The Efficacy of Preemployment Drug Screening for Marijuana and Cocaine in Predicting Employment Outcome

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We present a prospective, controlled study of the association between preemployment drug screening results and employment outcomes in 2537 postal employees. For identified marijuana users, relative risk for turnover was 1.56 (95% confidence interval [CI], 1.17 to 2.08); accidents, 1.55 (95% CI, 1.16 to 2.08); injuries, 1.85 (95% CI, 1.30 to 2.64); and discipline, 1.55 (95% CI, 1.03 to 2.32). Their mean absence rate was 7.1% compared with 4.0% for nonusers. For identified cocaine users, relative risk for turnover was 1.15 (95% CI, 0.65 to 2.05); accidents, 1.59 (95% CI, 0.95 to 2.67); injuries, 1.85 (95% CI, 1.01 to 3.39); and discipline, 1.40 (95% CI, 0.62 to 3.17). Their mean absence rate was 9.8%. Our study shows that a preemployment drug screen positive for marijuana or cocaine is associated with adverse employment outcomes. The level of risk, however, is much less than previously estimated. This finding has important implications for the social, legal, and economic arguments for and against drug testing.

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OVER THE last 25 years, the United States has experienced about a 20-fold increase in the nonmedical use of drugs.[1] The economic and health costs of illicit drug use were reported to be $47 billion in 1980, including $22 billion in lost productivity.[2] Claims have been made that drug-abusing employees have three to four times as many accidents at work,[3,4] have five times as many compensable injuries, and use 16 times as much sick leave.[5] While none of these claims has been empirically substantiated, concern regarding the potential magnitude of the cost of drug abuse to business has focused attention on the problem of drugs in the workplace.[5-8]

For editorial comment see p 2676.

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Many corporations and government agencies have addressed fears of adverse occupational effects from drug abuse by implementing preemployment drug testing programs. A recent survey has found that 20% of workers are employed by companies with drug testing programs.[9] Therefore, it is surprising that, to our knowledge, only one previous peer reviewed report has addressed the efficacy of preemployment drug screening in predicting employment outcome.[10]

We present the results of an empirical evaluation of preemployment testing for marijuana and cocaine use among postal workers. We defined a cohort of employees whose urine samples were tested for marijuana and cocaine at the time of their preemployment examination. This was a blind study: the employees, hiring officials, medical personnel, and management officials did not know the results of the urine drug screens at any time during the study. The study was designed to detect and measure any association between the presence of marijuana and/or cocaine on a preemployment drug screen and employment outcomes such as employee turnover, absenteeism, accidents, injuries, and discipline.

METHODS

Cohort Definition

The study sample was drawn from all applicants for career (nontemporary) craft positions in the US Postal Service's Boston Management Sectional Center who were examined between September 24, 1986, and January 6, 1989. Craft employees, those covered by the Postal Service's major union contracts, accounted for all but 11 new employees.

From September 24, 1986, to January 6, 1989, we performed urine drug screens on 4964 applicants for postal employment. Three groups of applicants were excluded from the study. Seven applicants were excluded by our prior agreement with the postmaster of Boston to individually evaluate any applicant whose urine tested positive for opiates. We also excluded 42 applicants with a clinical history of nonalcohol substance abuse before the results of their urine drug screen were known. Finally, 56 applicants were excluded without knowledge of the results of their urine drug screens because data entry errors made it impossible to track their outcome variables. We also eliminated 60 Hispanics, of whom 24 were hired, and two Native Americans, of whom one

was hired, because the numbers were too small to permit meaningful analysis. This left 4797 study applicants who were offered jobs. The 2537 applicants who accepted the offers before January 28, 1989, were the cohort for our analyses. They were followed up, on average, for 406 calendar days.

Urine Drug Screen

Each applicant was asked to provide a urine sample and was informed that a portion of this sample would be sent for a drug screen. Only one applicant refused to give a sample and, therefore, did not complete the application process. The applicants provided the sample in the privacy of a single-person bathroom using a clean container provided by the laboratory. Samples colder than 32.8° C were rejected and another sample was requested. This was a rare event. Samples were labeled with the applicant's name and sealed in a plastic bag with the name, birthday, and social security number of the applicant marked. They were then refrigerated at 3°C and transported to the laboratory within 24 hours.

All urine drug screens were performed by a national clinical laboratory. Throughout the study, cannabinoids were evaluated with an enzyme multiplied immunoassay technique (EMIT) screening test with a detection level of 50 μg/L. All positive results on the screening test were confirmed by gas chromatography/mass spectroscopy at a level of 15 μg/L. Only results that were positive on confirmation were reported as such; all other results were reported as negative. At these levels, cannabinoids could be detected up to 4 weeks after the last use. Prior to December 26, 1986, the urine samples were tested for other drugs, utilizing thin-layer chromatography. Results positive for cocaine were confirmed using either EMIT or gas chromatography/mass spectroscopy. On December 26, 1986, the laboratory began screening for all drugs using EMIT.

Positive urine samples were confirmed by gas chromatography/mass spectroscopy. Again, only confirmed positive results were reported. The detection level for cocaine was 300 μg/L of its metabolite, benzoylecgonine; the confirmation level was 150 μg/L. At these levels, benzoylecgonine could be detected up to about 72 hours after the last use. The laboratory also screened for amphetamines, barbiturates, benzodiazepines, methadone, methaqualone, opiates, phencyclidine, and propoxyphene. The change in method from thin-layer chromatography to EMIT was made to increase the sensitivity of this screen for cocaine.

To assess the reliability of our laboratory and evaluate misclassification bias, we submitted a series of clean and spiked urine samples. For cannabinoids, we submitted samples spiked at two levels: 50 to 75 and 125 to 150 μg/L. The spiked samples for cocaine contained cocaine at 200 μg/L, benzoylecgonine at 400 μg/L, and methylecgonine ester at 400 μg/L. The clean urine samples were provided by one of the investigators after abstaining from all prescription and nonprescription drugs for longer than 1 month. The spiked samples were submitted to the laboratory in the same fashion as those from real applicants. The laboratory found all 20 (100%) of the clean samples to be drug-free. Of the 20 samples spiked with cocaine, the laboratory found 19 (95%) to be positive for cocaine metabolites. Of the 20 samples spiked with cannabinoids at the lower level, the laboratory found 18 (90%) to be positive for cannabinoids. At the higher level, the laboratory found all 10 samples (100%) to be positive for cannabinoids. In sum, specificity was 100% and sensitivity ranged from 90% to 100%, as expected. Thus, misclassification on the basis of laboratory inaccuracies is unlikely to have had a major effect on the results of this study.

In our analysis, we classified drug test results in four categories: (1) those negative for all drugs tested, (2) those positive for cannabinoids only, (3) those positive for cocaine only, and (4) those positive for other nontherapeutic drugs or multiple drugs. Group 4 represents a heterogeneous cluster of drug users. Results concerning this group should be interpreted with caution.

End Points

In analyzing our data, we considered separately each of the following end points: time to termination, absence rate, time to first accident, time to first injury, and time to first discipline.

Time to Termination.—Individuals whose employment with the Postal Service had ended were considered to have "turned over." Thirty-three employees transferred to postal divisions outside of Boston. We were unable to obtain further outcome data on these employees and eliminated them from the analysis on the date of transfer. We divided turnover into two categories: voluntary and involuntary. Voluntary separations included resignations, transfers to another federal agency, and deaths. Any turnover initiated by the Postal Service was considered involuntary. We used time to voluntary termination and time to involuntary termination as secondary end points.

Absence Rate.—We considered absenteeism a function of sick leave (SL), leave without pay (LWOP), and work hours:

$$\text{Absence Rate} = \frac{\text{SL Hours} + \text{LWOP Hours}}{\text{SL Hours} + \text{LWOP Hours} + \text{Work Hours}}$$

Since employees earned a fixed number of hours of sick leave per year, new employees with serious illnesses requiring prolonged time off from work often must take leave without pay. Our absence rate end point was constructed to account for this situation.

Time to First Work-Related Accident.—Accidents were tracked using Postal Service form 1769, on which all work-related accidents are reported. Of 503 employees who had accidents, only 74 had two accidents and 13 had three or more accidents. The sparseness of the multiple accident data led us to analyze the time to first accident rather than accident rates.

Time to First Work-Related Injury.—Injuries were tracked using Office of Workers' Compensation Program form CA-1, which postal workers use to report occupational injuries. Of 312 employees injured, only 41 had two injuries, and eight had three injuries. Therefore, we analyzed the time to first injury rather than injury rates.

Time to First Report of Disciplinary Action.—Our union contracts define a formal discipline process to address inadequate performance, progressing from letters of warning to termination.

The end points were followed up until March 11, 1989. In interpreting the analyses, we note that many of the end points are related to each other. In particular, the three termination end points are related by definition; injuries and accidents overlap; and injuries, accidents, and discipline occur more frequently among those with high absenteeism. On the other hand, high rates of absenteeism, injury, accidents, and discipline are not associated with termination, and discipline is not associated with injuries or accidents. Hence, our results do capture multiple outcomes, though some are, in part, redundant.

Confounding Factors

We recognized that a number of potential confounding factors might be associated both with the risk variables of marijuana and cocaine use and with the outcome variables of turnover, absenteeism, accidents, injuries, and discipline. Potential confounders included age at hire, gender, race, job classification, smoking status, exercise habits,

and alcohol use or abuse. We collected data on all of these factors except alcohol use and abuse. We omitted the latter for lack of feasible objective tests of the use of alcohol and the unreliability of self-reported data on alcohol use in the context of a preemployment examination.

Race was categorized as white, black, or Asian by the practitioner who performed the physical examination.

Job classifications included the following categories: letter carriers, postal clerks, letter-sorting machine operators, computer-forwarding system clerks, mail handlers who handle large sacks and carts of mail, maintenance workers ranging from janitorial to skilled technical workers, and special delivery messengers.

Smoking status was characterized as current tobacco smoker or current nonsmoker. Anyone who had smoked three or more cigarettes per day over the last month was considered a smoker. The rest of the subjects were considered nonsmokers.

Exercise status was grouped into three categories based on self-report. Nonexercisers reported no regular exercise. Aerobic exercisers reported exercising for 20 minutes or more on three or more occasions per week in such a way as to have reasonably been expected to raise their resting pulse to 75% of their predicted maximum (eg, running, bicycling, swimming). All others were classified as moderate exercisers.

Analysis

To assess whether a positive drug test result was associated with the outcome variables, we used the Cox proportional hazards model[11] from the SUGI supplement of the SAS statistical package.[12] Drug-negative hires were used as the baseline group, so significantly positive Cox regression coefficients for any of the drug-use groups indicate a significantly increased risk of termination or accident, and so on. Likewise, a significantly negative Cox regression coefficient indicates a significantly decreased risk of the end point.

A large proportion of the workers had a 0% absence rate. Hence, it was not possible to use linear regression with absence rate as the outcome variable. Instead, absence rates were grouped into three categories: (1) 0% absence rate (n = 648), (2) 0% to 3.0% (n = 935), and (3) greater than 3.0% (n = 954).

The SAS polychotomous logistic regression was used to determine whether membership in one of the drug use groups puts an employee at higher risk of being in one of the high absence categories. The coefficients from the regression can be transformed to give an odds ratio, interpreted, for example, as the risk of a drug user being in the higher absence categories relative to a nondrug user.

In addition, because the four drug-use groups are not balanced with respect to craft or demographic or behavioral characteristics, the following covariates were simultaneously entered into the Cox and logistic regression models: age, sex, smoking, race (black, white, or Asian), exercise (none, aerobic, or nonaerobic), and job classification. This allowed adjustment for imbalances and for confounding between these variables and the use of drugs.[13] Job classification was divided into two or three categories for each end point; the categories were chosen without knowledge of the drug test result but with knowledge of each end point to create strata in which the end point was relatively constant. Hence, the job classification covariate is a significant predictor by definition; it is used to correct for confounding and should not be interpreted in its own right.

All P values are two-sided and are considered significant at .05. Confidence intervals were calculated using the SEs provided by the SAS statistical package for each risk factor.

Table 1.—Screened Applicants by Drug Test Results and Hiring Status

Hiring Status	Drug Test Results, No. (%)				
	Negative	Marijuana	Cocaine	Other Drugs	Total
Not hired	1983 (87.7)	158 (7.0)	43 (1.9)	76 (3.4)	**2260 (100)**
Hired*	2229 (87.9)	198 (7.8)	55 (2.2)	55 (2.2)	**2537 (100.1)**

*Percentages do not add up to 100% due to rounding.

Table 2.—Demographic Characteristics of Study Population by Drug Test Results

Demographic Characteristics	Drug Test Results				
	Negative	Marijuana	Cocaine	Other Drugs	Total
Sample size*	2229	198	55	55	**2537**
Average time of follow-up, d	409	391	393	318	406
Mean age, y	30.5	28.4	27.8	29.8	30.3
Sex, No. (%)†					
M	1465 (65.7)	146 (73.7)	33 (60.0)	28 (50.9)	**1672** (65.9)
F	764 (34.3)	52 (26.3)	22 (40.0)	27 (49.1)	**865** (34.1)
Race, No. (%)†					
W	2008 (90.1)	175 (88.4)	46 (83.6)	50 (90.9)	**2279** (89.8)
B	124 (5.6)	22 (11.1)	9 (16.4)	4 (7.3)	**159** (6.3)
Asian	97 (4.4)	1 (0.5)	0 (0.0)	1 (1.8)	**99** (3.9)
Smoking, No. (%)†					
Yes	684 (30.7)	94 (47.7)	22 (40.0)	25 (45.4)	**825** (32.6)
No	1542 (69.3)	103 (52.3)	33 (60.0)	30 (54.6)	**1708** (67.4)
Exercise, No. (%)					
Aerobic	301 (13.8)	28 (14.1)	5 (9.1)	6 (10.9)	345 (13.6)*
Nonaerobic	736 (33.1)	58 (29.3)	18 (32.7)	14 (25.5)	**826** (32.6)
None	1182 (53.2)	112 (56.6)	32 (58.2)	35 (63.6)	**1361** (53.8)
Job classification, No. (%)					
Carrier	802 (36.0)	70 (35.5)	23 (41.8)	20 (36.4)	**915** (36.1)
Clerk	147 (6.6)	9 (4.6)	2 (3.6)	7 (12.7)	**165** (6.5)
Letter-sorting machine clerk	673 (30.2)	45 (22.8)	15 (27.3)	13 (23.6)	**746** (29.4)
Mail handler	277 (12.4)	43 (21.8)	9 (16.4)	7 (12.7)	**336** (13.8)
Mail processer	150 (6.7)	16 (8.1)	2 (3.6)	4 (7.3)	**172 (6.8)**
Other	**180 (8.1)**	**14 (7.1)**	**4 (7.3)**	**4 (7.3)**	**202** (8.0)

*Since some covariates were not available for a few employees, sample sizes for some covariates may not add up to the overall totals.

†These characteristics differed by drug category, $P<.05$ using a χ^2 test.

RESULTS

Table 1 describes the applicants who accepted postal employment and compares them with the applicants who had physical examinations but were not hired. Although only 52.9% of those examined began work, the table shows that there were no major differences in drug use between the groups. Of the new hires, 7.8% showed cannabinoids in their urine, 2.2% showed cocaine metabolites, and 2.2% showed other nontherapeutic drugs or multiple drugs. These rates are similar to the rates of positive urine samples found in 21 other postal sites across the country.[14]

Table 2 presents the distribution of the covariates included in our model,

divided by drug use group. Those with drug-positive urine samples were younger. Marijuana-positive urine samples were associated with being male, but cocaine-positive urine samples were associated with being female. Blacks were more likely to have positive urine samples than were whites. Cigarette smoking was associated with positive urine samples, but our exercise variable was not associated with positive urine samples. Finally, mail handlers had higher levels of positive urine samples than other employees. Thus, except for exercise, all these variables were potential confounders.

Table 3 shows measures related to our end points broken down by drug screen result. For absence rate, we present both the mean and median because the distribution was markedly skewed to the right. No adjustments were made for any covariate in this table.

Table 4 presents the results of the Cox proportional hazards models. Our six covariates and four drug categories were included simultaneously in the models. Those with marijuana-positive urine samples had increased risks of termination, accidents, injuries, and discipline compared with those with negative urine samples. Those with cocaine-positive urine samples had no increased risk of termination. They did show a pattern of increased risks of accidents, injuries, and discipline relative to those with negative urine samples, but only the risk for injuries was statistically significant in our data set. The distribution of the absence rates of marijuana and cocaine users is significantly different from the rate of nonusers.

Table 3.—Job Performance Measures Compared With Drug Test Results

Job Performance Measures	Drug Test Results, %			
	Negative	Marijuana	Cocaine	Other Drugs
Turnover*	19.4	29.3	21.8	23.6
Voluntary	12.7	15.7	14.6	10.9
Involuntary	6.4	13.6	7.3	10.9
Accidents*	19.2	26.3	27.3	16.4
Injuries*	11.7	18.2	20.0	9.1
Discipline*	8.6	14.1	10.9	18.2
Absence rate				
Mean	4.0	7.1	9.8	7.9
Median	1.8	2.8	3.8	3.7

*Reported percentages represent the simple overall proportion of employees for whom the end point occurred. Analyses adjusted for time and covariates are reported in Table 4.

COMMENT

The only previous study of the predictive value of preemployment drug screening found no "relation between drug use and job performance."[10] However, that study was too small to sustain its conclusion. It was based on only 180 employees of whom only 22 were positive for drug use. It found that 45% of the drug-positive employees left within 1 year while only 35% of the drug-negative employees left, a relative risk of 1.29. This result was not statistically significant. However, in this data set, the power of detecting a relative risk of 1.29 was only 11%. Thus, our positive

Table 4.—Multivariate Analysis Results

Risk Factors	Study End Points*													
	Turnover						Accidents		Injuries		Discipline		Absence	
	Total		Voluntary		Involuntary									
	Relative Risk (95% CI)	P	Relative Risk (95% CI)	P	Relative Risk (95% CI)	P	Relative Risk (95% CI)	P	Relative Risk (95% CI)	P	Relative Risk (95% CI)	P	Relative Risk (95% CI)	P
Drug test														
Negative	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Marijuana	1.56 (1.17-2.08)	.002	1.34 (0.91-1.96)	.14	2.07 (1.33-3.20)	.001	1.55 (1.16-2.08)	.003	1.85 (1.30-2.64)	.001	1.55 (1.03-2.32)	.03	1.56 (1.17-2.07)	.002
Cocaine	1.15 (0.65-2.05)	.62	1.20 (0.59-2.43)	.61	1.09 (0.40-2.96)	.87	1.59 (0.95-2.67)	.078	1.85 (1.01-3.39)	.048	1.40 (0.62-3.17)	.42	2.37 (1.37-4.08)	.002
Other drugs	1.29 (0.74-2.25)	.36	0.95 (0.42-2.37)	.90	1.67 (0.73-3.80)	.22	1.03 (0.53-2.00)	.93	0.89 (0.37-2.17)	.81	3.17 (1.67-6.05)	.004	1.45 (0.85-2.48)	.17
Sex														
M	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
F	1.33	.002	1.43	.002	1.17	.32	1.11	.31	1.47	.002	0.89	.42	1.22	.02
Age (per year)	1.02	.001	1.01	.046	1.03	.002	1.00	.68	1.01	.054	0.97	.002	0.96	<.001
Smoking														
No	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Yes	1.01	.96	0.94	.59	1.17	.31	1.29	.01	1.40	.004	1.54	.001	1.26	.01
Exercise														
None	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Aerobic	1.08	.56	1.22	.24	0.89	.65	0.85	.25	0.97	.85	1.00	.99	1.20	.13
Nonaerobic	1.00	.96	1.02	.89	0.94	.71	0.94	.56	0.95	.70	1.09	.56	1.00	.99
Race														
W	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
B	1.42	.03	0.92	.75	2.43	<.001	1.03	.87	0.69	.22	1.44	.13	0.67	.01
Asian	0.66	.17	0.60	.18	0.83	.69	0.56	.11	0.58	.24	0.36	.08	0.42	<.001
Job classification														
Category 1	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
Category 2	0.75	.01	0.82	.15	0.61	.01	0.48	.08	0.88	.73	0.09	.02	0.57	<.001
Category 3	. . .	. . .	. . .	. . .	. . .	. . .	2.82	<.001	2.41	<.001	0.31	<.001	. . .	. . .

*CI indicates confidence interval.

associations are not inconsistent with this negative study.

In our study, we have not been able to control for the possible confounding effect of alcoholism. A substantial body of literature suggests that alcohol abuse correlates with the abuse of other substances.[15] Other literature suggests that alcoholics have poor employment outcomes.[2] We did not obtain alcohol levels in the test urine samples. Also, we did not administer any validated alcoholism questionnaires because we did not think they would provide accurate information in the context of a preemployment examination. Thus, we cannot exclude the possibility that the associations we found between substance abuse and employment outcome were confounded by alcohol abuse. This would not necessarily affect the predictive value of preemployment drug testing as a selection device but might limit the generalizability of our results to populations with different patterns of alcohol consumption.

We must also consider the possibility of misclassification bias in this study. For the first 3 months of the study, thin-layer chromatography was used as the initial screening test for cocaine rather than an EMIT assay. To the extent that thin-layer chromatography is less sensitive than EMIT there may have been some false-negative results introduced. In addition, our blinded quality control suggests a false-negative rate of up to 10% and a lower rate of false-positive results using the EMIT tests. Thus, we believe that the magnitude of any misclassification bias would be very small and that the bias would be toward a null result.

In this study, we have shown that there are associations between the results of a preemployment drug screen and some subsequent measures of employment outcome. However, the pattern of associations for marijuana differs from that for cocaine. Specifically, the risk of termination, especially involuntary termination, is associated with a urine sample positive for marijuana. There is no similar association for cocaine (Table 4). Given that the estimated relative risk is close to 1.0 for those with cocaine-positive urine samples, this negative finding cannot be attributed solely to the smaller number of cocaine-positive employees. Our study was not designed to explain whether this difference is due to the pharmacologic characteristics of the drugs, to differing patterns of drug consumption, or to differing social characteristics of the drug users.

For the other end points the pattern of employment outcomes is the same for marijuana and cocaine: increased risks of accidents, injuries, discipline, and absenteeism. While the magnitudes of the relative risks are similar (Tables 3 and 4), the risks for accidents and discipline among those with cocaine-positive urine samples are not statistically significant, possibly because there were only 55 employees with cocaine-positive urine samples. Assuming that the baseline survival observed in our group of 2229 drug negatives is to be compared with survival in a group of 55 individuals after 2.5 years, the analysis would have 85% power if the relative risk were 2.0 for termination, 1.9 for accidents, 2.2 for injuries, and 2.5 for discipline. With continued follow-up of our cohort, these relative risks may become statistically significant.

The findings of this study suggest that many of the claims cited to justify preemployment drug screening have been exaggerated. Drug users have been reported to be involved in 200% to 300% more industrial accidents,[3,4] to sustain 400% more compensable injuries, and to use 1500% more sick leave.[5] We found that those with marijuana-positive urine samples have 55% more industrial accidents, 85% more injuries, and a 78% increase in absenteeism. For those with cocaine-positive urine samples, there was a 145% increase in absenteeism and an 85% increase in injuries. These findings could be used to reevaluate the estimates of the cost of drug abuse to industry and the cost-effectiveness of preemployment drug screening.[16] They may also have implications regarding the utility of corporate employee assistance programs.

Although this study does not discuss the complex ethical, legal, economic, social, and political issues[17-19] related to preemployment drug screening, we hope it will provide an empirical background for these discussions.

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