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Introduction

When examining the risks of drug abuse, often the most compelling statistics relate to accidents, safety, and health. For example, according to the Federal Railroad Administration, errors attributed to substance-impaired employees caused 34 fatalities and 66 injuries in 48 separate incidents between 1975 and 1983.[1] In addition to these direct effects, however, there are also indirect effects, such as the impacts of drug use on worker productivity, health insurance costs, legal liability, and even employee-management relations.

Employees who are health-impaired due to substance abuse can be expected to exhibit lower productivity as a result of performance deficits, absenteeism, and higher turnover. One estimate of the financial impact of lost productivity due to substance abuse in the U.S. is $99 billion annually.[2]

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1   C. CORNISH, DRUGS AND ALCOHOL IN THE WORKPLACE: TESTING AND PRIVACY (1988). *See also,*50 Fed. Reg. 31,516 (1985).

2   M. ROTHSTEIN, MEDICAL SCREENING AND THE EMPLOYEE HEALTH COST CRISIS (1989); RESEARCH TRIANGLE INSTITUTE, ECONOMIC COSTS TO SOCIETY OF ALCOHOL AND DRUG ABUSE (1983); BNA SPECIAL REPORT, ALCOHOL AND DRUGS IN THE WORKPLACE: COSTS, CONTROLS, AND CONTROVERSIES 7 (1986) [hereinafter BNA

The health and safety risks of substance abuse can also be expected to impact insurance costs. Employees with substance-abuse problems, and their families, are more likely to use medical insurance, and the employees are more likely to file workers' compensation claims.[3] Estimates of the impact of substance abuse on health insurance premiums have been as high as $50 billion.[4]

Drug use has an undeniable effect on employee relations. Employee dissatisfaction can be caused by perceptions of increased workplace safety-and-accident-risks associated with substance-abusing colleagues, and by employee recognition that they are being required to carry a greater work burden to compensate for illness-and-accident-related absences of abusers. This employee dissatisfaction requires the commitment of a variety of extra resources to maintain satisfactory employee relations.

Finally, there is the issue of legal liability related to the wrongful acts attributable to employee drug use. Liability resulting from the activities of health-impaired employees extends to areas such as product defects, breach of contract, and injuries to employees and non-employees.

In an attempt to minimize the risks associated with drug abuse, many employers are resorting to drug testing of employees and job applicants. Requirements for the testing of certain types of government employees has accelerated the trend in workplace drug testing.[5] There

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SPECIAL REPORT]; D. MASI, DRUG FREE WORKPLACE: A GUIDE FOR SUPERVISORS (Bureau of National Affairs 1987).

3   ROTHSTEIN, *supra* note 2; MASI, *supra* note 2.

4   MASI, *supra* note 2; J. DRIZAY, FIFTY-BILLION DOLLAR DRAIN: ALCOHOL, DRUGS & THE HIGH COST OF INSURANCE 37 (P. Dilday-Davis ed. 1986).

5   CORNISH, *supra* note 1; Procedures of Transportation Workplace Drug Testing Programs, 49 C.F.R. Part 40; Glantz, *A Nation of Suspects: Drug Testing and the Fourth Amendment*, 79 AM. J. PUB. HEALTH 1427–1431 (1989); Dubowski, *The Role of the Scientist in Litigation Involving Drug-Use Testing*, 34 CLINICAL CHEMISTRY 788–792 (1988).

is some evidence that drug testing programs are useful in reducing the costs associated with the direct and indirect types of health and safety risks we have examined. For example, drug testing at Illinois Bell Telephone Company, and a subsequent rehabilitation program, is credited with leading to savings of $459,000 in reduced absences, accidents, and medical and disability benefits.[6]

The types of risks discussed thus far are the risks associated with having drug-impaired employees. However, there are also risks associated with drug-testing programs designed to eliminate such employees through identification leading to refusal to hire, or employee rehabilitation or termination. Ill-conceived or ill-conducted testing programs may result in legal liability for invasion of privacy, defamation, wrongful discharge, emotional distress/outrageous conduct, negligence, unreasonable publicity and false light, or other torts.[7] And, if falsely-accused workers are terminated, at the very least the employer loses the services of an acceptable employee.

Thus, if testing is not conducted or if the tests do not identify all drug abusers, then management faces certain risks arising from the activities of drug-impaired employees. On the other hand, if testing is conducted and some drug-free employees are falsely identified as drug users, then a different set of risks arises from potential legal actions of the falsely-accused workers, and from terminations of the falsely-accused drug-free employees.

In both cases, it is necessary to identify the costs of the events and their probabilities of occurrence. That is, to analyze the risks involved, it is necessary to identify: (1) the costs of events associated with drug-abusing employees; (2) the probabilities that employees will abuse drugs when testing is used, and when testing is not used; (3) the costs of

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6   DECRESCE, LIFSHITZ, MAZURA & TILSON, DRUG TESTING IN THE WORKPLACE (1989) [hereinafter DRUG TESTING].
7   CORNISH, *supra* note 1; ROTHSTEIN, *supra* note 2.

events associated with falsely accusing employees of using drugs; and (4) the probabilities of such false accusations.

This paper deals with the last of these four factors: the probability of falsely accusing employees of drug abuse. It is divided into sections addressing: the terminology to be employed, drug usage rates for employees in certain workplaces, laboratory proficiency studies, and Bayesian analyses of proficiency-study and drug-usage data. We review the concepts of accuracy that are most relevant and apply these concepts to data on drug usage by employees in certain workplaces, thereby identifying the potential problems that could occur in routine employee drug-testing programs. The clearest conclusion of this analysis is that seemingly accurate tests for abused drugs may, in fact, be inaccurate to a disturbingly high degree, under circumstances potentially present in many workplaces.

Terminology

When a specimen is tested for drugs, one of four outcomes must occur:

- true positive: specimen with drugs tests positive for drugs
- true negative: specimen with no drugs tests negative for drugs
- false positive: specimen with no drugs tests positive for drugs
- false negative: specimen with drugs tests negative for drugs.

Given that a specimen contains drugs, it must test either positive or negative. That is, the probability of a positive test result (given drugs are present) plus the probability of negative test result (given drugs are present) must equal 1.0. This may be written:

$$P(+|Drugs) + P(-|Drugs) = 1.0$$

In other words, when drugs are present in a specimen, the probabilities

of a true positive and a false negative must total one.

Likewise, a specimen without drugs must test either positive or negative. That is, when no drugs are present, the test must result in either a false positive or a true negative. This may be written:

$$P(+|NoDrugs) + P(-|NoDrugs) = 1.0$$

Now, let us turn to three measures of drug test accuracy that are used in the health-related professions: sensitivity, specificity, and predictive value. Sensitivity is the probability that a specimen with drugs will test positive. Thus, it is equal to the probability of a true positive, or:

$$Sensitivity = P(+|Drugs)$$

A second concept used in evaluating the accuracy of tests and labs is "specificity." Specificity is the probability that a drug-free specimen will test negative, or the probability of a true negative:

$$Specificity = P(-|NoDrugs)$$

Thus, sensitivity indicates the ability of the test to correctly report the presence of drugs, while specificity indicates the ability of the test to correctly report the absence of drugs.

In drug testing we are most concerned with incorrect results, that is, with false positives and false negatives. Sensitivity and specificity, however, are indirect indicators of the false result rates. That is, the probability of obtaining a false positive, $P(+|NoDrugs)$, is equal to (1 − Specificity). And, the probability of obtaining a false negative, $P(-|Drugs)$, is equal to (1 − Sensitivity). As can be seen, the higher the sensitivity rate, the lower the false negative rate. Likewise, the higher the specificity rate, the lower the false positive rate. What we would like for labs to do, therefore, is to maximize sensitivity and specificity, because this will minimize the false negative and false positive rates.

Another important concept, although not used in studies measuring laboratory proficiency, is the "predictive value" of a test. In the case of a drug test, the positive predictive value is the probability that the drug is

present in a specimen, given that the test yielded a positive result, that is, the posterior probability resulting from a Bayesian analysis:

Positive Predictive Value = P(Drugs|+)

For example, if 90 out of every 100 people testing positive for drugs truly have drugs in their systems, then the positive predictive value of the test would be 0.90. And, the probability that persons with positive test results truly do not have drugs in their systems would be 0.10. That is, if a drug test has a positive predictive value of X, then the probability is (1 − X) that a person who tests positive is, in truth, drug free. Thus, by maximizing the positive predictive value of a test, we also minimize the probability that specimens testing positive are truly drug free.

The importance of this concept is readily apparent, because it is the key to determining whether a positive result on a drug test provides sufficient evidence of drug usage. If, for example, positive results on a test are known to be untrue in one out of every ten cases, then a positive test probably would not be considered sufficient evidence of drug use. More importantly, if one wishes to protect the innocent from false accusation, then it is the positive predictive value of the test that is of prime concern.

Specificity, sensitivity, and predictive values may be stated as either probabilities or as percentages.[8] In this paper, we use both percentages and probabilities, as the context dictates.

Drug Usage Rates

Not surprisingly, estimates of drug usage vary widely. Because using drugs of abuse usually is illegal, but often is considered to be in style, self reports may not be too reliable. Likewise, many of those making pronouncements about the extent of drug abuse have strong

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[8] ROTHSTEIN, *supra* note 2; DRUG TESTING, *supra* note 6; B. ROSNER. FUNDAMENTALS OF BIOSTATISTICS (2nd ed. 1986).

incentives for showing that drug usage is at one extreme or the other. Finally, the characteristics of the group about which the estimates are made can cause wide variations, because drug usage varies significantly based on age, geographic location, and other variables. Considering these caveats, we provide several estimates of the extent of drug use in various workplaces.

The National Institute on Drug Abuse (NIDA), estimates, based on self-reports, that 7.0% of Americans over the age of 12 used some illegal substance at least once during the month prior to the NIDA 1988 household survey,[9] although this percentage drops sharply for people over 35 years old.[10]

A Department of Labor (DOL) report[11] looked at the workforce only, and based its estimates on the results of employer drug tests. For the industries surveyed in 1988, 8.8% of employees tested positive, with the employees of the smallest firms tending to have the lowest positive rates; furthermore, 11.9% of all job applicants tested positive.

The DOL report also provides data on positive test results in various industries. Wholesale trade had the highest employee positive rate, 20.2%, whereas retail trade had the highest applicant positive rate, 24.4%. Employee (applicant) rates for various segments of the economy are: wholesale trade 20.2 (17.4), retail trade 18.8 (24.4), services 3.1 (9.9), and communications and public utilities 7.8 (5.5). Notice that in some cases the positive rate for applicants is higher than for current employees, while in other cases it is lower.

In the 1986–87 period, tests of railroad workers involved in train

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[9] *Study Finds Overall Drug Reduction But Dramatic Rise In Cocaine, Crack*, 3 The National Report on Substance Abuse (Aug. 2, 1989) [hereinafter *Study*].

[10] *Study, supra* note 9; NATIONAL INSTITUTE ON DRUG ABUSE, U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES, DHHS Pub. No. (ADM) 87–1539, NATIONAL HOUSEHOLD SURVEY ON DRUG ABUSE: POPULATION ESTIMATES FOR 1985 (1987).

[11] BUREAU OF LABOR STATISTICS, U.S. DEPARTMENT OF LABOR, BUREAU, REPORT 760 SURVEY OF EMPLOYER ANTI-DRUG PROGRAMS (1989).

accidents revealed that 29 of the 759 people, or 3.8%, tested positive for drugs of abuse.[12] These were not random tests, of course, but tests administered under conditions where one would expect drug usage to be higher than usual.

The U.S. Department of Transportation randomly chose and tested more than 16,000 of its employees between July 1, 1988 and June 30, 1989. Of these, 99 tested positive, for a rate of 0.619%.[13]

Finally, results of tests of 3,600 employees of the U. S. Customs Service show a drug usage rate of 0.139%.[14]

Accuracy of Drug Testing

A topic no less subject to disagreement than the proportion of workers utilizing drugs is the accuracy of the tests for such substances. It appears that estimates of accuracy sometimes may be motivated more by the self-interest of the claimant than by sound empirical evidence. On the other hand, a variety of factors can cause large variations in accuracy, such as characteristics of the laboratories involved, concentrations of the drugs in spiked challenges, whether proficiency tests are open or blind, and other similar influences.

Because of the concerns over whether current testing correctly predicts the presence and absence of drugs, a number of studies have been conducted in which prepared samples have been sent to laboratories to determine the accuracy of their testing procedures.

Rather than review all of the laboratory proficiency studies, estimates from two articles published in the Journal of the American Medical Association (JAMA) are utilized.[15] We consider the studies on

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[12] *Drug tests are lousy*, 69 Labor 1–4 (Apr. 29, 1987).

[13] *DOT Did Not Obey HHS Rule, GAO Tells Senator in Report*, 3 The National Report on Substance Abuse (Nov. 8, 1989).

[14] *Court Backs Tests of Some Workers to Deter Drug Use*, N. Y. Times, Mar. 22, 1989, National ed., at 1.

which these articles are based to be the two best available to date. They were well-designed, with rigorous protocols, and were conducted by independent investigators. Also, very importantly, they include results of blind tests, where the laboratories were not aware that they were being tested.

The 1985 JAMA study reported the results of a series of blind and open proficiency tests for various drugs of abuse conducted in 1981 by the Centers for Disease Control in conjunction with the NIDA. The 1988 study reported on the blind and open proficiency tests of labs conducted by the NIDA in 1986–1987. Both studies used relatively large samples of labs with substantial experience in testing for abused drugs. Although it appears that these labs are likely to be better than most of the drug testing labs in the country, they are not likely to be representative of the very best either. That is, the results of these studies represent what could be expected from sound, well-established and experienced drug testing laboratories. Although the 1988 study may be more representative of recent experience, it can be expected that labs similar to those reported on in the 1985 study still exist.[16]

The results of open tests, those involving urine samples that labs knew were being used for quality checks, are not reported herein. Results of blind tests, those in which the labs did not know they were being tested, are much more representative of what one could typically expect if actual urine samples were submitted. Therefore, only blind test results are utilized herein.

Based on our calculations from data presented in the articles, the false positive rate (false positives/negative challenges), was 0.014 in the 1985 JAMA article, and 0.002 in the 1988 JAMA article, representing

[15] Hansen, Caudill & Boone, *Crisis in Drug Testing: Results of CDC Blind Study*, 252 J.A.M.A. 2382–2387 (1985); Davis, Hawks & Blanke, *Assessment of Laboratory Quality in Urine Drug Testing: A Proficiency Testing Pilot Study*, 260 J.A.M.A. 1749–1754 (1988).

[16] BNA SPECIAL REPORT, *supra* note 2.

findings on the proportions of drugless samples where drugs were incorrectly reported to be present. These statistics are estimates of P(+|NoDrugs), and are equivalent to specificity levels of 98.6% and 99.8%, respectively. The false negative rates, (false negatives/positive challenges) were 0.618 in the 1985 study and 0.311 in the 1988 study. These statistics estimate the P(−|Drugs), and reflect sensitivity levels of 38.2% and 68.9%, respectively.[17]

It should also be noted that the results from the 1988 study are based upon testing processes in which confirmation tests were conducted — that is, the initial positive result was confirmed by another test. The extent of confirmation testing in the 1985 study is uncertain. In fact, much of the difference between the rates from the two studies may be the result of confirmation testing.

Bayesian Analyses

Employers should take reasonable care to ensure that employees are not falsely accused of drug use due to questionable test results. But, if 99% of drug-free employees test negative, then many employers would conclude that reasonable doubt does not exist when an employee tests positive. Since the percentages of the drug-free specimens testing positive in the JAMA studies were 98.6 and 99.8%, it may appear that drug tests are accurate enough that reasonable doubt could not be established.

However, the results are not what they seem, as Bayesian analyses of AIDS test and transit drug test results have exhibited.[18] Consider the

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[17] A "negative challenge" is a specimen that does not contain a drug being tested for by the challenge, and a "positive challenge" is a specimen that does contain a drug being tested for by the challenge.

[18] Gleason, *Perceived Fairness in Risk Management: Bayesian Implications for AIDS Testing*, 9 RISK ANALYSIS 15–16 (1989); Gleason & Schweig, *Probabilistic Reasoning in Underwriting Decisions Regarding Routine AIDS Testing*, 42 J. AM. SOCY CLU & ChFC 86–91 (1988); Barnum & Gleason, *Reliability of Workplace*

first case in Table 1.

Table 1

Application of Bayesian Analysis to Drug Test Data

[1] Case	[2] State	[3] S_j	[4] $P(S_j)$	[5] $P(+/S_j)$	[6] $P(+/S_j)*P(S_j)$	[7] $P(S_j/+)$
1	Drugs	S_1	0.088	0.382	0.034	0.723
	No Drugs	S_2	0.912	0.014	0.013	0.277
	Total		1.000		$P(+) = 0.047$	1.000
2	Drugs	S_1	0.202	0.382	0.077	0.875
	No Drugs	S_2	0.798	0.014	0.011	0.125
	Total		1.000		$P(+) = 0.088$	1.000
3	Drugs	S_1	0.001	0.382	0.0004	0.028
	No Drugs	S_2	0.999	0.014	0.0140	0.972
	Total		1.000		$P(+) = 0.0144$	1.000
4	Drugs	S_1	0.088	0.689	0.061	0.968
	No Drugs	S_2	0.912	0.002	0.002	0.032
	Total		1.000		$P(+) = 0.063$	1.000
5	Drugs	S_1	0.202	0.689	0.139	0.986
	No Drugs	S_2	0.798	0.002	0.002	0.014
	Total		1.000		$P(+) = 0.141$	1.000
6	Drugs	S_1	0.001	0.689	0.0007	0.259
	No Drugs	S_2	0.999	0.002	0.0020	0.741
	Total		1.000		$P(+) = 0.0027$	1.000

Drug Testing: Organizational Implications, in PROCEEDINGS OF THE MIDWEST BUSINESS ADMINISTRATION ASSOCIATION 11–13, Chicago, IL, Mar. 1989; Barnum & Gleason, *Accuracy in Transit Drug Testing: A Probabilistic Analysis*, TRANSPORTATION RESEARCH RECORD, No. 1270, 1990, in Press.

As shown for Case 1 in columns 2 and 3 of the table, a urine specimen must either contain drugs (S_1) or contain no drugs (S_2). For this case, it is assumed that the probability is 0.088 that the urine specimens truly contain drugs, requiring that the probability be 0.912 (1 − 0.088) that they do not, as shown in column 4. These probabilities imply that 8.8% of the target population uses drugs; recall that this is the positive drug test rate for all current employees in the DOL survey. We use this rate as a prior probability for illustrative purposes only. Its use in this manner, of course, assumes high reliability in the DOL tests.

The next column, column 5, identifies the probability of the urine specimen testing positive for drugs when there truly are drugs present (0.382), and when there truly are no drugs in the sample (0.014). That is, $P(+|NoDrugs) = 0.014$, and $P(+|Drugs) = 0.382$. These probabilities are taken from the 1985 JAMA study.

The numbers in the sixth column are the products of the numbers in the two previous columns. That is, for the population being tested, the probability that a person truly is on drugs and tests positive for drugs is 0.034, while the probability that a person truly is not on drugs and tests positive for drugs is 0.013. Note that the sum of these two probabilities, denoted by $P(+)$ and equaling 0.047, is the probability of a positive test result.

Dividing each of the numbers in the sixth column by $P(+)$ yields the numbers in the seventh column, which are the probabilities of truly being in the particular states, given a positive test result. Thus, the probability that specimens that test positive will truly contain drugs is 0.723, meaning the test has a positive predictive value of 72.3%. And, the probability that specimens that test positive will truly contain no drugs is 0.277. That is, $P(Drugs|+) = 0.723$, and $P(NoDrugs|+) = 0.277$.

These same results can be developed more intuitively by considering a group of 1,000 employees who are tested for drug usage. If 8.8% of

the group are truly taking drugs, then 1000 * 0.088 = 88 will provide urine specimens that contain drugs, and the remaining 912 will provide specimens that are drug-free. Of the specimens containing drugs, 88 * 0.382 = 34 will test positive for drugs, and the remaining 54 will test negative. Likewise, of the specimens not containing drugs, 912 * 0.014 = 13 will test positive for drugs, and the remaining 899 will test negative. Thus, a total of 34 + 13 = 47 specimens will test positive for drug usage, whereas 13 of these 47 do not actually contain drugs. That is 13/47 = .277 (or 27.7%) of those testing positive for drug usage truly will be drug free.

Thus, more than one out of every four applicants testing positive truly will be drug free! With probabilities such as these, it is highly unlikely that a positive drug test would provide a preponderance of evidence that an individual was taking drugs, let alone meet higher levels of proof, such as clear and convincing evidence or evidence beyond a reasonable doubt. It would seem illogical, from the standpoint of good personnel practice, to eliminate an applicant on the basis of such unreliable evidence. Of course, the actual probabilities that a person who tests positive is not on drugs will differ under different assumptions about the percentage of the target population that is actually taking drugs, test specificity, and test sensitivity. Some different assumptions are presented in Cases 2 through 6. Recall that in Case 1 we assumed 8.8% of the population being tested actually had drugs in their systems. In Case 2 and Case 3, we use different estimates of the proportion of the target population on drugs. While the Case 1 estimate was based on results of tests of all job applicants in the DOL survey, the Case 2 estimate (20.2%) is based on test results for applicants in wholesale trade, and the Case 3 estimate (0.1%) is based on the aforementioned test results for U.S. Customs Service employees.[19]

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[19] *See supra* note 14.

In Cases 4, 5, and 6, we repeat the same three rates of drug usage (0.088, 0.202, and 0.001), but we substitute the 1988 JAMA article estimates of sensitivity and specificity, namely 68.9 and 99.8% (which represent, respectively, a false negative rate of 0.311 and a false positive rate of 0.002).

Thus, for Cases 1, 2, and 3, respectively, about one out of every four positives represent those who have not taken drugs when all employees are considered, one out of every eight positives represent drugless employees in wholesale trade, and 97 out of 100 positives represent drugless Customs Service employees. Under any of these circumstances, the positive test results have no value in proving drug use. If they are used in such a manner, great injustice will be done to many drug-free employees.

The error rates are lower for Cases 4, 5, and 6, where we use sensitivity and specificity rates from the 1988 JAMA article. In these three cases, 1 out of every 30 employees who test positive will be falsely accused, as will 1 out of every 70 employees in wholesale trade, and 3 out of 4 Customs Service employees. Although these results are better than those based on sensitivity and specificity rates from the 1985 JAMA study, there is still a relatively high error rate. And, because each of these scenarios may be applicable to some workplaces, error rates easily could be as high as the 97% figure from Case 3.

All of these six cases use sensitivity, specificity, and drug usage rates that may be found in some workplaces. However, because of the more rigorous standards required at the few NIDA-certified labs, it can be expected that such labs have higher accuracy rates. Thus, while our examples indicate what can happen in some circumstances, they should serve primarily to exemplify the process, and should not be considered to be representative of the expected results for any specific organization. That is, our results should serve to illustrate the types of inaccuracies

that might occur. Each organization must identify its own sensitivity, specificity, and drug usage rates, in order to develop the false conviction rate applicable to the organization.

Conclusions and Policy Implications of the Study

The clearest conclusion of this analysis is that allegedly-accurate tests for abused drugs may sometimes be inaccurate to a disturbingly high degree, under circumstances that may be present in many workplaces. Thus, both government regulators and employers should proceed slowly and with the utmost care in implementing drug testing policies, and they should consider the Bayesian implications of their proposed testing policies.

More specifically, results of employee drug tests should not be used as a basis for actions against employees, unless positive results are confirmed, e.g., with a gas chromatography/mass spectrometry test. However, remember that the false results from the 1988 JAMA study incorporated the use of confirmation testing, including the frequent use of the gas chromatography/mass spectrometry test, which is alleged to be highly accurate.

Note that the proportion of people falsely accused increases when a lower percentage of the population being tested is truly on drugs. Thus, positive results of employee drug tests conducted in environments where low drug usage rates could be expected (for example, tests of Customs Service employees) should be viewed with more skepticism than positive results in other environments (such as wholesale trade).

This paper has utilized accuracy data from good labs, where chain of custody was not a problem, and where there were no non-drug substances that could produce positive test results, since all challenges contained only the drugs to be tested for. If any of these factors come into play, then the reliability of the results will be even worse than those

presented.

The use of abused drugs by the nation's workers is a serious problem that must be addressed on many fronts. In the proper circumstances, urine testing is a valuable weapon in slowing drug use. However, while testing should be available, it should be used sparingly and with the utmost care. In particular, it is critical that appropriate accuracy information be developed, using data specific to each organization that utilizes drug testing. Otherwise, the potential benefits of the testing derived from improved health and safety may be offset by the losses growing out of the false positive results.