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DRUG-TESTING PROGRAMS AND THEIR IMPACT ON WORKPLACE ACCIDENTS: A TIME-SERIES ANALYSIS

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Abstract

Using a time-series design, this study examined the impact of introducing drug-testing programs on a workplace accidents. Using data from three separate hotels, we examined the impact associated with preemployment testing programs and the impact associated with programs that included both preemployment and random testing. The results of interrupted time-series analysis suggest that the introduction of preemployment testing did not affect the trend line for workplace accidents. However, the introduction of a program including both preemployment and random testing was associated with a significant reduction in workplace accidents resulting from a downward shift in the trend line for accidents. The implications for the design of drug-free workplace programs are discussed, as are the implications for future research.

It is well-established that drug abuse by employees exacts a substantial toll upon employers. Estimates suggest that substance abuse by employees cost employers over $100 billion annually because of its effect on absenteeism, workplace accidents, health care costs, and turnover [1, 2]. These financial estimates are

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supported by findings which show that employees who use illicit drugs are more likely than other employees to be absent, to be involved in accidents, to file workers' compensation claims, and to receive disciplinary sanctions [3-7]. It is also well-established that employers invest substantial resources to limit the harmful effects resulting from drug abuse by employees. Among firms with more than 500 employees, 65 percent rely on some form of drug-testing program [8].

Less is known, however, about the impact of employer efforts to control employee drug use. Specifically, little is known about whether the introduction of drug-testing programs actually results in improvements in human resource (HR) outcomes (such as workplace accidents) likely to be affected by drug use among employees. Indeed, there is substantial controversy about the effect associated with different types of testing programs [9]. For example, preemployment testing is widely used as a mechanism by which to control the effects of drug use. However, applicants have access to a number of mechanisms by which to interfere with the detection of drug use. As such, it is unclear whether preemployment testing significantly helps organizations avoid hiring those using illicit drugs. This, in turn, raises questions about whether testing is likely to improve HR outcomes (such as workplace accidents) that may be affected by employee drug use.

The purpose of this study was to examine how the introduction of drug testing affects workplace accidents—one key HR outcome likely to be influenced by employee drug use. Given that employers incur substantial costs as a result of employee drug use, it is appropriate for policies to be developed in an effort to control these costs. However, little empirical evidence about the effects of different types of testing programs is available to assist organizations in the development of policies regarding this issue. This study represents a first step in an effort to generate information about the effects of different types of testing programs on HR outcomes.

EMPLOYEE DRUG USE AND HR OUTCOMES

To understand how testing programs might affect HR outcomes such as workplace accidents, it is necessary to first examine the process by which drug use is likely to affect these outcomes. Sustained drug use has been found to affect health conditions and physical well-being. Sustained drug use has also been found to result in personality changes, changes in the value structure of the individual, and in antisocial attitudes and behavior. On-the-job drug use and after-effects of drug use have been found, under certain conditions, to affect the drug user's activation level as well as cognitive and physical skills [5, 10].

These findings regarding the impact of drug use suggest that substance abuse in the workplace clearly has the potential to affect workplace accidents as well as other HR outcomes [11]. With regard to workplace accidents, declining health conditions make those engaged in substance abuse more susceptible to on-the-job injury and illness. In addition, the negative effects of drug use on cognitive skills make it less likely that drug users will understand and follow instructions, making it more likely that accidents and injury will result [5]. The negative effects of drug use on physical skills also make accidents more likely. Loss of coordination and slower reaction times make accidents more likely. Finally, lower activation levels may increase carelessness in work, which is a clear predictor of workplace accidents [12].

While not the focus of this study, it is clear that drug use has the potential to affect other HR outcomes as well. Declining health is likely to affect ability to attend work and, thus, absenteeism. Productivity is likely to be affected as well if drug use results in the deterioration of cognitive and physical skills. Disciplinary action (including dismissal) is also more likely to the extent that employee performance and attendance suffers from drug use and to the extent that drug use results in increased levels of antisocial behavior. As such, while this study focuses on workplace accidents, other HR outcomes may also be affected by drug use and, in turn, by drug-testing programs.

DRUG TESTING PROGRAMS AND WORKPLACE ACCIDENTS

Drug-testing programs have the potential to affect HR outcomes such as workplace accidents through two different mechanisms. Effects can result from a testing program changing the composition of a firm's workforce or through changing the behavior of existing employees. Preemployment testing is designed to affect HR outcomes through its impact across time on the composition of a firm's workforce. By identifying those using illicit drugs in the applicant pool, organizations are able to reduce the number of new hires who are engaged in substance abuse [13]. Over time, as more hiring is done, the percentage of the workforce engaged in substance abuse should fall [11]. Similarly, random testing of current employees may also affect the composition of the workforce. By identifying current employees who are using illicit drugs, random testing programs allow the organization to reduce the number of drug users in its employ by terminating individuals who test positive [14].

Random testing also has the potential to change the attitudes and behavior of existing employees. With random testing, employees who engage in illicit drug use risk identification and termination [15]. This risk may be sufficient to discourage drug use among existing employees and thus may bring about a reduction in the level of drug use in a firm's workforce.

Both preemployment testing and random testing have the potential to affect the percentage of employees in the organization using illicit drugs. And given the evidence presented about the effects of drug use on employee behavior and attitudes, reducing the percentage of employees using drugs is likely to lead to fewer workplace accidents. Thus, we believe there is sufficient justification to hypothesize that drug-testing programs will lead to fewer workplace accidents.

With regard to preemployment testing, we argue that the testing program will affect the composition of the workforce but that this affect will be gradual in nature. Preemployment testing affects the composition of the workforce only as new hires are made. As a result, while we argue that introducing preemployment testing will reduce the number of accidents, we also argue that these reductions will occur gradually across time. Assume, for example, that the introduction of preemployment testing is being examined in an organization and that workplace accidents are tracked across time both before and after the introduction of testing. If a trend line for accidents is established for time periods prior to introduction of testing, we would hypothesize that the trend line after the introduction will be significantly different from the line prior to testing. Specifically, the trend line after testing will slope downward at a more rapid rate, slope upward at a less rapid rate, or switch to a downward slope following a pretesting line that either exhibited no trend or which sloped upward.

> Hypothesis 1: Significant differences in the slope of the trend line for accidents will be observed between time periods occurring before the introduction of preemployment testing and time periods following preemployment testing.

With regard to testing programs that include both preemployment and random testing, we again argue that the testing program will produce reductions in accidents and that these reductions will be observed only gradually across time. The effects of the preemployment test will, as noted above, be gradual in nature due to the gradual way it changes workforce composition. Similarly, random testing will not immediately identify and eliminate all drug users in the organization. Small percentages of the organization are selected for each test date and, thus, the entire organization will not be tested for a substantial period of time. Moreover, while the fear of job loss is likely to reduce drug use among current employees, that effect is unlikely to be immediate or abrupt in nature. Instead, this effect is likely to emerge gradually as employees observe random testing in operation and as they observe co-workers being terminated for testing positive. As such, we would hypothesize that programs which include both preemployment and random testing will affect accidents by producing an accident trend line in the posttesting phase that is significantly different from the trend line in the pretesting phase. Specifically, the trend line after testing will slope downward at a more rapid rate, slope upward at a less rapid rate, or switch to a downward slope following a pretesting line that either exhibited no trend or which sloped upward.

> Hypothesis 2: Significant differences in the slope of the trend line for accidents will be observed between time periods occurring before the introduction of programs which include preemployment and random testing and time periods following the introduction of testing.

METHOD

Research Design and Sample

The goal of this study was to examine how the introduction of drug testing affects workplace accidents. Thus, for each organization included in our sample, we employed a time-series design using data on workplace accidents collected on a monthly basis before and after the introduction of the testing program. Using statistical procedures, we then estimated a trend line for workplace accidents and examined whether the introduction of testing altered the trend line in the manner hypothesized.

In selecting organizations for inclusion in our study, our goal was to focus on firms within a single industry and within a single geographical region. Our reason for doing so was to enhance our ability to make comparisons across the different organizations studied. Additionally, given that OSHA requirements specify that records on accidents need only be kept for a limited period of time and given that we needed multiple data points after the introduction of testing, our goal was to focus on organizations that introduced testing between 1993 and 1995.

Guided by these objectives, we limited our sample to hotel organizations operating in Florida that introduced drug testing between 1993 and 1995. Working with the Florida Hotel and Motel Association, we identified member hotels that had drug-free workplace programs certified by the state of Florida. Certification was not possible unless, at a minimum, preemployment drug-testing was in place. Further, hotels with a testing program would be likely to seek certification because it provided for a 5 percent reduction in workers' compensation rates. Twenty hotels were identified through this process, and these hotels were contacted to determine when they introduced drug testing and whether they would be willing to participate in this study. Eight hotels introduced testing during the time period specified and, of these, three were willing to participate and had the necessary data covering the periods before and after the introduction of testing. From these three organizations, data were collected on workplace accidents experienced by the housekeeping staff from OSHA's Form 200. Hotels differ in the type of services offered and, thus, the composition of the workforce. Thus, to facilitate comparisons across the hotels examined, we focused only on the housekeeping staff. Data were collected on a monthly basis for both the preintervention and postintervention phases of the study.

The first hotel (Firm A) introduced preemployment testing in 1993. The testing program is supported by a formal policy. Firm A is located on the Florida panhandle and has over 1000 units. It offers conference facilities as well as resort activities. Data were collected for the time period between April 1990 and June 1995, with the intervention occurring in March 1993. During the 1990-1995 time period, Firm A hired 294 members of the housekeeping staff, while 296 left either voluntarily or involuntarily. Typically, Firm A employs fifty-five housekeeping staff members.

Firm B started a preemployment testing program in 1995. The program is supported by a formal policy and educational efforts aimed at both employees and supervisors. The property is located in central Florida and has over 1500 rooms. Meeting and banquet facilities are available on-site. Data were collected on accidents from January 1993 to December 1996, with the intervention occurring on January 1995. The facility typically employs 170 housekeeping staff members. During the 1993-1996 time period, over 350 members of the housekeeping staff left the organization, while a similar number of new hires joined the facility.

Firm C, located in southeastern Florida, introduced preemployment and random testing in 1994. The program is supported by a formal policy and education efforts aimed at employees. With regard to the random testing, five times per year (on days selected by the laboratory conducting the tests) a small percentage of employees are randomly selected for testing upon arrival at work. Since the testing dates are selected by the laboratory, employees are unaware of when the tests will occur. Since the program's inception, over ten employees have been terminated for testing positive for drug use. Firm C has 275 rooms and also provides conference and banquet facilities. Data were collected on accidents during the 1992 to 1996 time period, with the intervention occurring on July 1994. Firm C typically employs seventy housekeeping staff members. From 1992 to 1996, 170 staff members were hired into housekeeping positions, with a similar number having terminated their employment, either voluntarily or involuntarily.

Analysis

This study employed a time-series quasiexperimental design and used interrupted time-series analysis to assess the effect associated with the introduction of drug testing. A time-series design tracks one or more outcomes over some finite period of time. It attempts to ascertain whether there are reliable patterns of change in the outcomes. The primary use of interrupted time-series analysis (ITSA) is to discern whether an intervention interrupts the preintervention time-series pattern [16]. ITSA analysis develops a statistical model from the time-series data and fits the model to the postintervention phase to determine whether the actual data depart from what is predicted by the statistical model [17, 18, 19].

Imbedded in time-series data are three possible sources of variation that might obscure the results of an intervention on the posttreatment time-series data: 1) nonstationary trend or drift in the data; 2) seasonality patterns; and 3) fluctuations in the data not due to the intervention, trend, or seasonality.

Traditionally, ARIMA (p, d, q) time-series models have been used to deal with these sources of variation. The objective of ARIMA (p, d, q) is to understand the relationship between observations in a time-series and to explain how a disturbance in the series affects the trajectory of the series. It does so by identifying the nonstationary trend, seasonal patterns, and white noise and incorporates them into the model that represents the time-series data [19]. More specifically, three structural parameters are identified and included in the model.

The first parameter, p, is the order of the auto-regressive parameter that characterizes the direct relationship between adjacent observations. The second parameter, d, is the order of the differencing required before the time-series becomes stationary. To be stationary means there is no secular trend in the level of the time-series as they drift up or down across time [20]. The third parameter, q, is the order of the time-series, in which each value is determined by the average of the disturbance to the time-series [21].

The basic approach of the ARIMA (p, d, q) analysis includes: 1) obtaining estimates for the p, d, and q parameters and incorporating them into the time-series model; 2) adding dummy variables to represent the timing of the intervention and reestimating the time-series model to take the intervention into account; and 3) interpretation of the coefficient of the dummy variable as a measure of the effect of the intervention [21, 22].

Note, however, that the application of the ARIMA (p, d, q) modeling process has been criticized [16]. A serious problem facing researchers using ARIMA is the technique's sensitivity to the number of observations in the time-series. The inability to collect sufficient data from social settings limits the applicability of the technique. Leading authorities recommend collecting at least 50 to 100 observations both before and after the intervention to avoid Type I and Type II errors [22]. The model identification step in the ARIMA (p, d, q) process also introduces problems. Evidence suggests very high error rates among researchers when they estimate value for the parameters p, d, and q. Such errors in the estimates of these parameters lead to both Type I and Type II errors [23-25].

Concerns regarding the practical application of the ARIMA approach have led researchers to develop alternative approaches. Gottman proposed the Interrupted Time-Series Experiment which simplified the ARIMA (p, d, q) process by removing the autocorrelation requirements of ARIMA and assuming the post-intervention phase has a different intercept and slope than the preintervention phase [26]. The General Linear Model is used to determine whether there is a significant difference between the two slopes and intercepts [20]. This procedure estimates and controls for autocorrelation and then assesses whether there are statistically significant differences between the slope and intercept of the pre- and postintervention phases. This simplified procedure overcame the need for identifying the correct ARIMA (p, d, q) model but it did not eliminate the possibility that a short time-series would result in underestimates of the autocorrelation parameter, thereby increasing the likelihood of Type I error [25, 27].

This issue was addressed by Crosbie [27] and led to the development of a statistical program called ITSACORR. ITSACORR is based on the procedure developed by Gottman but inserts a different estimate of the autocorrelational parameter in the General Linear Model parameter matrix via linear constraints.

The resulting procedure controls for Type I and Type II errors and assesses the impact associated with an intervention. The preintervention and postintervention phase are represented by lines generated from the data, and ITSACORR compares the slopes and intercepts to determine change. Crosbie has shown that fifteen to twenty observations before and after the intervention could be used to obtain reliable and valid results using ITSACORR [25, 27]. This procedure, then, was used here to estimate the effect of introducing drug-testing programs at each of the organizations studied.

RESULTS

Table 1 displays the results of the interrupted time-series models estimated here using the ITSACORR program. As noted earlier, ITSACORR estimates and controls for autocorrelation, which allows for GLM procedures to estimate the intercept and slope for the pre- and postintervention phases. The omnibus F test is used to compare the two intercepts and the two slopes. *T*-tests are then used to examine separately the difference between the two intercepts and the difference between the two slopes.

As can be seen in Table 1, the omnibus F test is not significant in the model estimated for Firm A or for Firm B (the two organizations that introduced preemployment testing). Consistent with this, the *t*-tests for the difference between the intercepts and the *t*-tests for the difference between the two slopes are not significant. As such, no evidence was found to support the hypothesis that the slope of the trend line in the period prior to preemployment testing would differ

Table 1: Interrupted Time-Series Analysis Results

	Preemployment Testing		Random Testing
	Firm A	Firm B	Firm C
Omnibus F	.07	1.37	4.21**
Intercept			
Preintervention	.76	2.83	.07
Postintervention	.38	2.81	1.62
Change in Intercept: *t* Test	−1.38	−.02	1.31
Slope			
Preintervention	−.01	−.07	.21
Postintervention	−.01	−.09	−.04
Change in Slope: *t* Test	.03	−.19	−2.70**
Preintervention Observations	48	24	18
Postintervention Observations	56	24	30

*significant at $p < .05$
**significant at $p < .01$

from the slope of the trend line for the period following the introduction of preemployment testing.

By contrast, support was found for Hypothesis 2, in that the introduction of a program that included both preemployment and random testing appears to have affected the trend line for workplace accidents. As can be seen in the model estimated for Firm C, the omnibus F test is statistically significant at $p < .01$. Also, the t-test for the difference in the slope of the trend line between the pre- and postintervention phases is significant at $p < .01$. While the coefficient for the preintervention phase is positive, the coefficient for the postintervention phase is negative. The significant difference between these coefficients suggests that the introduction of a program that included both preemployment and random testing appears to have shifted the trend line for accidents downward during the postintervention phase. While the t-test for the difference between the intercepts was not significant, no hypothesis was made regarding this difference. Were the t-test for the intercept significant, it would suggest that an immediate and abrupt change in accidents occurred in association with the introduction of testing.

DISCUSSION

The costs imposed on employers by employee drug use argue for efforts to control substance abuse and its effects on the workplace [28]. Unfortunately, there is a dearth of information about the effectiveness of alternative methods for controlling drug use through testing. Our study represents an initial step to examine the effects of different drug-testing programs. Our findings suggest that random testing combined with preemployment testing significantly altered the trend line for workplace accidents in Firm C. No such effect in the trend line for accidents was observed with programs that included only preemployment testing.

The pattern of results observed here suggests the possibility that random testing must be included in a drug-testing program if the program is to affect employee behavior. Clearly, however, it would be premature to accept this conclusion based solely on this study. This is true for several reasons. First, while all of the organizations studied here were in the same industry and same geographical location, there may be other differences between the organizations that might account for the pattern of results. For example, it may be that management changes were introduced coincidental with the testing program at Firm C but not at Firm A or Firm B. This leaves open the possibility that management changes caused the reduction in accidents rather than drug testing. Second, it may be that the effect of preemployment testing takes longer to emerge due to the fact that change occurs only through new hires. This possibility cannot be eliminated, even though the organizations studied here had very high turnover rates and thus would have replaced much of their workforce with new hires during the postintervention phases examined here. Third, since we studied only accidents, we cannot eliminate the possibility that other employee behaviors would have been affected by preemployment testing. It is clearly possible that absenteeism and productivity would have been affected by preemployment testing even though accidents were not. Finally, the organizations studied here, by design, were from the same industry and same geographical location. As a consequence, the results obtained here may not generalize to other industries or to other locations.

The pattern of results obtained here raises important questions about the design of drug-free workplace programs. However, quite clearly, drawing practical implications must await further study. We believe that given the importance of the issues in question, further research is clearly warranted. Moreover, we believe the design and analytical approach used here offers a viable method for conducting research in this area. Given that drug-testing policies are introduced at discrete points in time, time-series models can be effectively used to isolate the effect of these policies. Using the approach reported here to study the effect of testing programs in other firms and in other industries and to study different employee behaviors is likely to generate valuable information for those responsible for drug-free workplace programs.

* * *

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