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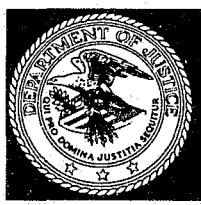

NATIONAL INSTITUTE OF JUSTICE
Research in Brief

Charles B. DeWitt, Director

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Testing Hair for Illicit Drug Use

by Tom Mieczkowski, Harvey J. Landress, Richard Newel, and Shirley D. Coletti

The rising popularity of cocaine since the mid-1980's gave new urgency to the long-standing interest in developing accurate ways to measure the incidence and prevalence of drug use. Accurate estimates of drug trends within an offender population are critical in the development of public policy and the efficient use of limited criminal justice resources.

To this end, a National Institute of Justice (NIJ) study among arrestees in an urban county jail compared tests of hair for signs of drugs of abuse with testing by urinalysis and with self-reports of drug use. The study also considered how applicable hair testing might be for monitoring the drug status of offenders. The study's results are summarized in this *Research in Brief*.

Monitoring offenders' drug use

At a variety of criminal justice system levels, monitoring the drug status of offenders is of considerable importance. Indeed, the use of drug monitoring to help determine particular criminal dispositions is already established in many local justice agencies,[1] and a person's drug use patterns and history often inform decisions related to placement, release and surveillance, and mandatory referral to treatment.

Urinalysis testing

Self-reported drug use has been the most widely used source of drug use data for the past three decades,[2] but since the early 1970's and the development of reliable and inexpensive immunoassay technology, urinalysis screening has become an important tool. Systems such as NIJ's Drug Use Forecasting (DUF) program, cofunded by the Bureau of Justice Assistance, proved the utility of urinalysis in acquiring accurate data among a criminal justice population.

Immunoassay technology, whether based on radioisotopes, enzymes, or fluorescence, enhanced our ability to measure illicit drug use. However, use of urine as the test medium imposes practical limitations on the frequency of collection when these techniques are applied. Opiates and cocaine are water-soluble and quite rapidly excreted, generally within 48 to 72 hours. Only marijuana, which is fat-soluble, has a slow, relatively long-term urine excretion rate (regular, heavy users can test positive for several weeks).

These characteristics suggest that urine-based data on cocaine and opiate use, derived from a single urine test, underestimate the true extent of opiate and cocaine use.

Use of hair testing

Use of hair as a test medium avoids the limitations of infrequent urine testing. Hair testing is relatively well established and uses a number of the same technologies as urine-based tests, including enzyme, radioisotope, and fluorescent immunoassays. The methodologies are identical; the distinction is in the medium.

Hair has several advantages over urine in testing for drugs of abuse:

From the Director

Testing for drug use is an essential element in the Nation's battle against drug abuse and drug-related crime. The Drug Use Forecasting (DUF) program established by the National Institute of Justice (NIJ) in 1987 relies upon urinalysis, a recognized indicator of drug use.

NIJ is seeking alternative techniques with complementary capabilities to strengthen detection and control of drug use. Hair testing may provide wider windows of detection and less opportunity for evasion.

Hair analysis offers unique advantages compared to other currently used drug testing methods. Hair retains drug components for longer periods, and drug use can be detected in hair for weeks or even months compared to the 2 to 3 days that cocaine or heroin can be detected in blood or urine.

As this *Research in Brief* points out, hair analysis also offers other advantages over other testing methods: for example, hair specimens can be readily obtained without the privacy problems associated with obtaining urine specimens or the invasiveness of drawing blood.

NIJ is currently conducting research into the effectiveness of the use of hair analysis, efforts that will explore the costs and operational issues involved in implementing this drug testing method in probation and parole settings.

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- Hair greatly expands the time window for the detection of an illicit drug. Urinalysis of a single specimen generally can detect the presence of drugs for a period of several days to a week or two, depending on the drug. Hair analysis can detect drug use for several months or more, depending on the length of the hair.

- Brief periods of abstinence from drugs will not significantly alter the outcome of hair analysis.

- Hair is relatively inert, easy to handle, and requires no special storage facilities or conditions. Compared with urine samples, it presents fewer risks of disease transmission.

- Having some hair snipped from the head is less invasive and embarrassing for most people than supplying a monitored urine specimen.

- Collecting comparable samples for repeat testing is easier with hair than with urine.

- Contaminating or altering a sample to distort or manipulate test results is much more difficult with hair than with urine. Preliminary research shows that even treating hair with a variety of strong compounds will not completely eliminate traces of illicit drugs.

Scientific basis for hair testing

Scientifically, the radioimmunoassay of hair (RIAH) rests on the fact that growing hair absorbs drugs and their metabolites into its structure from the circulatory system. Metabolites are the biochemical products of the breakdown of drugs within the body. For cocaine, both urine testing and hair testing detect the drug metabolites rather than the illegal drug itself.[3]

Once a drug metabolite is embedded in the hair shaft, a process which appears to occur while the hair is being formed in its follicle, the metabolite is very nearly permanent. As the hair shaft grows, it forms a longitudinal record of the compounds it has absorbed, including drugs of abuse.

Drug metabolites appear in detectable levels in hair approximately a week after ingestion.[4] Hair grows at an average rate of about half an inch every 30 days. The hair shaft can be cut into various lengths, allowing a "time line" analysis of drug consumption. Like a tape recording, a hair specimen can allow an analyst to construct a history of drug use. This "tape recording" presents an expanded time-monitoring window in contrast to single urine specimens collected at widely spaced intervals.

Additional research is needed to better understand such issues as the biochemical processes of the absorption of drugs and their metabolites into hair, dose-related cutoff levels, and the influence of external contamination. NIJ is currently conducting studies on these issues.

The Pinellas County project

Pinellas County (population 851,000), located on Florida's West Central coast, is the most highly urbanized and densely populated county in Florida. In fall 1989, officials from a local drug treatment provider (Operation PAR), the Pinellas County Sheriff's Office, and a researcher from the University of South Florida conducted a research project to (1) compare the results of hair testing, urinalysis, and self-reports of drug use among arrestees at the Pinellas County Jail, and (2) evaluate the implementation and utility of a hair-based drug monitoring system.

Funded by NIJ and the Pinellas County Sheriff's Department, the project was similar to NIJ's DUF program, and the method was essentially the same. Recent arrestees agreed to anonymous interviews and were tested for evidence of recent drug use. Using a modified DUF questionnaire, the project gathered self-reported drug-use data. Urine specimens were collected and analyzed. The research staff also collected hair samples from the arrestees and had those samples tested, using RIAH technology.

Between 250 and 300 arrestees who met the general eligibility conditions of the national DUF protocol were interviewed at the time of booking. Anyone arrested more than 24 hours before contact with the interviewer was excluded from the sample. In Pinellas, drug arrests constituted about 23 percent of the sample. Pinellas also included offenders brought in on drunk driving charges (DUI or DWI). Exhibit 1 provides a breakdown by type of crime for which those in the sample had been arrested.

The sample size and composition along with rates of donating both hair and urine are summarized in exhibit 2.

Exhibit 1. **Number of Arrestees, by Charge**

Drug sale, possession	70	Manslaughter	4
Driving intoxicated	51	Arson	3
Larceny	36	Family offense	3
Burglary	35	Homicide	1
Assault	17	Prostitution	1
Fraud	16	Damaged property	1
Forgery	10	Embezzlement	1
Auto theft	10	Kidnaping	1
Robbery	8	Resisting arrest	1
Stolen property	6	Rape	1
Sex offense	5	Other	17
Weapons	5		
		Total	**303**

Findings

Exhibit 3 compares the positive outcomes of hair analysis, urine testing, and self-reports by drug tested. The data show that the number of arrestees who self-reported they used cocaine or opiates within the past 30 days was not much greater than those who reported use within the past 48 hours. Both hair testing and urinalysis produced a larger number of positive results than did self-reports; more significantly, however, there was a substantially

greater proportion of positive hair assays than positive urine samples.*

Overall, the findings are consistent with the literature of recent years correlating self-reported drug use and the outcome of urine testing for drugs of abuse. One consistently finds patterns among arrestees of underreporting of personal drug use.[5] Other main findings can be summarized as follows:

- There were about four times more positive hair test results for cocaine than for self-reported use within the previous 30 days (46.5 percent vs. 11.2 percent).
- There were more than twice the number of positive hair test results for cocaine than positive urine tests (46.5 percent vs. 20.4 percent).
- There were 5 1/2 times more positive hair test results for cocaine than for self-reported use within the previous 48 hours (46.5 percent vs. 8.3 percent).
- There were 2 1/2 times more positive urine test results for cocaine than for self-reported use within the previous 48 hours (20.4 percent vs. 8.3 percent).
- There were nearly nine times more positive hair test results for opiates than for self-reported use within the previous 30 days (8.9 percent vs. 1 percent).

The outcomes for self-reports and one-time urinalysis testing display a clear pattern of underreporting. However, comparing urinalysis results to self-reported use within the previous 30 days reveals a relatively smaller amount of discrepancy.

In addition to urinalysis testing conducted by EMIT™ (enzyme multiplied immunoassay technique), urinalysis was conducted by a second method, fluorescence polarization immunoassay (FPIA). The analysis shown in exhibit 4 measured how EMIT and FPIA results compared with hair test results.

A total of 256 specimens were analyzed by radioimmunoassay of hair, and by EMIT and FPIA for urine. Of these, 153 had the same test result, whether positive or negative, when tested by RIAH, EMIT, and FPIA. The most important result is that 88 of the 256 specimens analyzed for opiates and cocaine were identified as drug positive by RIAH but negative by both urine testing techniques.

Of these 88 specimens, confirmatory testing was completed on 9 (10 percent) using a very accurate but expensive technique: gas chromatography/mass spectrometry (GC/MS). Budgetary constraints and hair specimen sizes precluded further confirmation tests. However, even though these tests used only the remaining portions of the hair samples, GC/MS detected cocaine in all nine specimens, indicating RIAH's potential to identify individuals who may be drug users but who probably have not taken drugs within a day or two of a urine test.

Seven specimens were positive by RIAH as well as by one of the two urine test methods. This difference is probably due to one of the urine tests being a "false-negative" result; that is, the drug metabolite was not present in sufficient quantity to be reliably identified as a drug-positive specimen.

Two specimens were negative by RIAH and negative on one of the urine tests but positive on another. This indicates a "false-positive" urine result; that is, the test result is reported as positive even though a drug metabolite is not truly present.†

Exhibit 2. **Sample Composition and Donation Rate**

		Gave urine		Gave hair	
		Yes	No	Yes	No
Race	White	210	13	219	4
	Black	63	12	69	6
	Hispanic	3	0	3	0
	Other	2	0	2	0
Sex	Male	253	21	266	8
	Female	25	4	27	2
	Total (n = 303)	**278**	**25**	**293**	**10**

Exhibit 3. **Comparisons of Positive Outcomes: Self-reports, Urinalysis, and Hair Analysis (n = 303)**

	Self-reported drug use		Assay results	
Have you used	in prior 48 hours	in prior 30 days	Urine (+)	Hair (+)
Any cocaine?	25 (8.3%)	34 (11.2%)	62 (20.4%)	141 (46.5%)
Opiates?	0 (0.0%)	3 (1.0%)	5 (1.7%)	27 (8.9%)
Marijuana?	47 (15.5%)	94 (31.0%)	120 (39.6%)	n/a

Quantitative analysis

The laboratory that tested the hair samples developed a tentative scale that categorizes specimen results into six groups based on the level of drug detected. In this "Psychemedics Scale," Group 1 RIAH results are the lowest detected level of an assayed drug, while Group 6 is the highest level. Group 0, no drug detected, is not reported here. Exhibit 5 shows the distribution of cocaine positive urine assays by FPIA and

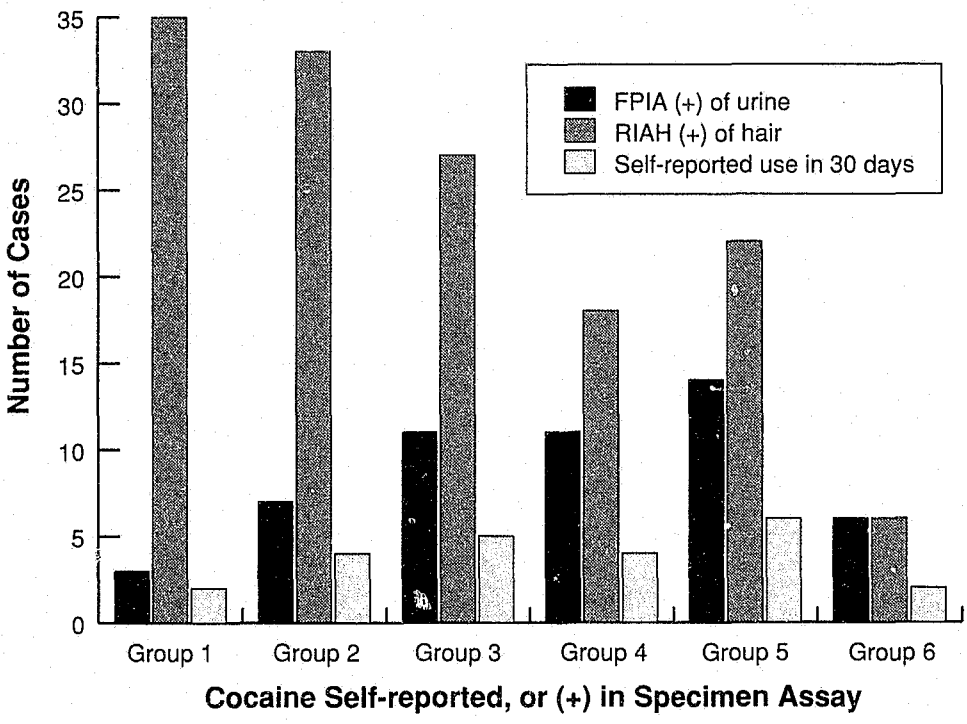
* This finding must be qualified. The hair samples were not assayed for marijuana because not enough hair was obtained to conduct assays for all desired tests.

† The data most difficult to explain are those that show 6 of 256 specimens (2.4 percent) negative by RIAH but positive by both urine-test methods. While there are several possible explanations, including the possibility that these were casual users, additional research is needed to explore the anomaly.

Exhibit 4. **Comparison of Urine and Hair Test Results for Opiates and Cocaine (n = 256)**

Urine results by FPIA and EMIT	Hair test results	
	(+)	(–)
Both positive (+)	40	6
Both negative (–)	88	113
One positive (+) and one negative (–)	7	2

Exhibit 5. **Distribution of Hair and Urine Assays Positive for Cocaine and Self-reported Cocaine Use, Grouped by Psychemedics Scale**



Example: Of the 35 persons testing hair (+), in Group 1, 3 of them were also (+) by urinalysis and 2 self-reported cocaine use.

Note: Group 1 has the lowest detected level by radioimmunoassay of hair (RIAH).
Group 6 has the highest detected levels.
Group 0 (none detected) is not shown.

self-reported cocaine use grouped by the Psychemedics Scale.

At low levels of cocaine use (Groups 1 and 2), RIAH appears to detect about 10 times as many drug users as urinalysis, based on currently accepted cutoff levels. Thus, a single hair test appears to have the potential of identifying many more drug users than would otherwise become known by a single urine screen.

At comparable levels, urinalysis techniques cannot differentiate between users who have recently consumed very small amounts of a drug and those who have consumed significant amounts but have had a more than 2- or 3-day lapse between ingestion and testing.

At moderate levels of cocaine use (Groups 3 and 4), RIAH appears to detect three to four times as many users as urinalysis. As the intensity of cocaine use rises, RIAH and FPIA urinalysis values come into close alignment, with negligible differences between them. This makes intuitive sense. Daily or near-daily users would likely be detected by any assay method, inasmuch as such users are virtually always excreting the drug or its metabolites.

Among the criteria used by the laboratory to assign each specimen an intensity-of-use scale number, the staff included judgments that reflected the extent to which the hair sample had been previously treated by commercial hair products. For this reason, the group numbers assigned reflect not only rigid cutoffs in nanograms per 10 milligrams of hair, but also the clinical judgments of the laboratory staff.

Conclusions

Radioimmunoassay of a single hair specimen detects more drug exposure than is self-reported or detected by a single urine test. The degree of this underreporting appears to vary to some extent with the type of drug. These research findings are most relevant for cocaine: It was detected in a relatively large number of subjects, and three disparate types of data—self-report, urinalysis, and RIAH—were available. Although more work must be done in establishing standard protocols and procedures for using RIAH as a routine screening device, sufficient information is available to support the utility of hair testing for detecting drugs of abuse.

Hair testing appears to have a number of advantages, including its less invasive method of collection, the extended time window of results, the stability of the medium, and the difficulty of tampering with the medium to evade positive test results. Some practical difficulties may occur in collecting specimens from individuals with short or no head hair.

RIAH's applicability in the monitoring of offender drug use may very likely permit a better determination of drug exposure over longer timeframes than is currently available using urine screening methods conducted less than twice a week. In fact, hair-based testing could be conducted with less frequency than would be required in order to achieve a comparable level of confidence with urinalysis testing.

Finally, hair testing appears to hold promise as a useful tool in drug epidemiology. Yet, a substantial amount of field testing is still required before it attains the degree of acceptance now accorded urinalysis testing. Nevertheless, the outcome of this project indicates that such testing ought to continue.

Notes

1. E.D. Wish and B. Gropper, 1990. "Drug testing by the criminal justice system." In *Drugs and Crime*, ed. Michael Tonry and James Q. Wilson, vol. 13 of *Crime and Justice: A Review of Research*. Chicago, University of Chicago Press.

2. T. Mieczkowski, 1990. "The accuracy of self-reported drug use: An analysis of new data." In *Drugs, Crime and the Criminal Justice System*, ed. R. Weisheit, Cincinnati, Ohio, Anderson.

3. W. Baumgartner, V. Hill, and W. Blahd, 1989. "Hair analysis for drugs of abuse." *Journal of Forensic Sciences* 34, 6: 1433–53.

4. E. Cone, 1990. "Testing human hair for drugs of abuse: Individual dose and time profiles of morphine and codeine in plasma, saliva, urine, and beard compared to drug-induced effects on pupils and behavior." *Journal of American Toxicology* 14: 1–7.

5. Mieczkowski, n. 2 above.

Tom Mieczkowski, Ph.D., is an assistant professor of criminology at the University of South Florida. Associated in this research were three officials of Operation PAR, Inc., a St. Petersburg drug treatment provider whose name stands for "Parental Awareness and Responsibility." Harvey J. Landress, ACSW, is deputy director for planning and development, Richard Newel is a program evaluator, and Shirley D. Coletti is president of Operation PAR.

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