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Relationships Between Urinalysis Testing for Substance Use, Medical Expenditures, and the Occurrence of Injuries at a Large Manufacturing Firm[†]

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ABSTRACT

Drug use among employees continues to be a serious concern for American employers. Over 80% of the large employers in the United States use some form of testing to detect drug use, but this practice is controversial and the cost-effectiveness of drug testing remains

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largely unknown. This study begins an empirical investigation of the consequences of drug testing by estimating its impact on medical care expenditures and injury rates at a large manufacturing firm in 1996–1999. Multiple regression analyses of a pooled cross-sectional time-series data set were used to separate the impact of drug testing from other factors and to help find the optimal level of testing that was associated with minimum medical expenditures. Results indicated that medical expenditures would be minimized when 42% of the employees in a calendar quarter were drug tested. This implies that, on average, employees should be tested 1.68 times a year. The results also indicated that doubling the testing rate would reduce the odds of incurring any injuries on the job by over half, but the injury rate was already so low that this impact was very small. Hopefully the results of this study will inform the policy debate over drug testing by focusing on real data, as opposed to supposition or political considerations that seem to dominate many discussions.

Key Words: Drug testing; Economics; Evaluation.

INTRODUCTION

Drug use and its impact on the workplace continue to be a serious concern in corporate America (1–6). Catastrophic events such as the Exxon Valdez incident and the tragic 1986 Conrail accident in Chase, Maryland, momentarily focus public awareness of the human tragedy and the economic and environmental consequences that drugs and alcohol can wreak when used in the workplace, but drug and alcohol events occur each and every day.

Although the National Household Survey on Drug Abuse (7) reports that 65–75% of all current users of illicit drugs are employed, we do not have a clear picture of how that affects economic measures important in the workplace. The Office of National Drug Control Policy (8) estimated that the overall cost of drug abuse was $143.4 billion in 1998 and was projected to exceed $160 billion in 2000. Productivity losses were by far the largest component of these costs, which were estimated to be $98.5 billion in 1998 and projected to increase to $110.5 billion in 2000. However, examination of the available research does not clearly identify which components of productivity are affected. The National Academy of Sciences (9) noted that field studies have consistently linked substance use to absenteeism and accident rates but found that less consistent evidence linked substance use to other negative work behaviors. They further commented that the sparse empirical evidence available does not support the preventive effects of drug testing programs (p. 11). Nevertheless, other studies suggest that some costs

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can be reduced by screening out drug abusers. The U.S. Postal Service estimated that screening out drug-positive applicants saved $105 million in turnover and absentee costs during their employment tenure (10). Blank and Fenton (11) showed that sailors who tested positive for marijuana upon entry into the Navy Recruit Training Center yet were allowed to continue in service and be treated equally along with a drug-negative cohort were 2.5 times as likely to attrite from naval service before the end of their enlistment. This was a costly consequence, considering the Navy's heavy investment in training programs. In an early Swedish study (12) and a set of follow-up articles (13), Kristenson and colleagues note significant reductions in absenteeism and hospital days following serum tests for elevated gamma-glutamyltransferase and subsequent monitoring and counseling.

With respect to workplace safety, the results are equivocal. For the U.S. Postal Service, workers who tested positive in a preemployment drug screening were no more likely to become involved in an accident or have an injury than workers who tested negative (10). On the other hand, researchers at Utah Power and Light (14) did find a relationship between illicit drug use and accidents. Likewise, Miller et al. (15) found that, in a transportation company, alcohol and drug users had the highest risk of injury and were more likely to be hospitalized for that injury. With respect to the use of medical benefits, Salyards (16) found that U.S. Postal Service employees who tested positive for drug use before employment were 1.7 times as likely to file above-average numbers of claims and 1.9 times as likely to file above-average dollar amounts of claims, compared to those who tested negative. However, Crouch et al. (14) found that Utah Power and Light employees who tested positive in preemployment drug screens subsequently cost the company slightly less in medical claims than those who tested negative. Polen (17) found that there were no differences in medical histories or health costs of marijuana users compared to non-users.

Despite scarce or contradictory data in this area, drug-free workplace programs involving drug testing have become standard business practices in the American workplace over the last 15 years. A study conducted by the American Management Association (18) found that nearly 80% of surveyed firms had antidrug policies and tested employees for the illegal use of drugs. American businesses have invested substantial resources to implement these drug-free workplace programs.

The justification for these programs is based on their prevention and deterrence components. Perhaps the most compelling evidence of a deterrence effect comes from the military's substance abuse program. Both the anonymous survey results of drug use as well as the drug-positive data from workforce testing collected over the past 20 years have shown substantial declines in drug and alcohol use. The negative effects associated with these

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drugs have declined as well, as a result of an aggressive drug-testing policy and program. For example, use of any illicit drugs during the past 30 days was reduced from almost 29% in 1980 to less than 3% in 1995 (19). However, the military program is unusual in that, in addition to preemployment tests, military members are subjected to random drug testing as often as 2.5–3 times per year. Such a high testing rate might not be feasible, cost-effective, or even necessary in the private sector.

Indeed, the question of how much testing to do is often raised by private sector companies in the process of establishing a drug-free workplace program. Without clear objective evaluations of drug-free workplace programs that provide information as to what types of programs or interventions yield the greatest benefit for dollars invested (cost-effectiveness), their continued integration into business practice is in jeopardy.

Ozminkowski et al. (20) noted that the true cost-benefit ratio for drug testing remains unknown. Normand et al. (9) point out that the interest from a business perspective is on relatively short-term returns on investment at the organizational level, which would include reductions in the costs of diminished performance, accidents, health care costs, attrition, disciplinary actions, drug-related criminal behavior, etc. Some authors (21,22) cite other non-tangible effects, such as fostering public trust by assuring the public that drug use is taken seriously or that drug testing can enhance workforce morale.

To approach this issue and begin to address the controversies over drug testing from a scientific perspective, we examined the effects of different drug-free workplace programs, interventions, and initiatives on health care. Within the broader context of a managed care evaluation, the focus of this article is the study of a specific aspect of the overall problem, the effect of drug testing frequency on health care costs and accident rates in a manufacturing company.

Our research hypothesis was that a deterrent effect would be created by an increased frequency of random drug testing and that, in turn, would result in a decrease in substance abuse and related health care costs and accident rates. By focusing on relationships between the frequency of drug testing and changes in medical expenses and injuries among employees, we would be able to evaluate the strength of this association in a business setting.

METHODS

Sample

The sample for this research included all 1791 employees at 15 sites operated by a $200 million U.S.-based manufacturing company. All sample

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members were enrolled in the fee-for-service health plans sponsored by the company sometime during the 1996–1999 study period. Employees at four company sites were excluded from the study, either because they were covered by an HMO that could not produce person-level medical claims and expenditure data (at one site) or because their sites were too small (with fewer than 50 employees) and, therefore, unlikely to ever introduce a comprehensive drug testing program.

The Intervention: Drug Testing at Company Sites

The subject company implemented a drug-free workplace program in the early 1990s. The substance abuse policy implemented at this company has been described elsewhere (20) and is part of a comprehensive employee-relations initiative promoting a drug-free lifestyle for employees and their families. The basic components of the policy include:

- Drug testing for preemployment, reasonable cause, postaccident, and random testing.
- Discharge of an employee who tests positive for drugs of abuse with no legal explanation using those drugs.
- The opportunity to accept a managed care substance abuse treatment program under the supervision of professionals, for employees who self-disclose substance abuse prior to testing.
- A postsubstance abuse treatment follow-up consisting of a 2-year monitoring program verified by random drug testing, only for employees who self-disclose.
- An economic incentive available to employees who invest in their own health and well-being.
- Eligibility for disability pay if the employee is on a medical leave of absence for confined substance abuse treatment.
- Job termination if the employee returns to illegal drug use following substance abuse treatment.

Random testing and discharge for any policy violation were expected to deter the use of illegal drugs. Random drug testing was conducted at different rates in various company locations, varying from 0 to 95.6% per quarter, with some locations increasing testing rates over the study period. This allowed us to estimate relationships between changes in testing rates and the outcomes of interest, which included medical expenditures and injury rates.

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Random drug testing was conducted on urine specimens to detect the use of amphetamines, opiates, cocaine, marijuana, and phencyclidine (PCP). All drug-testing specimens were screened by a laboratory certified by the U.S. Department of Health and Human Services (DHHS) or through a forensically similar process using FDA-approved on-site tests [see Ozminkowski et al. (20) for details]. All urine specimens that screened positive were confirmed in a DHHS-approved laboratory and then reviewed by a fully qualified medical review officer. Employees with positive tests and no legal explanation for drug use were discharged.

Data Sources and Analytic File

By using information from medical claims and personnel files, an analytic file was created, which recorded medical expenditures, the occurrence of injuries, and other variables such as demographics, job type, and the number of different types of medical problems experienced by each employee with health care coverage. These variables were measured for each employee-month from January 1996 to December 1999. The 1791 employees in the sample contributed 44,885 person-months of data. The analytic file also included the drug-testing rates for the sites where each employee worked. The drug-testing data were available quarterly, not monthly, for each company site included in the analysis.

Analyses

Once the analytic file was created, descriptive studies were conducted to characterize the employees in terms of their demographics, health status, and testing rates and to present mean values for the expenditure and injury rates of interest. The expenditure variables of interest included total medical expenditures and expenditures for substance abuse and related services. The latter were defined on the basis of payments for claims with a diagnosis code for substance abuse treatment or treatment for related conditions, such as cirrhosis of the liver; gastrointestinal hemorrhage; alcohol poisoning; alcoholic psychoses; poisoning by narcotics, sedative hypnotics, or psychotropic drugs; and many others (the full list is available upon request). As it turned out, very few employees had any expenditures for substance abuse treatment or related problems. Therefore, the statistical analyses focused on the odds of having any medical expenditures, the magnitude of those expenditures, the odds of having any substance abuse or related expenditures, and injury rates.

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Estimating Relationships Between Testing Rates, Expenditures, and Injuries

The purpose of the main set of statistical analyses (other than the descriptive statistics noted above) was to estimate the impact of drug testing on 1) total medical expenditures, 2) the occurrence of any substance abuse or related expenditures, and 3) the occurrence of any injuries on the job. The following questions were of particular interest:

- Would increasing the drug testing rate result in higher, lower, or no change in medical expenditures or the occurrence of injuries?
- If there were an impact, would more testing continue to increase or decrease expenditures?
- Alternatively, would increased testing affect medical expenditures only up to a point, beyond which a different impact would be felt?

Multiple regression analyses were used to estimate the impact of testing on medical expenditures and the occurrence of injuries. The dependent variable outcome measures for these regressions included 1) a binary (yes or no) indicator of whether any medical expenditures were incurred in each month for each employee, 2) the natural log value of medical expenditures when they were incurred in any given month, 3) an indicator for whether any substance abuse treatment or related expenditures were incurred by each person in each month, and 4) an indicator for whether any work-related injury was suffered by each employee in each month of the study period.

The generalized estimating equations (GEE) procedure in SAS (i.e., PROC GENMOD) (23) was used to estimate the regression equations. The choice of regression strategy was dictated in part by the nature of the data. In particular, the regression analyses were complicated by two key factors:

- *Multiple observations of medical expenditures, injuries, and drug testing were available for each person.* Medical expenditures and injuries on the job were measured monthly for each employee, and drug-testing rates were measured quarterly at each employee's work site. These observations were recorded over a 4-year period spanning calendar years 1996–1999. Observations on the same person tend to be correlated, leading to bias unless the correlation is taken into account in the estimation procedure.
- *Many people had no medical expenditures in any given month.* Typically, only 70–80% of the beneficiaries of a health plan will use any medical care in any given year (24). The utilization rate at

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> the subject company was lower, with only about 50% of the employees having any medical expenditures in any given year. Due to seasonal differences in the pattern of health care use, monthly utilization rates could be much lower. Thus, in any given month, most employees had no medical expenditures, whereas others may have had quite high expenditures. Without some adjustment, ordinary least squares regression techniques can produce misleading results in situations like this (25).

The GEE procedure in SAS was used to deal with multiple expenditure observations available for each person. The GEE procedure was estimated as a two-part regression model that accounted for the fact that many employees had no expenditures in any given month.

The Changing Impact of Drug Testing on Medical Expenditures

The GEE regression analyses were designed to detect whether the impact of testing was constant, or whether it would be non-linear and eventually change direction once a certain optimum level of testing occurred. The rationale for a non-linear relationship between drug testing and medical expenditures is fairly easy to envision. As more testing is done, more drug users will be found with drugs or drug metabolites in their systems. According to company policy, these employees will be discharged and lose their insurance coverage. Concerns about this may help deter drug use. If their substance use prior to testing is associated with higher medical expenditures, reductions in substance use as a result of drug testing's deterrent effect should reduce overall medical expenditures.

This deterrent effect may not continue as testing rates increase further, however. There may be diminishing returns to higher levels of testing. For example, an employee might think that (s)he could avoid drug detection by a preemptory self-referral for evaluation and/or substance abuse treatment. The more individuals that take this action, the higher will be their expenses. Alternatively, drug-abusing employees who expect to be detected, but who do not elect to self-refer, may simply decide to use health care services before their employment termination results in the loss of insurance coverage subsequent to a positive urinalysis. In either case, it seems reasonable to expect that increasing the amount of drug testing will first diminish medical expenditures, due to a deterrent effect, but eventually medical expenditures may increase as evaluation and treatment expenses or expenses for other

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medical problems increase. If this is true, there must be some level of testing associated with minimum medical expenditures.

To be able to find the level of drug testing associated with minimum medical expenditures, testing rates at each employee location and the squared values of these testing rates were included as key independent (predictor) variables in the GEE expenditure regressions. To enhance the reliability of the results, the test rate was centered before it was squared, and the centered test rate and its square were included in the regression models.[a] Once the regressions were estimated, additional mathematics were applied to the regression results to account for the centering and to find the test rate associated with minimum health care expenditures.

The Mathematics

Because the regressions for total medical expenditures were estimated as a two-part system, the total impact of testing on expenditures can be found by multiplying the impact of testing on the probability of having any medical expenditures in a month by the magnitude of the testing impact on dollars once medical expenditures are incurred. The first part of the two-part regression process included a binomial regression analysis with a logit link to estimate the impact of testing on the probability of incurring any medical expenditures. For the sake of explanation, one can refer to this regression model as P(x), where P refers to the probability of having any medical expenditures and x refers to the centered testing rate. (Other predictor variables aside from the centered testing rate were included in the regression too; they are noted below but we ignore them here for the immediate purpose of explaining the mathematics of finding the optimal testing rate.)

The second part of the two-part regression process included the linear regression used to estimate the impact of testing on the natural log of medical expenditures in months when those expenditures were incurred. One can refer to this regression model as Y(x).

The total impact of testing on medical expenditures requires consideration of both parts of the two-part regression process, which must be multiplied together to obtain a total expenditure estimate as a function of x

[a]Centering refers to subtracting the mean value of the testing rate from each observation of it, thereby creating a testing rate centered on a mean of zero. The process of centering reduces the correlation between the test rate variable and its square. This may lead to more reliable regression results.

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(the centered testing rate). In our notation, this multiplication can be referred to as P(x)*Y(x). To find the optimal level of testing, we solved for P(x)*Y(x) many times, each time plugging in different values for x. We then noted the value of x associated with the lowest value of P(x)*Y(x). This will be the centered testing rate associated with minimum medical expenditures.

Once the minimum expenditure value was found and associated with a particular centered testing rate, we accounted for the centering by adding back the constant that was initially subtracted from each test rate observation to center the testing data in the first place. The value of that constant was 0.1687, reflecting an overall average testing rate of 16.87% per quarter. Once the centering constant was added back, we arrived at the optimal testing rate (as opposed to the optimal centered testing rate) that was associated with minimum medical expenditures.

Estimating the Impact of Testing on the Occurrence of Any Expenditures for Substance Abuse or Related Treatment

Once the medical expenditure analyses described above were completed, the focus switched to a study of the impact of testing on the odds of having any expenditures for substance abuse or related treatment. The rationale for considering a non-linear relationship between drug testing and the occurrence of any expenditures for substance abuse or related services is as follows. As testing increases, one might expect the odds of incurring any expenditures for substance abuse and related care to increase, if those who expect to be found positive self-referred to the doctor for evaluation and substance abuse treatment, to preempt the loss of employment and insurance coverage. Eventually, the odds of incurring such expenditures might top off and then decline, if the rate of positive tests begins to fall off. This might happen if drug users voluntarily leave the company rather than wait to be tested positive and then released.

If very few employees self-refer, one might expect to see little or no relationship between testing and expenditures for substance abuse treatment, or perhaps a small linear relationship that does not change direction as the amount of testing increases. In our case study, very few people self-referred or had any substance abuse or mental health expenditures (but some still did), so we allowed the statistical analyses the flexibility to show whether any linear or non-linear relationship existed.

Binomial regression analysis with a logit link was used to estimate how the centered drug testing rate, its square, and other variables influenced the probability of having any expenditures for substance abuse treatment or related problems. Once the equation was estimated, the impact of testing was

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found by taking the first derivative of the regression equation relative to the centered testing rate, setting it equal to zero, and solving for x (the optimal centered test rate). We then accounted for the centering process to find the level of testing (not centered testing) associated with the maximum probability of having any substance abuse treatment or related expenditures.

Estimating the Impact of Testing on Injuries

In contrast to the expenditure analyses, we expected the relationship between drug testing and injury rates to be linear. If drug testing has a deterrent effect on injury rates, one might expect those rates to decrease as testing continues.

Controlling for Confounding Factors

The GEE regression analyses were used to estimate the effect of increasing the drug testing rate because regression analyses can also control for the impact of confounding factors that influence the outcomes of interest. The confounding factors considered here included demographics (age and gender), job type (machine operators or laborers/handlers vs. all others), and health status (measured as of the number of unique major diagnostic categories (MDCs) reflected by the diagnoses included in the claims data for these employees). The count of MDCs roughly measured the number of different body systems affected by an employee's medical problems. The assumption made was that the higher the number of body systems affected, the more severely ill the employee would be.

Other variables were also considered but not used in the regression models because they occurred so rarely in the sample. For example, about 97% of the sample was Caucasian, making information about racial composition less compelling. Similarly, the vast majority of the sample members were either laborers or machine operators, so information on other job types was less useful.

RESULTS

The results from the descriptive analyses are shown in Table 1. This table characterizes the sample in terms of demographics, job type, tenure with the employer, and the drug testing rate. Table 1 notes that the average age of

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Table 1. Characteristics of employees (n = 1791).

	Mean
Drug testing rate per quarter (%)	16.87
Age	42.57
Male (%)	76.78
African American (%)	1.72
White/other (%)	98.28
Machine operators and laborers/handlers (%)	79.89
Mean years with company	10.14

the sample was about 43 and about 77% were male. Only about 2% were non-white race. About 80% were either machine operators or laborers/handlers. The average tenure with the company was about 10 years. The average drug-testing rate per quarter was about 17%.

Table 2 presents information on the expenditure and injury rate variables considered for the regression analyses. The mean medical expenditure per person-month over the study period was about $120 (measured in terms of year 2001 dollars to account for inflation). Fewer than 1% of the sample members incurred any mental health or substance abuse services in any given month, and average expenditures for substance abuse services were quite low over the entire study period (i.e., only about $0.52 per employee per month). The monthly injury rate per employee was about 0.6% during the study period.

Major findings from the regression analyses are noted in Table 3. This table shows that the centered drug testing rate and its square significantly influenced the odds of incurring any medical expenditures. The centered testing rate (but not its square) also significantly influenced the magnitude of expenditures (in log-dollars), once those expenditures were incurred.

Table 2. Expenditure and injury variables (measured per employee-month).

	Mean	SD
Medical expenditures	$119.93	$1216.68
Substance abuse expenditures	$0.52	$41.62
With any mental health expenditures (%)	0.80	8.90
With any substance abuse expenditures (%)	0.07	2.60
With injuries (%)	0.55	7.40

Notes: Expenditures are all in constant 2001 dollar.

Table 3. Regression results ($n = 1791$ employees contributing 44,885 person-months of data).

	Regression for odds of having any expenditures	Log (expenditures) for those with expenditures[a]	Regression for odds of having any substance abuse or related expenditures	Regression for odds of incurring any injuries
Intercept	−2.9533(<.0001)	4.2971(<.0001)	−8.8896 (<.0001)	−5.9749 (<.0001)
Centered testing rate in quarter	−0.3295(0.0002)	−0.3572(<.0001)	−1.0356 (0.3504)	−0.5856 (0.0532)
Centered testing rate squared	0.86(0.0025)	.5677(0.0921)	−7.8107 (0.0822)	
Age	0.0052(0.0096)	−0.0005(0.7942)	−0.0277(0.2229)	−0.0297 (<.0001)
Male	−0.1197(0.0362)	0.2776(<.0001)	0.8471(0.1992)	−0.0677 (0.6980)
Machine operators and laborers/ handlers	0.0034(0.9539)	0.0104(0.0636)	1.8296(0.3323)	2.20237 (<.0001)
Severity of illness (unique count of major diagnostic categories affected by illness)[b]	0.4857(<.0001)	0.1372(<.0001)	0.3276(<.0001)	0.0784 (0.004)

Notes: All models were estimates using General Estimating Equations procedures in SAS.
p-values are shown in parentheses.
[a] Expenditures were measured in 2001 dollars before regressions were estimated.
[b] Major diagnostic categories roughly correspond to body systems affected by illness.

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Table 3 also shows that neither testing rate variable significantly influenced the odds of incurring any expenditures for substance abuse or related treatment.

Finally, Table 3 provides evidence of a marginally significant ($p = 0.0532$) relationship between drug testing and injury rates. The results imply that doubling the testing rate would result in a 57% decline in the odds of having any injuries. However, the injury rate at this company was already quite low, so the probability (not the odds) of having an injury would decrease by only about 0.01% per month.

The Testing Rate Associated with Minimum Medical Expenditures

As noted earlier, we used a simulation based on the regression results to find the drug testing rate associated with minimum expenditures. An answer of 0.42 was obtained (i.e., a quarterly testing rate of 42% would be required to minimize medical expenditures).

DISCUSSION

The results from the simulation methods noted above showed that medical expenditures would be minimized when 42% of the employees in a calendar quarter were drug tested. Thus, to the extent that management values the importance of minimizing total medical expenditures, the results suggest that 42% of the employees should be randomly tested each quarter for the use of illicit substances. This implies that, on average, employees would be tested 1.68 times a year.

The results also indicated that doubling the testing rate would reduce the odds of incurring any injuries on the job by over half. Because the relationship between testing and injury rates was linear, higher testing rates would continue to reduce injuries. However, the injury rate at the company was already quite low, so reducing the odds by half would reduce the probability of incurring an injury by only about 0.01% per month.

This study was conducted at only one company and it is not clear how generalizable the results from these analyses may be. The demographic profile and health care utilization patterns for the employer examined in this study may not be similar to others. The specifics of this company's drug testing may differ from other companies as well, with regard to termination for a positive test or other factors. However, there is a key advantage to a case-study design

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involving just one company. Much of the variability that could have occurred if two or more companies were chosen for the study was ruled out by studying a single firm.

To address generalizability, we recommend that these analyses be replicated at other employers. For this particular employer, the results indicated statistically significant relationships between testing rates, medical expenditures, and injury rates. These relationships point to testing strategies that can be used to find substance users, minimize total medical expenditures, and reduce injuries as well.

It was interesting to find a U-shaped relationship between drug testing and medical expenditures. Perhaps testing beyond cost-minimizing levels only encourages unnecessary use of medical care, or more rapid use of care to avoid losing health insurance if employment is terminated due to a positive test. If this is true, testing about 42% of the population per quarter (or everyone an average of 1.68 times a year) may be sufficient to find employees in this case-study company who are at higher risk for medical complications from drug use.

Finally, more studies of the relationship between drug testing and other outcomes should be conducted. Such outcomes should relate to job turnover (voluntary or not), employee morale, theft, performance on the job, and absenteeism. Studies of these outcomes would yield more information on the economic and non-economic returns to workplace drug testing.

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