Technical Note

Evaluation of Ten Oral Fluid Point-of-Collection Drug-Testing Devices*

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Abstract

Previously, the laboratory evaluations of six point-of-collection oral fluid (POC-OF) drug testing devices were reported. Four additional devices, Oralstat® (American Bio Medica); SmartClip (Envitec); Impact® (LifePoint®); and OraLine® IV s.a.t (Sun Biomedical Laboratories), were recently evaluated for their ability to meet the claimed (and proposed) cutoff concentrations set by the manufacturers for the detection of amphetamine(s), cocaine/metabolite, opiates, and cannabinoids (Oralstat also benzodiazepines). With the exception of the Sun Biomedical device, actual false-positive results were not encountered. Most devices performed well for the detection of opiates and amphetamine(s), but approximately half had amphetamine(s) cutoff concentrations greater than that proposed by the Substance Abuse and Mental Health Services Administration (SAMHSA). Only three devices had cocaine cutoffs less than or equal to 20 ng/mL (SAMHSA), and a number of false-negative results were obtained. The devices still were not capable of detecting Δ^9-tetrahydrocannabinol at 4 ng/mL (SAMHSA). However, sensitivities improved since the initial studies, and approximately half of the devices met the THC-COOH cutoff proposed by SAMHSA. Results from the current and previous evaluations are presented in the paper and indicate that the sensitivity and performance of commercial OF drug testing devices is improving, but remains problematic for the reliable detection of cannabinoid use.

Introduction

During the past decade, there has been an increasing scientific and public interest in testing for abused drugs in non-traditional matrices (1). In a fashion analogous to that of the development of point-of-collection (POC) urine testing devices, oral fluid (OF) drug testing devices are also evolving (2). The advantages of OF testing are that collections can be totally observed and are less invasive than those of many other body fluids, parent drug(s) can often be detected, drugs are readily extracted from OF, and OF-drug concentrations may mirror those in the blood (1,3). Given these advantages, OF is an attractive specimen for forensic and diagnostic on-site drug testing. In two previous publications, the performance of six commercially available OF drug-testing devices was reported (4,5). In those publications, the devices were evaluated against the performance claims and proposed workplace cutoff concentrations of the manufacturers for OF testing (4–7). The ultimate goal of the evaluations was to select those devices that showed promise in the laboratory for use in an on-going drugged-driver field study (8). The purposes of the current publication were similar. This study reports the in-laboratory evaluation of four additional OF testing devices: Oralstat (American Bio Medica, Kinderhook, NY, "American Bio Medica"); SmartClip (Envitec, Wismar, Germany, "Envitec"); Impact (LifePoint, Ontario, CA, "Life Point"); and OraLine IV s.a.t (Sun Biomedical Laboratories, Blackwood, NJ, "Sun Biomedical"). The devices were assessed in the laboratory for their performance at the manufacturer's cutoffs and proposed federal standards with the ultimate goal of further evaluating the promising devices in the field research study (6,7). The drugs evaluated included those commonly detected by instrumented and non-instrumented immunoassay tests, such as amphetamine, methamphetamine, cocaine and benzoylecgonine (BE), opiates (morphine), Δ^9-tetrahydrocannabinol (THC) and 11-carboxy-THC (THC-COOH), and the benzodiazepines (BZP) temazepam and oxazepam.

Methods

The device evaluations were performed by The Walsh Group, a toxicologist from the Wisconsin State Laboratory of Hygiene, and the toxicology staff of the Center for Human Toxicology at the University of Utah in a manner similar to previous studies (4,5). Using the manufacturer product information and the Substance Abuse and Mental Health Services Administration (SAMHSA) draft guidelines (6,7), target drugs and their concentration(s) for the evaluation were selected. The target

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analytes and cutoff concentrations varied for each device. However, an attempt was made to challenge the devices with drug-free (negative, $n = 5$ and $n = 1$ 0) of low (~½× – ~½ times), medium (~2×), and high (~10×) controls prepared in OF and based on the proposed SAMHSA cutoff concentrations. Device cutoffs for the cannabinoids varied dramatically, such that THC challenges were fortified at 1.25×, 5×, 12.5×, and 25×, and THC-COOH control concentrations were fortified at 2.5×, 12.5× and 25× their respective SAMHSA cutoffs. Concentrations of the fortified OF control solutions were verified by either high-performance liquid chromatography or gas chromatography with mass spectrometry (MS) detection ($n = 3$) (4,5). All controls were prepared and verified prior to use, except the THC and THC-COOH challenges that were prepared on the day of use and subsequently verified. The controls were encoded with a study number and tested such that they were "blind to the analyst," as described previously (4,5).

As a condition of participating in the studies, a summary of cutoff concentrations and antibody cross-reactivities was required from each manufacturer. The manufacturers were also invited to provide any additional training materials that they wished and give on-site instruction for the proper use of their device. All analyses were performed in accordance with the manufacturer training materials, and written and verbal instructions. The use of Drugwipe® (Securetec, Ottobrunn, Germany, "Drugwipe"), OralLab®, (Ansys Technologies, Lake Foster, CA, "Ansys"), Oratect®, (Branan Medical Corporation, Irvine, CA, "Branan"), RapiScan®, (Cozart, Bioscience Ltd., Abingdon, Oxfordshire, U.K., "Cozart"), SalivaScreen®, (Ulti-Med, Ahrensberg, Germany, "Ulti-Med"), and Uplink® (OraSure Technologies Inc., Bethlehem, PA, "OraSure") have been described previously (4,5). Of these devices, the Cozart and OraSure were instrumented, and the remaining devices were visually interpreted. Of the additional devices reported here, the American Bio Medica, Envitec, and Sun Biomedical were visually interpreted, and the LifePoint product was instrumented. For those devices that were subjectively interpreted, two analysts (a primary and secondary) read and recorded each result. Data tapes from the instrumented devices were reviewed by a second analyst to ensure accurate data recording. After the results of the analyst were summarized, the data were evaluated based on the expected result given for the device cutoff, the target analyte, and the concentration of the control challenge. The results from each device were then categorized by drug as a true positive (TP), true negative (TN), false positive (FP), or false negative (FN). If the target concentration of the control was greater than or equal to the cutoff of the device, the device was expected to produce a positive result. Conversely, an FP was assigned if the target concentration of the control was less than the device cutoff and a positive result was observed (see the Discussion section).

Results

As discussed, there were substantial differences in the cutoff concentrations between the devices, and, at this time, no OF-cutoffs are universally accepted. Therefore, the devices

Table I. Summary of Controls and Cutoff Concentrations

Drug Class Target Drug Units	Amphetamine Amphetamine ng/mL	Methamphetamine Methamphetamine ng/mL	Opiates Morphine ng/mL	Cocaine Cocaine ng/mL	Cocaine Benzoylecgonine ng/mL	Cannabinoids Δ⁹-THC ng/mL	Cannabinoids THC-COOH ng/mL	Benzodiazepines Temazepam ng/mL	Benzodiazepines Oxazepam ng/mL
SAMHSA target	50	50	40	20	20	4	4	NA*	NA
Study target	50	50	40	20	20	10	10	5	25
Negative	0	0	0	0	0	0	0	0	0
Study 1, 2 and 3†	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative (study 1)	Negative (study 3)
Low	25	25	20	10	10	5	10	2.5	12.5
Study 1	***‡	***	***	***	NA	***	***	16%	NA
Study 2	***	***	***	***	NA	***	***	NA	NA
Current study	***	***	***	***	***	99%	***	NA	***
Medium	100	100	80	40	40	20	100§	10	50
Study 1	***	***	***	***	NA	***	***	***	NA
Study 2	***	***	***	***	NA	***	***	NA	NA
Current study	***	***	***	***	***	***	–30%	NA	***
High	500	500	400	200	200	100	200	50	250
Study 1	***	***	***	***	NA	–27%	***	***	NA
Study 2	***	***	***	***	NA	***	***	NA	NA
Current study	***	***	***	***	***	***	***	NA	***

* NA = not applicable.
† Study 1 (reference 4), Study 2 (reference 5), Study 3 (current study).
‡ Analysis within + 15% of target.
§ Fortified at 100 ng/mL in study 1 and 50 ng/mL in studies 2 and 3.

were evaluated against the published cutoffs of the manufacturers using the proposed SAMHSA OF-cutoffs as a guide for selecting the control concentrations. Table I shows the SAMHSA screening target analytes and cutoff concentrations, study target analytes, fortified control concentrations, and assayed control concentrations for the challenges in each of the three studies. Those MS-verified concentrations that exceeded ± 15% of target are indicated in Table I, and their percent differences from the target are shown. Not surprisingly, the greatest variability was found with the cannabinoid controls. One THC-COOH control assayed 30% lower than its target concentration, and two THC controls varied by greater than 15%. A review of the preparation notes for the expected 5 ng/mL THC control indicated that it was inadvertently fortified at 10 ng/mL (assay 9.95 ng/mL). The only other control concentration that exceeded ± 15% of its target was the low BZP control in study 1 (target = 2.5 ng/mL; assay = 2.9 ng/mL). Tables II through IX provide a comprehensive comparison of the 10 devices evaluated in the three studies. The tables illustrate drug class, study number, device target analyte and cutoff

Table II. Summary of Amphetamine Results

Device	Study Number	Device Cutoff (ng/mL)	Challenge (ng/mL)	Expected Results	TP	TN	FP	FN
American Bio Medica	3	25	Neg (0)	Neg	0	5	0	0
			Low (25)	Pos/Neg	9	0	0	1
			Medium (100)	Pos	10	0	0	0
			High (500)	Pos	8	0	0	2
Ansys	1	160	Neg (0)	Neg	0	5	0	0
			Low (25)	Neg	0	10	0	0
			Medium (100)	Neg	0	10	0	0
			High (500)	Pos	10	0	0	0
Branan	2	50	Neg (0)	Neg	0	5	0	0
			Low (25)	Neg	0	5	5	0
			Medium (100)	Pos	10	0	0	0
			High (500)	Pos	10	0	0	0
Cozart	1	150	Neg (0)	Neg	0	5	0	0
			Low (25)	Neg	0	5	5	0
			Medium (100)	Neg	0	0	10	0
			High (500)	Pos	10	0	0	0
Envitec	3	50	Neg (0)	Neg	0	5	0	0
			Low (25)	Neg	0	0	10	0
			Medium (100)	Pos	8	0	0	2
			High (500)	Pos	10	0	0	0
LifePoint	3	100	Neg (0)	Neg	0	5	0	0
			Low (25)	Neg	0	10	0	0
			Medium (100)	Pos/Neg	4	0	0	6
			High (500)	Pos	10	0	0	0
OraSure	2	25	Neg (0)	Neg	0	5	0	0
			Low (25)	Pos/Neg	8	0	0	2
			Medium (100)	Pos	10	0	0	0
			High (500)	Pos	10	0	0	0
Securetec	1	100	Neg (0)	Neg	0	5	0	0
			Low (25)	Neg	0	10	0	0
			Medium (100)	Pos/Neg	0	0	0	10
			High (500)	Pos	10	0	0	0
Sun Biomedical	NA*							
Ulti-Med	NA							

* NA = not applicable.

concentration, challenge concentration, the expected result, and whether the result was categorized as TP, TN, FP, or FN. As stated, those assignments were made based on the fortified concentration of the quality control challenge. Despite the subjective interpretation of most results, discrepancies between the primary and secondary analyst designation of positive or negative were not common. When a discrepancy occurred, it was discussed, and an additional analysis was performed to verify the determination.

Amphetamine performance

Table II presents results from the amphetamine evaluations. As shown, the cutoff varied from 25 to 160 ng/mL, and two devices were not designed to detect amphetamine. Most devices

Table III. Summary of Methamphetamine Results

Device	Study Number	Device Cutoff (ng/mL)	Challenge (ng/mL)	Expected Results	TP	TN	FP	FN
American Bio Medica	3	25	Neg (0)	Neg	0	5	0	0
			Low (25)	Pos/Neg	10	0	0	0
			Medium (100)	Pos	10	0	0	0
			High (500)	Pos	10	0	0	0
Ansys	1	160	Neg (0)	Neg	0	5	0	0
			Low (25)	Neg	0	10	0	0
			Medium (100)	Neg	0	10	0	0
			High (500)	Pos	10	0	0	0
Branan	2	50	Neg (0)	Neg	0	5	0	0
			Low (25)	Neg	0	9	1	0
			Medium (100)	Pos	10	0	0	0
			High (500)	Pos	10	0	0	0
Cozart	1	150	Neg (0)	Neg	0	5	0	0
			Low (25)	Neg	0	10	0	0
			Medium (100)	Neg	0	9	1	0
			High (500)	Pos	1	0	0	9
Envitec	3	100	Neg (0)	Neg	0	5	0	0
			Low (25)	Neg	0	10	0	0
			Medium (100)	Pos/Neg	7	0	0	3
			High (500)	Pos	6	0	0	4
LifePoint	3	100	Neg (0)	Neg	0	5	0	0
			Low (25)	Neg	0	10	0	0
			Medium (100)	Pos/Neg	10	0	0	0
			High (500)	Pos	10	0	0	0
OraSure	2	25	Neg (0)	Neg	0	5	0	0
			Low (25)	Pos/Neg	10	0	0	0
			Medium (100)	Pos	10	0	0	0
			High (500)	Pos	10	0	0	0
Securetec	1	100	Neg (0)	Neg	0	5	0	0
			Low (25)	Neg	0	10	0	0
			Medium (100)	Pos/Neg	8	0	0	2
			High (500)	Pos	9	0	0	1
Sun Biomedical	3	20	Neg (0)	Neg	0	5	0	0
			Low (25)	Neg	10	0	0	0
			Medium (100)	Pos	10	0	0	0
			High (500)	Pos	10	0	0	0
Ulti-Med	1	50	Neg (0)	Neg	0	5	0	0
			Low (25)	Neg	0	8	2	0
			Medium (100)	Pos	10	0	0	0
			High (500)	Pos	10	0	0	0

were effective at discriminating positive from negative samples at their cutoff. However, only the American Bio Medica, Branan, Envitec, and OraSure had cutoffs less than or equal to that suggested by SAMHSA (50 ng/mL). FP results were recorded with the Branan and Envitec devices at 25 ng/mL and Cozart at 25 and 100 ng/mL. FN results were recorded with the American Bio Medica product at 500 ng/mL and the Envitec at 100 ng/mL. The performance at the cutoff (for American Bio Medica, LifePoint, OraSure, and Securetec) was predictably mixed.

Methamphetamine performance

Table III shows the results from the methamphetamine eval-

Table IV. Summary of Cocaine Results

Device	Study Number	Device Cutoff (ng/mL)	Challenge (ng/mL)	Expected Results	TP	TN	FP	FN
American Bio Medica	3	200	Neg (0)	Neg	0	5	0	0
			Low (10)	Neg	0	10	0	0
			Medium (40)	Neg	0	10	0	0
			High (200)	Pos/Neg	0	0	0	10
Ansys	1	20	Neg (0)	Neg	0	5	0	0
			Low (10)	Neg	0	0	10	0
			Medium (40)	Pos	10	0	0	0
			High (200)	Pos	10	0	0	0
Branan	2	20	Neg (0)	Neg	0	5	0	0
			Low (10)	Neg	0	10	0	0
			Medium (40)	Pos	10	0	0	0
			High (200)	Pos	10	0	0	0
Cozart	1	30	Neg (0)	Neg	0	5	0	0
			Low (10)	Neg	0	10	0	0
			Medium (40)	Pos	0	0	0	10
			High (200)	Pos	1	0	0	9
Envitec	3	20	Neg (0)	Neg	0	5	0	0
			Low (10)	Neg	0	10	0	0
			Medium (40)	Pos	9	0	0	1
			High (200)	Pos	10	0	0	0
LifePoint	3	24	Neg (0)	Neg	0	5	0	0
			Low (10)	Neg	0	10	0	0
			Medium (40)	Pos	8	0	0	2
			High (200)	Pos	10	0	0	0
OraSure	2	200	Neg (0)	Neg	0	5	0	0
			Low (10)	Neg	0	10	0	0
			Medium (40)	Neg	0	10	0	0
			High (200)	Pos/Neg	1	0	0	9
Securetec	2	50	Neg (0)	Neg	0	5	0	0
			Low (10)	Neg	0	10	0	0
			Medium (40)	Neg	0	10	0	0
			High (200)	Pos	10	0	0	0
Sun Biomedical	3	30	Neg (0)	Neg	0	5	0	0
			Low (10)	Neg	0	1	9	0
			Medium (40)	Pos	10	0	0	0
			High (200)	Pos	10	0	0	0
Ulti-Med	1	30	Neg (0)	Neg	0	5	0	0
			Low (10)	Neg	0	10	0	0
			Medium (40)	Pos	3	0	0	7
			High (200)	Pos	10	0	0	0

uations. As shown, the cutoff varied from 20 to 160 ng/mL, and all devices were designed to detected methamphetamine. Only one-half of the devices had cutoffs less than or equal to that suggested by SMAHSA (50 ng/mL). FP results were rare, with the Branan and Ulti-Med devices having one and two each, respectively, at 25 ng/mL and Cozart having a single FP at 100 ng/mL. FN results were more common and recorded with the Cozart, Envitec, and Securetec devices at 500 ng/mL and Envitec and Securetec at 100 ng/mL. Performance at the cutoff (for American Bio Medica, Envitec, LifePoint, OraSure, and Securetec) was mixed.

Cocaine performance

The results from the parent cocaine evaluations are shown in Table IV. Device cutoffs varied from 20 to 200 ng/mL for cocaine, and only three devices had cutoffs less than or equal to that suggested by SMAHSA (20 ng/mL). FP results were recorded with the Anysis and Sun Biomedical devices having 10 and 9, respectively, when challenged at 10 ng/mL. FN results were far more common and were observed with 6 of the 10 devices. Only the Anysis, Branan, Securetec, and Sun Biomedical devices had no FN results. Performance at the device's cutoff of 200 ng/mL for American Bio Medica and OraSure accounted for the majority of FN results with these devices.

BE performance

Table V shows the results from the BE evaluations. Only those devices evaluated in the third study were assessed for BE performance. Two of the devices had cutoffs equal to 20 ng/mL, as suggested by SMAHSA. The American Bio Medica device cutoff was less than (12 ng/mL) and Envitec's was greater (400 ng/mL) than SAMHSA's proposed cutoff concentration. FP results were recorded with the Envitec when challenged at 200 ng/mL and with the Sun Biomedical at 10 ng/mL. FN results were uncommon. Two FN results were observed with the 200 ng/mL challenge when testing with the American Bio Medica device, and one FN was observed at 40 ng/mL with LifePoint. There were no challenges at any the cutoff of any device.

Opiate performance

Table VI shows the results of the opiate (morphine) evalua-

Table V. Summary of Benzoylecgonine (BE) Results

Device	Study Number	Device Cutoff (ng/mL)	Challenge (ng/mL)	Expected Results	TP	TN	FP	FN
American Bio Medica	3	12	Neg (0)	Neg	0	5	0	0
			Low (10)	Neg	0	10	0	0
			Medium (40)	Pos	10	0	0	0
			High (200)	Pos	8	0	0	2
Ansys	NA*							
Branan	NA							
Cozart	NA							
Envitec	3	400	Neg (0)	Neg	0	5	0	0
			Low (10)	Neg	0	10	0	0
			Medium (40)	Neg	0	10	0	0
			High (200)	Neg	0	8	2	0
LifePoint	3	20	Neg (0)	Neg	0	5	0	0
			Low (10)	Neg	0	10	0	0
			Medium (40)	Pos	9	0	0	1
			High (200)	Pos	10	0	0	0
OraSure	NA							
Securetec	NA							
Sun Biomedical	3	20	Neg (0)	Neg	0	5	0	0
			Low (10)	Neg	0	0	10	0
			Medium (40)	Pos	10	0	0	0
			High (200)	Pos	10	0	0	0
Ulti-Med	NA							

* NA = not applicable.

tions. The device cutoffs were less variable than with the analytes discussed previously and ranged from 10 to 40 ng/mL. All devices targeted morphine at a concentration less than or equal to that suggested by SMAHSA (40 ng/mL). FP results were only observed with the Envitec and Ulti-Med devices at 20 ng/mL. FN results were recorded with American Bio Medica, Anysis, Envitec, and Securetec devices. Performance at the cutoff (American Bio Medica, Branan, OraSure, and Securetec) was predictably mixed.

THC performance

Results from the THC evaluations are presented in Table VII.

Table VI. Summary of Opiate Results

Device	Study Number	Device Cutoff (ng/mL)	Challenge (ng/mL)	Expected Results	TP	TN	FP	FN
American Bio Medica	3	20	Neg (0)	Neg	0	5	0	0
			Low (20)	Pos/Neg	9	0	0	1
			Medium (80)	Pos	0	10	0	0
			High (400)	Pos	8	0	0	2
Ansys	1	40	Neg (0)	Neg	0	5	0	0
			Low (20)	Neg	0	10	0	0
			Medium (80)	Pos	8	0	0	2
			High (400)	Pos	10	0	0	0
Branan	2	20	Neg (0)	Neg	0	5	0	0
			Low (20)	Pos/Neg	10	0	0	0
			Medium (80)	Pos	10	0	0	0
			High (400)	Pos	10	0	0	0
Cozart	1	30	Neg (0)	Neg	0	5	0	0
			Low (20)	Neg	0	10	0	0
			Medium (80)	Pos	10	0	0	0
			High (400)	Pos	10	0	0	0
Envitec	3	40	Neg (0)	Neg	0	5	0	0
			Low (20)	Neg	0	0	10	0
			Medium (80)	Pos	8	0	0	2
			High (400)	Pos	10	0	0	0
LifePoint	3	40	Neg (0)	Neg	0	5	0	0
			Low (20)	Neg	0	10	0	0
			Medium (80)	Pos	10	0	0	0
			High (400)	Pos	10	0	0	0
OraSure	2	20	Neg (0)	Neg	0	5	0	0
			Low (20)	Pos/Neg	10	0	0	0
			Medium (80)	Pos	10	0	0	0
			High (400)	Pos	10	0	0	0
Securetec	1	20	Neg (0)	Neg	0	5	0	0
			Low (20)	Pos/Neg	4	0	0	6
			Medium (80)	Pos	10	0	0	0
			High (400)	Pos	10	0	0	0
Sun Biomedical	3	10	Neg (0)	Neg	0	5	0	0
			Low (20)	Pos	10	0	0	0
			Medium (80)	Pos	10	0	0	0
			High (400)	Pos	10	0	0	0
Ulti-Med	1	30	Neg (0)	Neg	0	5	0	0
			Low (20)	Neg	0	0	10	0
			Medium (80)	Pos	10	0	0	0
			High (400)	Pos	10	0	0	0

As shown in the table, device cutoffs varied dramatically from 15 to 600 ng/mL and none approached the suggested SMAHSA cutoff of 4 ng/mL. FP results were obtained with the LifePoint, OraSure, and Sun Biomedical devices. With the LifePoint and OraSure devices, the FP results were near their cutoff concentrations. However, with the Sun Biomedical device, FPs were obtained at all concentrations, including the drug-free challenge (see the manufacturer statement). FN results were recorded with American Bio Medica, Ansys, and Branan devices at the high challenge concentration of 100 ng/mL. Per-

Table VII. Summary of Cannabinoid (THC) Results

Device	Study Number	Device Cutoff (ng/mL)	Challenge (ng/mL)	Expected Results	TP	TN	FP	FN
American Bio Medica	3	25	Neg (0)	Neg	0	5	0	0
			Low (5)	Neg	0	10	0	0
			Medium (20)	Neg	0	10	0	0
			High (100)	Pos	7	0	0	3
Ansys	1	100	Neg (0)	Neg	0	5	0	0
			Low (5)	Neg	–*	–	–	–
			Medium (20)	Pos	0	10	0	0
			High (100)	Pos/Neg	4	0	0	6
Branan	2	100	Neg (0)	Neg	0	5	0	0
			Low (5)	Neg	0	10	0	0
			Medium (20)	Neg	0	10	0	0
			Medium/high (50)	Neg	0	10	0	0
			High (100)	Pos/Neg	0	0	0	10
Cozart	1	600	Neg (0)	Neg	0	5	0	0
			Low (5)	Neg	–	–	–	–
			Medium (20)	Pos	0	10	0	0
			High (100)	Pos	0	10	0	0
Envitec	NA†							
LifePoint	3	15	Neg (0)	Neg	0	5	0	0
			Low (5)	Neg	0	0	10	0
			Medium (20)	Pos	10	0	0	0
			High (100)	Pos	10	0	0	0
OraSure	2	25	Neg (0)	Neg	0	5	0	0
			Low (5)	Neg	0	10	0	0
			Medium (20)	Neg	0	8	2	0
			Medium/high (50)	Pos	10	0	0	0
			High (100)	Pos	10	0	0	0
Securetec	2	30	Neg (0)	Neg	0	5	0	0
			Low (5)	Neg	0	10	0	0
			Medium (20)	Neg	0	10	0	0
			Medium/high (50)	Pos	10	0	0	0
			High (100)	Pos	10	0	0	0
Sun Biomedical	3	100	Neg (0)	Neg	0	0	5	0
			Low (5)	Neg	0	9	1	0
			Medium (20)	Neg	0	0	10	0
			High (100)	Pos/Neg	10	0	0	0
Ulti-Med	1	> 100	Neg (0)	Neg	0	5	0	0
			Low (5)	Neg	–	–	–	–
			Medium (20)	Pos	0	10	0	0
			High (100)	Pos	0	10	0	0

* Not challenged
† NA = not applicable.

formance of the devices near their cutoff concentration was generally acceptable. However, FN results for the Ansys and Branan devices were observed at the devices' cutoff concentrations.

THC-COOH performance

Results from the THC-COOH evaluations are presented in Table VIII. The device cutoffs varied 15-fold from 2 to 30 ng/mL for THC-COOH, but bracketed the suggested SMAHSA cutoff of 4 ng/mL. FP results were obtained with the Branan, Cozart, OraSure, Sun Biomedical, and Ulti-Med devices. With the Branan, Cozart, OraSure, and Ulti-Med devices, the FP results occurred with the low control of 10 ng/mL. However, with the Sun Biomedical device, FPs were obtained with the Neg challenge. FN results were only recorded with the American Bio Medica device at challenge concentrations of 10 and 50 ng/mL. The performance of the devices was not challenged at their cutoff concentrations.

Table VIII. Summary of Marijuana Metabolite (THC-COOH) Results

Device	Study Number	Device Cutoff (ng/mL)	Challenge (ng/mL)	Expected Results	TP	TN	FP	FN
American Bio Medica	3	2	Neg (0)	Neg	0	5	0	0
			Low (10)	Pos	5	0	0	5
			Medium (50)	Pos	8	0	0	2
			High (200)	Pos	10	0	0	0
Ansys	1	6	Neg (0)	Neg	0	5	0	0
			Low (10)	Pos	10	0	0	0
			Medium (100)	Pos	10	0	0	0
			High (200)	Pos	10	0	0	0
Branan	2	20	Neg (0)	Neg	0	5	0	0
			Low (10)	Pos	0	0	10	0
			Medium (50)	Pos	10	0	0	0
			High (100)	Pos	10	0	0	0
Cozart	1	30	Neg (0)	Neg	0	5	0	0
			Low (10)	Neg	0	5	5	0
			Medium (100)	Pos	10	0	0	0
			High (200)	Pos	10	0	0	0
Envitec	NA*							
LifePoint	3	4	Neg (0)	Neg	0	5	0	0
			Low (10)	Pos	10	0	0	0
			Medium (50)	Pos	10	0	0	0
			High (200)	Pos	10	0	0	0
OraSure	2	25	Neg (0)	Neg	0	5	0	0
			Low (10)	Neg	0	0	10	0
			Medium (50)	Pos	10	0	0	0
			High (100)	Pos	10	0	0	0
Securetec	2	3	Neg (0)	Neg	0	5	0	0
			Low (10)	Pos	10	0	0	0
			Medium (50)	Pos	10	0	0	0
			High (100)	Pos	10	0	0	0
Sun Biomedical	3	3	Neg (0)	Neg	0	0	5	0
			Low (10)	Pos	10	0	0	0
			Medium (50)	Pos	10	0	0	0
			High (200)	Pos	10	0	0	0
Ulti-Med	1	15	Neg (0)	Neg	0	5	0	0
			Low (10)	Neg	0	1	9	0
			Medium (100)	Pos	10	0	0	0
			High (200)	Pos	10	0	0	0

* NA = not applicable.

BZP performance

Only two of the manufacturers had devices designed to detect BZPs, as shown in Table IX. BZPs are not regulated by SMAHSA, but the device cutoff concentrations were 25 ng/mL for American Bio Medica (as oxazepam) and 15 ng/mL for Cozart (as temazepam). No FP results were obtained and a single FN result was obtained with the devices. Device performance was not challenged at the cutoff concentrations.

Discussion

Numerous studies have been published that investigated the reliability of POC urine and OF drug testing devices (2). The general design of those studies has been to compare the device test results with those obtained from one or more alternate methods. There are several potential variables that should be considered in this type of comparison, many of which have not always been acknowledged in previous work (9). The study design should ensure that samples are analyzed by the different testing technique as contemporaneously as possible to avoid sample or analyte degradation. The target analyte, specificity, and cross-reactivity of each immunoassay test should be considered. The performance of the device at its cutoff also needs to be considered. In our evaluations, it was assumed that, if an analyte was fortified at a concentration greater than or equal to the device cutoff, the device should test positive. This assumption was somewhat conservative because, theoretically, at the cutoff one would expect the device to alternatively test positive and negative for 50% of the challenges, respectively. Also, when analyzed by MS, some challenges were less than their targeted concentration (Table I). However, there was also a variability in the MS analyses, such that control samples, with concentrations at or near the device cutoff, might have had "true" concentrations above, equal to, or slightly below the device cutoffs. Unfortunately, drawing meaningful conclusions from evaluations given these myriad variables can sometimes become quite complex and subject to reporter discretion, especially if the limitations of the study are not fully divulged. However, if it was assumed that a device should have tested positive only if the MS determined concentration of the challenge was greater than or equal to the device cutoff, it would not have changed the findings for amphetamine and methamphetamine (with a single exception). When testing with OraSure at its cutoff, the 10 TPs would have been 10 FPs. The performance of OraSure at its cocaine cutoff of 200 ng/mL would have improved from one TP and nine FNs to one FP and nine TNs. In all studies, the opiate 20 ng/mL challenge quantified less than 20 ng/mL (range 18.6 to 19.6 ng/mL), which would have affected the interpretation of the American Bio Medica, Branan, OraSure, and Securetec data. Perhaps the most problematic data were those of the cannabinoids because the control challenge concentrations varied from their target more

Table IX. Summary of Benzodiazepine (BZP) Results

Device	Study Number	Device Cutoff (ng/mL)	Challenge (ng/mL)	Expected Results	TP	TN	FP	FN
American Bio Medica	3	25 (oxazepam)	Neg (0)	Neg	0	5	0	0
			Low (12.5)	Neg	0	10	0	0
			Medium (50)	Pos	10	0	0	0
			High (250)	Pos	9	0	0	1
Ansys	NA*							
Branan	NA							
Cozart	1	15 (temazpam)	Neg (0)	Neg	0	10	0	0
			Low (2.5)	Neg	0	10	0	0
			Medium (10)	Neg	0	10	0	0
			High (50)	Pos	10	0	0	0
Envitec	NA							
LifePoint	NA							
OraSure	NA							
Securetec	NA							
Sun Biomedical	NA							
Ulti-med	NA							

* NA = not applicable.

than any other analyte. The 99% error in fortifying the low THC control in study three actually had no effect on the device's performance because none had a 5 or 10 ng/mL cutoff. However, with the higher control concentrations of THC, some results were potentially affected. The Ansys 100 ng/mL results would change from four TPs and six FNs, to six TNs and four FPs. The Branan 100 ng/mL results would change from 10 FNs to 10 TNs. The Sun Biomedical results at 100 ng/mL would deteriorate significantly from 10 TPs to 10 FPs (control assay = 87.5 ng/mL).

A significant finding from this and the previous evaluations was that, with the exception of the Sun Biomedical device, no negative control samples tested positive (no actual FP results). Again, consistent with the previous studies, the overall performance of the devices reported was variable by drug class and device (4,5). Most devices performed well for the detection of opiates. All devices targeted morphine and had cutoff concentrations at or below that proposed by SAMHSA. Most of the devices also performed well for the detection of methamphetamine and amphetamine, and approximately one-half had cutoff concentrations at or below that proposed by SAMHSA. Only three of the devices had a cocaine cutoff less than or equal to 20 ng/mL as proposed by SAMHSA, and a number of FN results were obtained when testing the medium and high challenges (American Bio Medica, Cozart, Envitec, LifePoint OraSure, and Ulti-Med). Performance for BE was only evaluated in study three. With the exception of Envitec, the cutoff concentrations met, or exceeded, those recommended by SAMHSA, but performance varied. Ten FPs were observed with Sun Biomedical with the low challenge. Although the devices still were not capable of detecting THC at 4 ng/mL as proposed by SAMHSA, sensitivities have improved from study 1 to study 3 (4, 5, and the current study). The best claimed sensitivity was that of LifePoint (15 ng/mL) and that device tested positive for all low challenges indicating that, perhaps, it could detect 4 ng/mL concentrations. The Sun Biomedical device also tested positive at low concentrations, but it showed an inability to discriminate between drug-free and fortified samples. Approximately one-half of the devices had cutoffs for THC-COOH that met, or exceeded that proposed by SAMHSA. As with the THC results, the Sun Biomedical device demonstrated an inability to discriminate between drug-free and fortified samples. With that exception, there was a trend toward an improved sensitivity and performance during the time course of the three studies. Only two of the manufacturers offered tests for benzodiazepines, and their sensitivities may need to be improved to detect these drugs that are highly protein bound and unlikely to distribute readily into OF.

In summary, the sensitivity and performance on POC-OF drug testing devices appears to be improving as manufacturers continue to refine their products. With the exception of the Sun Biomedical device, actual FP results were not encountered. Cutoffs are now approaching those recommended by SAMHSA for amphetamine, methamphetamine, cocaine, BE, opiates, and THC-COOH. The detection limits are improving for THC, but reliable detection of marijuana use in forensic investigations, such as driving under the influence and the workplace, remains problematic given that THC is the analyte most likely to be detected following use.

Note

M. Sun. Manufacturer quoted, "The OraLine IV was developed to achieve optimal test results using fresh oral fluid samples. The manufacturer does not recommend using altered or aged saliva samples, as these samples may have inconsistent flow patterns and yield unsatisfactory results with the test." OraLine Package Insert version F 2005 (2005).

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