordinators

Explore the Predictive Validity of Drug Evaluation and Classification (DEC) Program Tests

Project Summary for DRE State Coordinators

Background

Research investigating the impairing effects of various drugs on a driver's ability to safely operate his/her car has not provided definitive outcomes. Law enforcement officers who are certified as Drug Recognition Experts (DREs) are trained to utilize a variety of readily observable signs and symptoms that are accepted in the medical community as reliable indicators of drug influence. The program enables officers to determine whether a subject is under the influence of alcohol and/or drugs; and if so, the DRE combines basic medical knowledge about drug pharmacodynamics with the administration of psychomotor tests to determine the category of drugs. This form of training is costly in time and resources.

Conducting a DEC evaluation is extensive and requires a lot of time. It is a 12-step procedure which takes about 30-45 minutes to complete. The evaluation has more than 60 different elements in numerical, narrative, and pictorial form which are documented during the DEC procedure. At the end of the evaluation, it requires a request for a biological specimen (blood or urine) to support the DRE's evaluation. It is unclear whether it is necessary for DREs to collect all of the information that the evaluation currently requires. Previous research suggests it may be possible to limit the evaluation to a core set of measures without significantly compromising accuracy (Porath-Waller, et al., 2009).[9]

Project Overview

The Office of Behavioral Safety Research at the National Highway Traffic Safety Administration is currently funding a research project to collect and code all the information from a large sample of DEC cases dated 2006 or later that have resulted from traffic stops to determine which combination(s) of psychophysical tests and clinical indicators provide the most efficient and effective means to predict the toxicology-confirmed results of the evaluation. The specific objectives of this study are to:

a) gather a sample of DEC evaluation cases confirmed by toxicological analysis of blood samples;
b) code the information from the DEC cases and create a database of measures from the sample; and
c) analyze the data to determine connections between the measures and drug class confirmed by blood samples and determine which combination of factors offers the best predictive validity in the most efficient and effective manner.

[9]Porath-Waller, A. J., Beirness D. J., & Beasley, E. E. (2009). Toward a more parsimonious approach to Drug Recognition Expert evaluations. *Traffic Injury Prevention, 10*, 513-518.

The NHTSA project manager is Dr. Dereece Smither. The co-principal investigators of this research study are Drs. Amy Porath-Waller and Douglas Beirness from the Canadian Centre on Substance Abuse (CCSA).

Requests for DEC Cases

This project will require a sample of 4,000 DEC cases total, across the selected States (a case includes the DIE face sheet, narrative, and toxicology results). The co-principal investigators have permission from the International Association of Chiefs of Police, NHTSA Headquarters and the NHTSA Regional Administrators to obtain the needed data from the selected States.

Several States have already agreed to participate in this research study and have provided DEC cases including California, Minnesota, Montana, North Carolina and Pennsylvania.

In an effort to minimize the workload associated with this request, the two principal investigators for this project will travel to the selected States to obtain the data and/or make photocopies of the DEC cases. We simply ask for your cooperation with meeting this request and your assistance, when needed. The selected States can opt to provide the DEC cases directly to the study investigators. In appreciation of their assistance with this request, CCSA will provide the participating States with a State-specific summary of the data collected for the project.

Confidentiality Assurance

We recognize that there is a potential privacy issue given that DEC cases contain several pieces of confidential information (e.g., name of the accused). In order to maintain confidentiality throughout this study, the personal information contained in the DEC cases will not be coded for inclusion in the study. If preferred, these data can be blocked out from the DIE face sheets and narratives prior to the cases being provided to the study's principal investigators.

All of the DEC cases and identities of the DREs) will be kept confidential and no DREs will be singled out. All copies of DEC cases will be stored in a locked storage room onsite at CCSA's office. The electronic data will be stored on a password protected computer that will only be accessible internally by the project team. The CCSA project team has extensive experience working with DEC cases and has never experienced a breach in confidentiality of the information contained in these cases. Moreover, all members of the CCSA research team have received security clearances from the Royal Canadian Mounted Police to work with DEC cases.

Next Steps

If you are interested in participating in this research study, please contact one of the study personnel cited below. We will then schedule a teleconference to discuss the project in more detail, the request for DEC cases, and the logistics surrounding the obtainment of these cases. This teleconference will also provide the opportunity to ask questions of both the co-Principal Investigators as well as the Project Manager from NHTSA.

Appendix E: Data Coding Instrument

State: enter 2-character code for State

1. Entry number *assign each face sheet with a number (i.e., the first file you enter into the database will be assigned number 1, etc.) and write this number on the actual face sheet.

2. File number
    -enter the File # from the face sheet

3. Type of Crash (1) *if there is more than one type of crash, then code the highest level of crash – i.e., fatal, injury, property, in this order.
    0 – none
    1 – fatal
    2 – injury
    3 – property

5. Date of Birth (DOB)
    -enter the year of birth

5a. Age
    Enter 2 digits
6. Sex
    0 – male
    1 – female

7. Date Examined
    -enter the date as is on the face sheet without any spaces or hyphens (ddmmyyyy)

8. Time Examined
    -enter time without any spaces or colons according to the 24-hour clock (4 digits)

9. Breath Results
    -enter 3 digits after the decimal (add a trailing zero if necessary) Don't enter the decimal point. (usually it will be expressed as a percent)
    -if the test was refused, then enter 999
    -if the words "fail" are included in this section, then enter 100 (as per police instructions)
    -the Instrument # is not required

10. Chemical Test (1) * If more than one test is selected, then code each one using a separate variable.
    0 – refused
    1 – urine
    2 – blood
    3 – oral fluid/saliva

11. Chemical Test (2)
    0 – refused
    1 – urine
    2 – blood
    3 – oral fluid/saliva

12. Eaten Today (what the subject has eaten is not important; just whether or not he/she has eaten)

0 – no
1 – yes

13. Time of Eating Today (1)

-enter time without any spaces or colons according to the 24-hour clock

14. Time of Eating Today (2)

-if the time of eating is not expressed numerically on the face sheet (i.e., dinner time), then enter what is written using text

15. Time of Last Drink (1)

-enter time without any spaces or colons according to the 24-hour clock

16. Time of Last Drink (2)

-enter the text if not written using the 24-hour clock

17. Time Now

-enter time without any spaces or colons according to the 24-hour clock

18. Time of Last Sleep

-enter what is written in this section of the face sheet

19. Duration of Last Sleep (in hours)

-enter the number

20. Sick or Injured

0 – no
1 – yes

21. Sick or Injured Commentary

-enter any text that is written in this section of the face sheet

22. Diabetic or Epileptic

0 – no
1 – yes

23. Taking of Insulin

0 – no
1 – yes

24. Physical Defects or Disabilities

0 – no
1 – yes

25. Type of Physical Defects or Disabilities or Oother Commentary

-enter any text that is written in this section of the face sheet

26. Under Care of Doctor or Dentist
    0 – no
    1 – yes

27. Under Care of Doctor or Dentist Commentary
    -enter any text that is written in this section of the face sheet

28. Taking of Medication or Drugs
    0 – no
    1 – yes

29. Taking of Medication or Drugs Commentary
    -enter any text that is written in this section of the face sheet

30. Attitude
    -enter any text that is written in this section of the face sheet

31. Coordination
    -enter any text that is written in this section of the face sheet

32. Breath
    -enter any text that is written in this section of the face sheet

33. Face
    -enter any text that is written in this section of the face sheet

34. Speech
    -enter any text that is written in this section of the face sheet

35. Eyes (1)*if more than one box is checked in this section of the face sheet, code the subsequent checkmarks using the variables Eyes (2) and Eyes (3)
    0 – normal
    1 – reddened conjunctiva
    2 – bloodshot
    3 – watery

36. Eyes (2)
    0 – normal
    1 – reddened conjunctiva
    2 – bloodshot
    3 – watery

37. Eyes (3)
    0 – normal
    1 – reddened conjunctiva
    2 – bloodshot
    3 – watery

38. Blindness
    0 – none
    1 – left eye
    2 – right eye
    3 – partial
    4 – total

39. Tracking
    0 – equal
    1 – unequal

40. Corrective Lenses
    0 – none
    1 – glasses
    2 – contacts

41. Type of Contacts
    0 – soft
    1 – hard

42. Pupil Size
    0 – equal
    1 – unequal

43. Pupil Size Explain
    -enter any text that is written in this section of the face sheet

44. Ability to Follow Stimulus
    0 – no
    1 – yes

45. Eyelids
    0 – normal
    1 – droopy
    2 - retracted

46. Pulse 1
    -enter the number that is written in this section of the face sheet (3 digits)

47. Pulse 1 Time
    -enter time without any spaces or colons according to the 24-hour clock (4 digits)

48. Pulse 2
    -enter the number that is written in this section of the face sheet (3 digits)

49. Pulse 2 Time
    -enter time without any spaces or colons according to the 24-hour clock

50. Pulse 3
    -enter the number that is written in this section of the face sheet (3 digits)

51. Pulse 3 Time
    -enter time without any spaces or colons according to the 24-hour clock

52. Left Eye Lack of Smooth Pursuit
    0 – no
    1 – yes
    2 – unable to perform test

53. Left Eye Maximum Deviation
    0 – no
    1 – yes
    2 - unable to perform test

54. Left Eye Angle of Onset
    -enter the angle number (2 digits)
    -if "none", then enter ”00”
    02 – unable to perform test

55. Right Eye Lack of Smooth Pursuit
    0 – no
    1 – yes
    2 – unable to perform test

56. Right Eye Maximum Deviation
    0 – no
    1 – yes
    2 – unable to perform test

57. Right Eye Angle of Onset
    -enter the angle number
    -if "none", enter zero
    -02 – unable to perform test

58. Vertical Nystagmus
    0 – no
    1 – yes

59. Convergence *If the arrows for both eyes are pointing together (right eye at 3 o'clock position and left eye at 9 o'clock position) then this indicates that convergence is present; otherwise, there is an absence of convergence.
    0 – no (absent)
    1 – yes (present)
    -enter 2 if unable to perform the test

60. Completion of One Leg Stand Test for the Left Leg *there is not a specific box on the face sheet for this. There will often be a comment in the One Leg Stand diagram portion of the face sheet indicating "Test Stopped." You can also determine which portion of the test (i.e., left leg or the right leg) was stopped by looking at the diagram and the checklist that is located below the diagram. (Note that the test for the left leg appears on the left side of the diagram and the test for the right leg appears on the right side of the diagram). If there is/are no (often circled) number(s) above a set of "footprints" and no check marks in the corresponding column below, then this suggests that the test was not completed for that

particular leg. You can also confirm whether the test was stopped by consulting the "Psychophysical Tests" portion of the narrative for this test (located on page 2 of the face sheet).

0 – not attempted
1 – attempted but stopped
2 – attempted and completed

61. Completion of One Leg Stand Test for the Right Leg *there is also not a specific box on the face sheet for this.

0 – not attempted
1 – attempted but stopped
2 – attempted and completed

62. Left One Leg Stand – Sways While Balancing

-enter the number of check marks/tallies. If none, then enter zero. If there are no check marks/tallies because the test was not attempted or completed, then assign a value of9
-enter 5 if "constant" or "continuous" is written

63. Left One Leg Stand – Uses Arms to Balance

-enter the number of check marks/tallies. If none, then enter zero. If there are no check marks/tallies because the test was not attempted or completed, then assign a value of 9
-enter 5 if "constant" or "continuous" is written

64. Left One Leg Stand - Hopping

-enter the number of check marks/tallies. If none, then enter zero. If there are no check marks/tallies because the test was not attempted or completed, then assign a value of 9
-enter 5 if "constant" or "continuous" is written

65. Left One Leg Stand – Puts Foot Down

-enter the number of check marks/tallies. If none, then enter zero. If there are no check marks/tallies because the test was not attempted or completed, then assign a value of 9
-enter 5 if "constant" or "continuous" is written

66. Right One Leg Stand – Sways While Balancing

-enter the number of check marks/tallies. If none, then enter zero. If there are no check marks/tallies because the test was not attempted or completed, then assign a value of 9
-enter 5 if "constant" or "continuous" is written

67. Right One Leg Stand – Uses Arms to Balance

-enter the number of check marks/tallies. If none, then enter zero. If there are no check marks/tallies because the test was not attempted or completed, then assign a value of 9
-enter 5 if "constant" or "continuous" is written

68. Right One Leg Stand - Hopping

-enter the number of check marks/tallies. If none, then enter zero. If there are no check marks/tallies because the test was not attempted or completed, then assign a value of 9

69. Right One Leg Stand – Puts Foot Down

-enter the number of check marks/tallies. If none, then enter zero. If there are no check marks/tallies because the test was not attempted or completed, then assign a value of 9
-enter 5 if "constant" or "continuous" is written

70. Type of Footwear
-enter any text that is written in this section of the face sheet

71. Completion of Romberg Balance Test *there is not a specific box on the face sheet for this. There will often be a comment in the Romberg Balance diagram portion of the face sheet indicating "Test Stopped." There will also be information in the narrative section of the face sheet.
0 – not attempted
1 – attempted but stopped
2 – attempted and completed

73. Romberg Balance Front to Back Test – Front to back Measurement **some of the numbers might be given in cm. If so, convert to inches so that all of the data are in the same units.
-enter the first number above the "stickman"
-if no number is provided, then enter zero if the test was done
-enter 9 if the test was not completed

75. Romberg Balance Side to Side Test Measurement
-enter the first number (is in inches) above the "stickman"
-if no number is provided, then enter zero if the test was done
-enter 9 if the test was not completed

77. Romberg Balance Internal Clock
-enter the number (in secs)
-if test was not attempted or completed, enter 99

78. Presence of Eyelid Tremors (there isn't always a separate box for this – it might be written in the Romberg test box)
0 = no
1 = yes

79. Presence of Leg Tremors
0 = no
1 = yes

79a. Presence of Body Tremors (there isn't always a separate box for this – it might be written in the Romberg test box)
0 = no
1 = yes

80. Completion of Walk and Turn Test *there is not a specific box on the face sheet for this. There will often be a comment in the Walk and Turn Test diagram portion of the face sheet indicating "Test Stopped." There will also be information in the narrative section of the face sheet.
0 – not attempted
1 – attempted but stopped
2 – attempted and completed

81. Walk and Turn Test - Cannot Keep Balance *In cases where the words "continuous" or "all" are provided in the various boxes for this test (instead of check marks or tallies), enter the number 05 (2 digits)
-enter the number of check marks/tallies (if none, then enter 00)

82. Walk and Turn Test - Starts too Soon
-enter the number of check marks/tallies (if none, then enter 00)

83. Walk and Turn Test 1st Nine – Stops Walking
-enter the number of check marks/tallies (if none, then enter 00)

84. Walk and Turn Test 1st Nine – Misses Heel to Toe
-enter the number of check marks/tallies (if none, then enter 00)

85. Walk and Turn Test 1st Nine – Steps Off Line
-enter the number of check marks/tallies (if none, then enter 00)

86. Walk and Turn Test 1st Nine – Raises Arms
-enter the number of check marks/tallies (if none, then enter 00)

87. Walk and Turn Test 1st Nine – Actual # of Steps
-enter the number from the box (if none, then enter 00)

88. Walk and Turn Test 2nd Nine – Stops Walking
-enter the number of check marks/tallies (if none, then enter 00)

89. Walk and Turn Test 2nd Nine – Misses Heel to Toe
-enter the number of check marks/tallies (if none, then enter 00)

90. Walk and Turn Test 2nd Nine – Steps Off Line
-enter the number of check marks/tallies (if none, then enter 00)

91. Walk and Turn Test 2nd Nine – Raises Arms
-enter the number of check marks/tallies (if none, then enter 00)

92. Walk and Turn Test 2nd Nine – Actual # of Steps
-enter the number from the box (if none, then enter 00)

93. Describe Turn from Walk and Turn Test
-enter any text from this section of the face sheet

94. Cannot do Test (Explain)
-enter any text from this section of the face sheet

95. Nasal Area
-enter any text that is written in this section of the face sheet

96. Hit on Finger to Nose Test 1 (Draw Lines to Spots Touched) *each test corresponds to the triangle with the corresponding number inside it. A hit is when the tip of the finger touches the tip of the nose. These diagrams can be hard to read and so it is often useful to consult the narrative portion of the face sheet.

0 – no
1 – yes
9 did not attempt/complete

97. Hit on Finger to Nose Test 2
0 – no
1 – yes
9 did not attempt/complete

98. Hit on Finger to Nose Test 3
0 – no
1 – yes
9 did not attempt/complete

99. Hit on Finger to Nose Test 4
0 – no
1 – yes
9 did not attempt/complete

100. Hit on Finger to Nose Test 5
0 – no
1 – yes
9 did not attempt/complete

101. Hit on Finger to Nose Test 6
0 – no
1 – yes
9 did not attempt/complete

102. Use of Pad of the Finger during Finger to Nose Test *This will be noted on the face sheet. If this happens at least once, then code as "yes"
0 – no
1 – yes

103. Left Pupil Size – Room Light
-enter the number (no decimal)
104. Left Pupil Size - Darkness
-enter the number (no decimal)

105. Left Pupil Size - Direct
-enter the number (no decimal)

106. Right Pupil Size – Room Light
-enter the number (no decimal)

107. Right Pupil Size - Darkness
-enter the number (no decimal)

108. Right Pupil Size - Direct
-enter the number (no decimal)

109. Oral Cavity
-enter any text that is written in this section of the face sheet

110. Rebound Dilation
    0 – no
    1 – yes

111. Reaction to Light
    -enter any text that is written in this section of the face sheet

112. Right Arm Injection Sites
    0 – none
    1 – old
    2 – fresh
    3 - both

113. Left Arm Injection Sites
    0 – none
    1 – old
    2 – fresh
    3 - both

114. Blood Pressure – Systolic
    -enter the first number (3 digits)

115. Blood Pressure – Diastolic
    -enter the second number (3 digits)

116. Temperature (degrees F)
    -enter the number (4 digits - no decimal)

117. Muscle Tone
    0 – near normal
    1 – flaccid
    2 – rigid

118. Muscle Tone Commentary
    -enter any text that is written in this section of the face sheet

119. Type of Medication/Drug 1 Taken *If more than one type of medication/drug is provided, code each one using a separate variable (e.g., Type of Med/Drug 2 Taken, etc.)
    -enter any text that is written in this section of the face sheet

120. Amount of Medication/Drug 1 Taken
    -enter any text that is written in this section of the face sheet

121. Time of Medication/Drug 1 Use (1)
    -enter time without any spaces or colons according to the 24-hour clock

122. Time of Medication/Drug 1 Use (2)
    -if the time of medication/drug use is not expressed numerically on the face sheet, then enter what is written using text, or any other comments in this section of the face sheet

123. Type of Medication/Drug 2 Taken
-enter any text that is written in this section of the face sheet

124. Amount of Medication/Drug 2 Taken
-enter any text that is written in this section of the face sheet

125. Time of Medication/Drug 2 Use (1)
-enter time without any spaces or colons according to the 24-hour clock

126. Time of Medication/Drug 2 Use (2)
-if the time of medication/drug use is not expressed numerically on the face sheet, then enter what is written using text, or any other comments in this section of the face sheet

127. Type of Medication/Drug 3 Taken
-enter any text that is written in this section of the face sheet

128. Amount of Medication/Drug 3 Taken
-enter any text that is written in this section of the face sheet

129. Time of Medication/Drug 3 Use (1)
-enter time without any spaces or colons according to the 24-hour clock

130. Time of Medication/Drug 3 Use (2)
-if the time of medication/drug use is not expressed numerically on the face sheet, then enter what is written using text, or any other comments in this section of the face sheet

131. Type of Medication/Drug 4 Taken
-enter any text that is written in this section of the face sheet

132. Amount of Medication/Drug 4 Taken
-enter any text that is written in this section of the face sheet

133. Time of Medication/Drug 4 Use (1)
-enter time without any spaces or colons according to the 24-hour clock

134. Time of Medication/Drug 4 Use (2)
-if the time of medication/drug use is not expressed numerically on the face sheet, then enter what is written using text, or any other comments in this section of the face sheet

135. Date of Arrest
-enter the date as is on the face sheet without any spaces or hyphens (ddmmyyyy)

136. Time of Arrest
-enter time without any spaces or colons according to the 24-hour clock

137. Evaluation Start Time
-enter time without any spaces or colons according to the 24-hour clock

138. Time Completed
-enter time without any spaces or colons according to the 24-hour clock

139. Opinion of Evaluator – Drug 1 *If more than one drug is selected, then code each one using a separate drug variable. **On some face sheets these options are not included at the bottom, so you will need to read the narrative aspect of the face sheet for this information.

0 – rule out
1 – medical
2 – alcohol
3 – CNS depressant
4 – CNS stimulant
5 – hallucinogen
6 – dissociative anesthetic (PCP)
7 – narcotic analgesic
8 – inhalant
9 – cannabis
-if left blank on the face sheet, then leave blank in the database

140. Opinion of Evaluator – Drug 2

0 – rule out
1 – medical
2 – alcohol
3 – CNS depressant
4 – CNS stimulant
5 – hallucinogen
6 – dissociative anesthetic (PCP)
7 – narcotic analgesic
8 – inhalant
9 – cannabis
-if left blank on the face sheet, then leave blank in the database

141. Opinion of Evaluator – Drug 3

0 – rule out
1 – medical
2 – alcohol
3 – CNS depressant
4 – CNS stimulant
5 – hallucinogen
6 – dissociative anesthetic (PCP)
7 – narcotic analgesic
8 – inhalant
9 – cannabis
-if left blank on the face sheet, then leave blank in the database

142. Opinion of Evaluator – Drug 4

0 – rule out
1 – medical
2 – alcohol
3 – CNS depressant
4 – CNS stimulant
5 – hallucinogen
6 – dissociative anesthetic (PCP)
7 – narcotic analgesic
8 – inhalant

9 – cannabis
-if left blank on the face sheet, then leave blank in the database

143. Opinion of Evaluator – Drug 5
0 – rule out
1 – medical
2 – alcohol
3 – CNS depressant
4 – CNS stimulant
5 – hallucinogen
6 – dissociative anesthetic (PCP)
7 – narcotic analgesic
8 – inhalant
9 – cannabis
-if left blank on the face sheet, then leave blank in the database

144. Toxicology Results – Drug 1
0 – rule out
1 – medical
2 – alcohol
3 – CNS depressant
4 – CNS stimulant
5 – hallucinogen
6 – dissociative anesthetic
7 – narcotic analgesic
8 – inhalant
9 – cannabis
-if left blank on the face sheet, then leave blank in the database

NOTE RE: ALCOHOL – if Alcohol is checked as an "Opinion of Evaluator" use the BAC from (variable #9 on this sheet) to confirm that alcohol was indeed present. Most Tox reports will not report Alcohol because they typically don't test for it in these cases. The breath test result is the only confirmation necessary.

145. Toxicology Results – Drug 2
0 – rule out
1 – medical
2 – alcohol
3 – CNS depressant
4 – CNS stimulant
5 – hallucinogen
6 – dissociative anesthetic
7 – narcotic analgesic
8 – inhalant
9 – cannabis
-if left blank on the face sheet, then leave blank in the database

146. Toxicology Results – Drug 3
0 – rule out
1 – medical
2 – alcohol

3 – CNS depressant
4 – CNS stimulant
5 – hallucinogen
6 – dissociative anesthetic
7 – narcotic analgesic
8 – inhalant
9 – cannabis
-if left blank on the face sheet, then leave blank in the database

147. Toxicology Results – Drug 4
0 – rule out
1 – medical
2 – alcohol
3 – CNS depressant
4 – CNS stimulant
5 – hallucinogen
6 – dissociative anesthetic
7 – narcotic analgesic
8 – inhalant
9 – cannabis
-if left blank on the face sheet, then leave blank in the database

148. Toxicology Results – Drug 5
0 – rule out
1 – medical
2 – alcohol
3 – CNS depressant
4 – CNS stimulant
5 – hallucinogen
6 – dissociative anesthetic
7 – narcotic analgesic
8 – inhalant
9 – cannabis
-if left blank on the face sheet, then leave blank in the database

149. A series of five variables have been added here. These are text fields. Please enter the name of the drugs found from the tox report plus the quantity of drug reported and the units of measurement. One drug per field.

150. Circumstances of Arrest
Few words to summarize the events that lead to the arrest of the subject.

151. Reason for medical rule out
Few words to summarize the events that resulted in a medical rule out

Appendix F: Statistical Methods Terms

Statistical Analysis	Description
Bivariate Analysis	This type of analysis is used determine if there is a relationship between two measurements.
Multivariate Analysis	This type of analysis is used determine if there is a relationship between two or more measurements.
Binary or Binomial Logistic Regression	This analysis is used when the observed outcome for a dependent variable can have only two possible types, "0" and "1" (e.g., "dead" vs. "alive" or "CNS Depressant" vs. "no drug")
Multinomial Logistic Regression	This analysis is used to predict an outcome variable that has more than two categories from a set of predictor variables that may be continuous, discrete, dichotomous or a mix of these. Logistic regression also permits the calculation of classification rates for the outcome categories to provide an estimate of the relative success or effectiveness of the model in correctly predicting the category of drugs used.
Type I Error	This type of error occurs when one rejects a true null hypothesis (a false positive—e.g., testing positive when there is no drug).
Area Under the Curve (AUC) and ROC Curve	AUC is used to determine which of the models is most likely to accurately predict a drug or drug combination. An example of its application are ROC curves.
Receiver Operating Curve (ROC)	ROC is determined by plotting the true positive rate against the false positive rate. For this study ROC was derived from the logistic regression model to obtain an overall assessment of how well the model predicts which subjects have used a particular drug category and those who have not used any drugs.

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**National Highway
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