

# The Impact of Regulatory Enforcement and Consultation Visits on Workers' Compensation Claims Incidence Rates and Costs, 1999–2008

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**Background** *Studies of regulatory effectiveness have shown mixed evidence of impact of inspections on injury rates. We examine changes in workers compensation claims rates and costs for Washington employers having either an inspection, with or without citation, or a voluntary consultation activity.*

**Method** *We merge 10 years of enforcement and consultation activity with workers compensation records at the individual workplace level for stable firms with a single business location and at least 10 full-time employees. The change in claims incidence rates (CIRs) was estimated, controlling for workplace claims rate history, size, and industry. Separate analyses were performed for non-musculoskeletal and musculoskeletal (MSD) CIRs, claims costs and for enforcement activities with citation and without citation.*

**Results** *Enforcement activities are associated with a significant reduction in CIRs and costs. Similar results may also be attributable to consultations. Inspections were associated with a 4% decline in time-loss claims rates relative to uninspected workplaces. The effect strengthens when MSD claims are excluded. Citations for non-compliance are associated with a 20% decline in non-MSD CIRs relative to uninspected workplaces. There is also some evidence for a reduction in MSD claims rates beginning in the second year following inspection. Enforcement and consultation activity is associated with substantial decreases in claims costs.*

**Conclusions** *Enforcement activities make a significant contribution to reducing CIRs and costs. Similar results following consultations may also exist. Inspections with citations are more effective than those without. Claims rates for non-MSD injuries, related to hazards covered by specific standards, are more affected in the year following the visit, while those for MSDs take longer to begin falling. Am. J. Ind. Med. 55:976–990, 2012. © 2012 Wiley Periodicals, Inc.*

**KEY WORDS:** *regulatory effectiveness; injuries; enforcement; workers' compensation claims*

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## INTRODUCTION

In the four decades since the Occupational Safety and Health Act of 1970 (OSHAct) was passed in the United States the basic set of tools with which it has been enforced has changed very little. Under its provisions the Occupational Safety and Health Administration (OSHA), or the state agencies authorized to administer the program, is empowered to formulate specific regulations relating to health and safety, to enforce compliance with these rules through inspections and financial penalties, to offer

voluntary compliance assistance to employers requesting it, and to conduct other educational outreach activities with employers and workers with the goal of preventing injuries and illnesses.

The demand for public intervention in the workplace is based on the theory that, absent regulation, the level of injury prevention effort generated by the free market interactions of employers and workers would be below the socially optimal level. Given that labor markets are characterized by poor information about workplace hazard exposures on the part of both parties, inadequate wage premiums paid to workers as compensation for bearing risk, weak bargaining power among workers where low-cost labor substitution is available, limited ability of employers to realize and recoup the long-term financial benefits to up-front safety investments, inadequate experience rating in workers' compensation premiums, and incomplete workers' compensation insurance paid to workers injured on the job, public intervention in setting and enforcing standards is required [Dorman and Hagstrom, 1998; Silverstein, 2008].

It has long been recognized that several preconditions must exist for occupational health and safety (OHS) regulation and enforcement to reduce injury and illness rates. Standards need to directly address the most prevalent and burdensome hazards afflicting the workplace; rules and educational materials must be clearly written so that employers understand their responsibilities and how to achieve compliance; and regulatory authorities must be able to detect and punish violators [Gray and Scholz, 1993; Tompa et al., 2007]. Some skeptics of OHS regulatory effectiveness have based their critiques on studies of the politics of regulation. These studies emphasize the degree to which the regulators' ability to write or update appropriate standards is undermined by opponents through bureaucratic hurdles, extended timelines, or court challenges and initiatives to repeal regulations through the legislature or the ballot box. Industries affected by proposed rules may seek to "capture" the regulatory agenda by limiting the scope of rules, challenging the scientific basis for regulation, disputing the analysis of costs and benefits of the rule, and influencing legislatures to reduce agency budgets in order to deflect regulation or enforcement strategy [Shapiro and Rabinowitz, 1997]. This may lead to a lack of rules which adequately address the root causes of injury hazards, or to a proliferation of narrowly focused rules which must each be shepherded through the rule-making process.

Other critiques of OHS regulatory effectiveness center on organizational factors among both the regulators and employers. The ability of inspectors to detect non-compliance may be reduced due to the limited number of inspectors per workplace or a lack of experience with emerging industry settings and processes. Efforts to use past injury rates or claims history to target resources more

effectively may be partially thwarted by under-reporting on injury logs or by discouraging claim filing [Azaroff et al., 2002]. Even if hazards are detected, inspectors' ability to bring about compliance is limited by the weakness of available legal and financial sanctions under current statute. Finally, pressures on inspectors to find and cite non-compliance may lead to a focus on violations of specific rules not directly related to the predominant hazards causing injuries [Mendeloff, 1984; Gray and Scholz, 1993; Mendeloff and Gray, 2005]. An industry-level study of OSHA safety enforcement, industry compliance and injury rates found a strong link between OSHA enforcement activity and industry compliance, but only a weak link between non-compliance and injury rates [Bartel and Thomas, 1985]. Subsequent research on the separate impact of OSHA enforcement on compliance with standards, as opposed to their effect on injury rates, has shown effectiveness. A plant-level study of repeat enforcement visits from 1972 to 1983 found that the number of citations on the second visit fell by an average of about 50% as compared to the first visit [Gray and Jones, 1991]. Another study extended this analysis of violations through 2006 and found similar effects but with decreasing incremental results after the second visit [Ko et al., 2010].

Even where regulations are closely connected to major hazards, are clearly written, and inspectors are capable of detecting non-compliance, injury hazards may not be adequately addressed without an actual inspection taking place. This can happen if the firm underestimates the probability of an inspection and citation or if the expected penalties are too low [Gleason and Barnum, 1978; Ruser and Smith, 1990]. The argument is that if a firm is fully informed of all relevant regulations and of the penalties incurred if non-compliance is detected, then according to standard rational choice models, firms will increase safety expenditures to reduce hazards as long as the marginal costs of the additional resources used are less than the marginal benefit accruing to the firm from avoiding worker injuries and OSHA penalties. If compliance with OSHA rules occurs at a level of expenditure where marginal benefits exceed marginal costs, then the firm will exceed OSHA requirements. Otherwise it may be rational to be non-compliant. We cannot determine if "general deterrence"—where the existence of a rule combined with the threat of inspection is sufficient to elicit compliance—is successful without more information about the costs of compliance and expected penalties. It should also be noted that, under the assumption of a fully informed, profit-maximizing firm, "specific deterrence"—where the firm alters its behavior upon being inspected and penalized—should be negligible since the event of an inspection would not change the firm's information set or its calculations going forward [Gray and Scholz, 1993]. But if firms overestimate the costs of reducing hazards, or underestimate the

full cost of worker injuries, or if the decision-making processes within the firm are not well-described by the rational choice perspective, then the event of having a serious injury or an inspection with penalties may cause a significant change in managers' understanding of hazards present in the workplace and of the techniques available to prevent them as well as of the probability of adverse events. This may result in greater attention devoted to prevention efforts and, with time, in reduced injuries. It may also result in a greater response to a broad range of safety issues by employers than would be predicted by the rational choice model. Gray and Scholz [1993] propose an adaptive theory of manager behavior in which, because of limited information and a multiplicity of issues demanding manager attention, decision-making only focuses on safety issues when they arise out of an unexpected event such as a serious injury or an OSHA inspection. In this case, management may respond to the new issue by increasing effort across a broad range of safety issues rather than just by addressing the specific violations cited by OSHA. Over time these measures result in reduced injuries across a broad range of hazards, although the impact in the short run is likely to be small. Bartel and Thomas [1985] suggest, however, that citations and penalties increase compliance by shifting safety investments toward the cited violations and might even raise injury rates if this reaction preempts alternative safety steps that more directly address major hazards.

These conflicting predictions of management response to inspections are matched by the mixed results from a broad range of empirical studies that have been carried out on the deterrent effects of OSHA inspections. These studies take two main approaches: industry-level studies that seek to measure the strength of general deterrence arising out of the existence of OSHA regulations and the threat of detection and punishment; and establishment level studies that test the strength of a specific deterrence effect resulting from OSHA inspections on subsequent injury rates at the inspected facilities. Among the former, a study by Bartel and Thomas [1985] looked at OSHA safety inspections in 22 states from 1974 through 1978 at the three-digit SIC industry level. They find that OSHA visits have a strong effect on compliance activity in heavily inspected industries, but only a weak connection was found between compliance activity and reduced injury rates as reported by employers on OSHA injury logs. They also find that in industries where the marginal costs of compliance are high, levels of compliance are lower and penalties higher. Viscusi [1986] finds a similarly modest degree of impact on reported lost work-day injury rates in an industry level study from 1973 through 1983 [Viscusi, 1986]. These studies, by measuring the relationship between variations in enforcement intensity across industries to variations in injury rates, test the general

deterrence expectation that firms in industries with higher expected probabilities of inspection and penalty respond by increasing the level of compliance effort. These studies find that an increased inspection rate, though it results in higher compliance, does not lead to significantly reduced injury rates. But industry-level studies, by including both inspected and uninspected firms, can hide the incremental effects of specific deterrence [Gray and Scholz, 1993].

Among studies examining the specific deterrence effects of OSHA inspections, evidence is mixed that inspections alone are associated with reductions in injury rates, but much stronger for the proposition that inspections together with financial penalties reduce injury rates [Tompa et al., 2007]. A number of plant level studies conducted in the 1970s found only mixed or no impact of inspections on injury rates as reported on OSHA logs [Smith, 1979]. These studies, using a method developed by Smith, compare annual injury rates at workplaces inspected early in the year to those of workplaces inspected late in the year. This avoids comparing inspected plants to uninspected plants, which, because of OSHA targeting of high injury rate workplaces, introduces the possibility of endogeneity leading to bias in the measurement of inspection impact. The logic is that if inspections reduce injuries the impact will be greater where there is more time left to affect that year's injury rate. This method, however, may underestimate specific deterrence if the impact of an OSHA visit on management safety measures takes more than a few months to fully emerge.

Other plant-level studies do show a reduction in injuries. Among these, Cooke and Gautschi found, in a study of large manufacturing plants in Maine, that workplaces receiving the most OSHA citations experienced the greatest decline in lost work days due to injury over the period from 1970 through 1976 [Cooke and Gautschi, 1981]. Two related plant-level studies among manufacturing firms found support for specific deterrence effect as well as a more delayed general deterrent effect of inspections [Scholz and Gray, 1990; Gray and Scholz, 1991]. These studies also found the effects were larger for medium-sized establishments of 100–500 employees than for either smaller or larger plants. Finally, these studies found that while the size of penalty did not correlate with injury reduction, the intensity of inspection effort did. Inspections that only focused on recordkeeping were not effective, whereas more comprehensive health inspections were associated with reduced injury rates. In a reanalysis of this panel data set, Gray and Scholz [1993] estimated that inspections with citations induced a 22% decline in injuries reported on OSHA logs over following years. This was accompanied by a 20% decline in lost workdays. They note that since their model finds that perfect compliance with standards would have resulted in only a 10% decline in injury rates, there is support for the theory that

experiencing an actual inspection with penalties focuses management attention on safety concerns across a much broader front of issues beyond simply achieving compliance with cited standards [Gray and Scholz, 1993]. Similar results appear when injuries are measured by workers' compensation claims incidence rates (CIRs). In a workplace-level analysis of the impact of Washington State inspections in 1999 on the change in workers compensation CIRs it was found that, when controlling for establishment size, industry type and CIR history, an enforcement visit at a non-construction workplace was associated with a 22.5% decline in time-loss CIRs in the year following the visit, as compared to a 7% decline for workplaces without an inspection [Baggs et al., 2003]. In this 1-year study no evidence was found that OSHA consultation activity in the workplace had any statistically significant effect on time-loss CIRs. Difficulties in measuring the effectiveness of consultation activities, and thus their relative value as policy, have also been noted by the Government Accountability Office [GAO, 2004].

Two other plant-level studies also lend support to the idea that OSHA inspections with citations constitute what the authors call a "behavioral shock" event that leads to firms addressing hazards beyond just those related to the cited violations. Both studies estimate changes in rates by injury type among manufacturing firms and find significant impact even on injuries unrelated to specific OSHA standards [Mendeloff and Gray, 2005]. This is all the more surprising given the evidence that hazards for musculoskeletal disorders (MSDs), one of the most common and costly workplace injuries, receive relatively low priority among OSHA inspections with citations [Courtney and Clancy, 1998].

Lastly, an update of the Gray and Scholz study of 1993 found evidence that the injury reducing effects of inspections with penalties has declined over the decades from about 19% in the 1979 through 1985 panel, to 11% in the 1987 through 1991 group, and only 1% in the 1992 through 1998 group [Gray and Mendeloff, 2005]. This waning effect was seen across all size, industry, and inspection types. As before, this study found greater effects when inspections resulted in penalties.

The studies reviewed above have been largely focused on the manufacturing sector. While they provide strong evidence for effectiveness of inspections with penalties in manufacturing, there is much less evidence for effectiveness in other major industries. In particular in construction, where OSHA devotes a significant portion of its resources, few studies exist and evidence of impact is scant. In examining OSHA enforcement activity in construction during the period 1987 through 1993, one study of a sample of large construction firms found only modest evidence for compliance with standards despite a high probability of frequent inspection [Weil, 2001]. The study

also found that the standards cited most frequently did not address the major hazards causing injuries in construction. In the study in Washington State, only a modest, non-significant effect for enforcement visits was found at non-fixed-site industries such as construction [Baggs et al., 2003].

In this study, we propose to extend the analysis of OHS regulatory effectiveness in several ways. First, by examining not just inspections and penalties but also the impact of voluntary compliance assistance within the same analytical framework, we hope to get a more comprehensive view of the effectiveness of OHS activity in Washington State. Second, we examine not just larger firms in the manufacturing sector, but all single establishment firms with at least 10 full-time equivalent (FTE) employees across all industries. Third, to address the distinction between rule compliance and injury reduction and the differential impact of OSHA enforcement across injury types, we group injuries into two types: MSDs and all others. Since there are no specific standards written to address the major hazards causing MSDs, and because MSD CIRs may respond more slowly to a reduction in hazards, we believe a comparison of the separate impact of enforcement and consultation visits on non-MSD CIRs and MSD CIRs will be illuminating. Fourth, we pool together 10 years of OHS activities and CIRs in Washington State. Pooling across activity-years reduces the year-to-year volatility in CIRs and allows us to extend the analysis by stratifying the impact measurement by activity type (inspection vs. consultation), general industry grouping, injury type, injury severity (medical-only or lost workday cases), and whether or not citations were issued. We also examine the impact of OHS activity on workers compensation claims costs.

The objective of this study is to answer the following questions: (1) What impact did enforcement inspections and consultation visits have on claims incidence rates? (2) Did the impact differ by type of injury? (3) Was there any evidence for enforcement inspections that result in citations having a greater impact than that of enforcement inspection without citations? (4) What was the impact of enforcement inspections and consultation visits on claims costs?

## METHODS

With the exception of the federal government, and employers of railroad and long-shore workers, Washington State employers are required to obtain workers' compensation insurance through the Washington State Department of Labor and Industries (L&I) industrial insurance system unless they are able to self-insure. The L&I State Fund provides workers' compensation to approximately 160,000 employers and covers 66% of the employed workforce.

The remaining 480 (primarily large) employers self-insure and employ approximately one-third of the Washington workforce.<sup>1</sup> L&I maintains claims databases for both State Fund and self-insured employers, however, the information collected from self-insured employers is more limited, has incomplete claim costs and lost workdays data. L&I defines claims either as “non-compensable” (for which injured employees are reimbursed for medical treatment costs only) or “compensable” (for which both medical costs and wage-replacement benefits for lost work-days are paid). To qualify for definition as a “compensable” claim, the injury must have resulted in four or more lost work-days.

In addition to the state workers’ compensation system, L&I also houses the Division of Occupational Safety and Health (DOSH), the state OSHA plan enforcement and consultation agency. All data on enforcement and consultation activities, including employers visited and citations issued, are maintained in the WISHA Information Network (WIN) database. DOSH activity can thus be linked by employer account number to the employers’ workers’ compensation CIR (CIR) record, allowing a way to test whether the intervention is associated with a decrease in the time trend of claims.

The evaluation of 10 years of enforcement and consultation activities in this study begins as a series of 10 separate annual studies. Each annual study covers a 4-year time frame divided into three time periods: a 2-year pre-study period, a 1-year baseline period called the DOSH activity year, and a 1-year measurement period. For each period the number of claims, hours, and DOSH activity were extracted from the LINIIS and WIN databases for each state fund employer workers compensation account. In order to minimize uncontrolled influences and bias, all of the following inclusion criteria must be satisfied.

At the accounts level:

- (1) Accounts covered by the State Fund only.
- (2) Accounts with only a single business location. Note that this does not exclude businesses with multiple job sites as is typical in construction.
- (3) Accounts must have an average size of at least 10 full-time equivalent employees per year (FTE-YR) during the pre-study period to minimize CIR volatility.

And then, for inclusion in each of the ten 4-year studies:

- (4) Accounts must report hours each quarter throughout the 4-year study period associated with each baseline year.
- (5) Accounts must not have had any enforcement or consultation activity during the pre-study period.

A depiction of the selection process is shown in Figure 1. The eligibility criteria with the greatest impact on inclusion were those for the 10-FTE minimum size threshold and the 4-year account survival. For each selected account, CIRs, defined as the count of claims per 100 FTE, and DOSH activity were determined during the baseline period. Finally, during the measurement period CIRs were determined for each account and compared to those from the baseline period for various categories of DOSH activity. Accounts with DOSH activity in the “baseline year” (year 3 of each 4-year study) were categorized into either the inspection cohort or the consultation cohort. Accounts with no DOSH activity throughout the 4 years of each study were categorized into the No DOSH cohort.

It should be noted that over 93% of eligible accounts had no DOSH inspection at all over the entire study period. About 5% had only one inspection and about 2% had

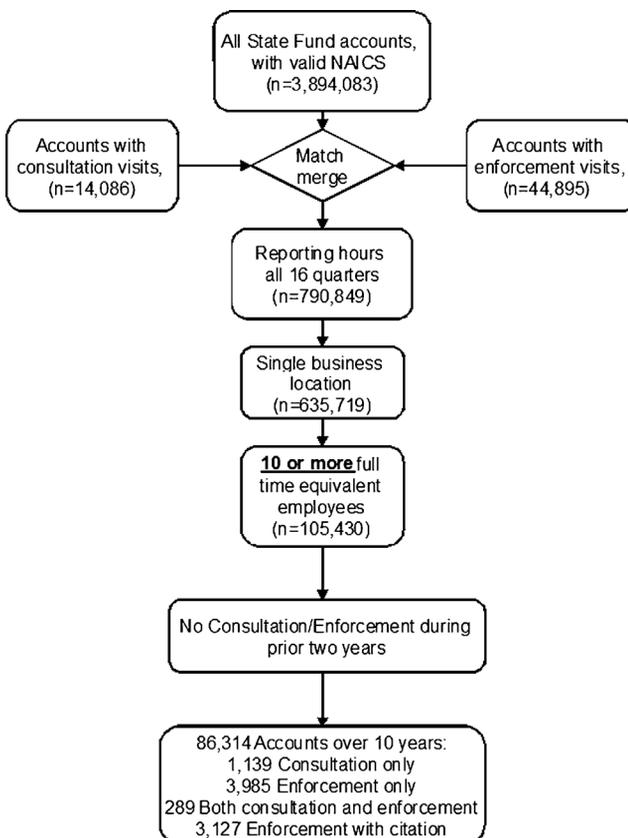


FIGURE 1. Workers’ compensation business account selection procedure.

<sup>1</sup> The L&I State Fund offers elective workers’ compensation coverage for self-employed workers and household employers with two workers or less, and other defined exemptions listed in Revised Code of Washington (RCW) Title 51. This segment of the workforce accounts for approximately 7% of the total employed.

two or more inspections. Only about 2% of accounts had at one or more consultations over the study period.

The following factors were considered in shaping the inclusion criteria. First, accounts should be allowed equivalent time for rates to decrease during similar periods. Therefore, only accounts that reported hours in equivalent time periods throughout the study period were selected. Second, L&I does not require owners of multiple location businesses to report worker hours for each separate business location. Instead, hours are reported for the entire account. Because of this limitation CIRs cannot be calculated for each business location within a business with multiple locations. Therefore, only accounts with a single business location were included. This ensures that CIRs correspond directly to the business location in which the DOSH activity occurred. Third, only 4% of self-insured (SI) accounts have a single business location. In addition, as mentioned, L&I receives only a limited set of information on self-insured claims costs and lost workdays. For these reasons, only State Fund accounts were included. Fourth, accounts were limited to those with an average pre-study period size of at least 10 FTE-YR. Accounts with less than 10 FTE-YR tend to have highly unstable CIRs since the influence of a single claim can be substantial. Fifth, in order to reduce the influence from previous DOSH activity, only accounts with no DOSH activity during the pre-study period were included. Finally, accounts were classified into either the “fixed site” industry group or the “non-fixed site” group. The non-fixed site group was comprised of those accounts with NAICS codes within the construction and transportation industries (NAICS codes 23 and 48 and all sub-categories). All other NAICS industries are considered as fixed-site. This categorization was developed since DOSH effectiveness may well vary between these two categories. Given the number of workplaces satisfying the criteria for our study design, we were unable to control for industry at a more disaggregated level such as the one-digit NAICS sectors.

Taken together, these restrictions allow for a rigorous, controlled evaluation of the effect of about 15% of all DOSH visits.

## Data Analysis

For each of the 10 individual study periods, selected accounts were followed for 4 years on a quarterly basis beginning with the pre-study period. For each employer we extracted claims and number of hours reported, along with DOSH activity for each quarter of the study period. Closing dates were used to determine quarter of DOSH activity. Yearly CIRs for each account were calculated.

IRB approval was not sought as this study examined only the change in CIRs and costs at the employer-level and all results are reported at the aggregated industry

sector level. Also, for this reason, written informed consent was not sought from individual claimants.<sup>2</sup>

Changes in CIRs for accounts with and without DOSH activity were compared through multivariate Poisson regression analysis. Multivariate Poisson models are especially well suited for estimation of rates based on count data. However, Poisson models often suffer from over-dispersion; therefore standard errors were adjusted for over-dispersion [Allison, 1999]. Because the quarterly observations for each employer are not independent, we used a generalized estimating equations (GEE) approach to estimate the Poisson models. An autoregressive correlation matrix was specified, though other models were attempted with similar results. Accounts were classified into mutually exclusive groups according to DOSH activity status at baseline period: (1) NO DOSH—no DOSH activity during the baseline period; (2) consultation—one or more consultation activities; (3) enforcement—one or more enforcement inspections. Accounts with both consultation and enforcement activity in the same baseline period were dropped to avoid misclassification. Preliminary work indicated that CIRs vary by employer size. In general, in a given industry, larger employers have lower CIRs. Furthermore, the year-to-year stability of CIRs varies by employer size, with smaller employers having greater instability. Because average firm size and prior history of CIRs can have an influence on CIRs, changes in CIRs were examined in multivariate analyses controlling for these factors. Using this model, CIRs for each quarter from the start of the baseline period through the end of the measurement period were modeled on DOSH activity status, controlling for average pre-study period size and CIR, and NAICS industry grouping. Separate models were estimated for accepted medical-only claims and time-loss claims as well as claims grouped by whether the injury type was a non-traumatic MSD or not. In addition, the impact on CIRs of DOSH enforcement activities resulting in a citation was compared to that of DOSH enforcement visits that do not result in a citation. Finally, the change in medical and wage-replacement costs for claims following DOSH enforcement and consultation activity was estimated using the same set of covariates.

## Pooling

After modeling CIR changes for each of 10 individual study periods, we found that the impact of enforcement or consultation varied substantially across study years due to the small numbers of eligible DOSH visits, together with

<sup>2</sup> This work was conducted as part of the authors' official duties to evaluate the effectiveness of state OSHA. Legal authority to use claims information for this research is conferred by statute under RCW 49.17.210; 49.17.260; and 51.04.020 (7).

high CIR volatility. We therefore decided to pool together all 10 individual study periods into one analysis. For this purpose, we constructed Poisson regression models with repeated measures. As with the individual studies, we used an autoregressive correlation matrix to handle modeling the correlated errors among measures within firms. The outcome variables were time-loss and medical only claims. Within each of these types of claims, we considered all injury types first, and then subdivided these into MSDs and non-MSDs. The independent variables were DOSH activity classified as either enforcement or consultation, and enforcement with or without citation. We also adjusted for average size and CIRs in the 2-year pre-study period in the multivariate Poisson regression modeling. The results of the Poisson model produced log-linear relationships between the mean CIR and DOSH activity type. These were converted into percentage changes in mean CIRs between the DOSH activity year and the measurement year.

To study the DOSH effect on claim related costs due to injury using the pooled 10-year data, we estimated linear regression models to model the changes in medical costs and wage-replacement costs between the DOSH visit year and the following year. Bootstrapping methods were used to reduce variance, with re-samples set at 500 [Cole, 1999].<sup>3</sup> The outcome variables were the difference in costs per FTE between the DOSH visit year and the following year. The independent variables were DOSH visit types: enforcement and consultation. A second model was limited to enforcement visits with or without citations. Other factors included in both models were average employer size and claims costs per FTE 2 years prior to DOSH visits.

## RESULTS

Multivariate Poisson models were used to examine the effect of DOSH activities on the CIRs, adjusting for pre-study period CIRs and average size in each of 10 baseline years from 1999 through 2008. Estimations were made separately for the fixed and the non-fixed-site industry accounts. The results from model estimation are presented in Table I. Workplaces not receiving any DOSH activity nevertheless saw their compensable CIR fall in 9 of the 10 years covered by the study. This conforms with what has been observed both in workers compensation claims data from the other jurisdictions as well as in injury rate reports to the Bureau of Labor Statistics in the annual Survey of Occupational Injuries and Illnesses. At

workplaces which did not receive any DOSH activity the pooled average annual change in compensable CIR was  $-3.6\%$  for fixed-site workplaces and  $-4.4\%$  for non-fixed-site workplaces. DOSH enforcement inspections in fixed-site industries were associated with a  $4.3\%$  greater decrease (CIR  $-7.9\%$ ,  $P = 0.017$ ) in compensable CIRs relative to employers with no DOSH activity across the 10 years pooled together (see Fig. 2). However, there is substantial year-to-year variability in this result, as can be seen in the annual outcomes in Table I. This instability is due both to the underlying volatility of CIRs at individual workplaces, even when including only those employing more than 10 FTEs, and to the relatively small numbers of workplaces satisfying all the necessary criteria for inclusion in the study. This instability appears in both the enforcement and consultation groups and in both fixed and non-fixed industry groupings. This is why we use the pooled 10-year results. For non-fixed-site workplaces there was  $3.1\%$  greater decrease (CIR  $-7.5\%$ ,  $P = 0.031$ ) in compensable CIRs following DOSH enforcement relative to employers with no DOSH activity. Note that, due to CIR volatility and small numbers of eligible visits, there was no statistically significant result among the individual annual studies. When we pooled across the 10 annual studies a statistically significant result emerged. DOSH consultation visits in fixed-site workplaces were not associated with a statistically significant decrease in compensable CIRs relative to employers with no DOSH activity (CIR  $-6.4\%$ ,  $P = 0.18$ ). However, at non-fixed-site workplaces, DOSH consultation visits were associated with an  $8.5\%$  greater decrease in compensable CIRs relative to employers with no DOSH activity (CIR  $-12.9\%$ ,  $P = 0.043$ ). Pooling across study years allowed this result to be seen, since the volatility of the annual results is even greater for consultation than it is for enforcement. This is due to very small numbers of eligible visits and because of the small size of visited workplaces.

A similar pattern holds for the association between DOSH activity and medical-only claims. Results of the 10-year pooled analysis for this and other claim types are presented in Table II. We find workplaces in fixed-site industries receiving DOSH enforcement experienced a  $3.3\%$  greater decline in medical-only CIR in the following year than amongst NO DOSH workplaces (CIR  $-7.7\%$ ,  $P < 0.001$ ). However, in non-fixed-site workplaces the decline following enforcement is  $2.3\%$  less than that for NO DOSH workplaces (CIR  $-3.0\%$ ,  $P = 0.20$ ). For DOSH consultation at fixed-site workplaces there was a  $0.4\%$  greater decline in medical-only CIR than for NO DOSH workplaces (CIR  $-4.8\%$ ,  $P = 0.08$ ). However, this is significant only at the 10% level. In non-fixed-site workplaces, by contrast, DOSH consultation is associated with a substantial and statistically significant  $8.2\%$  greater decrease in medical-only CIRs ( $-13.5\%$ ,  $P = 0.006$ ). These

<sup>3</sup> Bootstrapping was used to estimate the costs of claims because the theoretical distribution of costs is complicated. The cost data set in our study contains outliers which would greatly influence the sample mean. The bootstrapping procedure helps reduce the bias in variance estimates.

**TABLE I.** Association Between DOSH Activity and Lost-Workday Claims Incidence Rates, 1999–2008

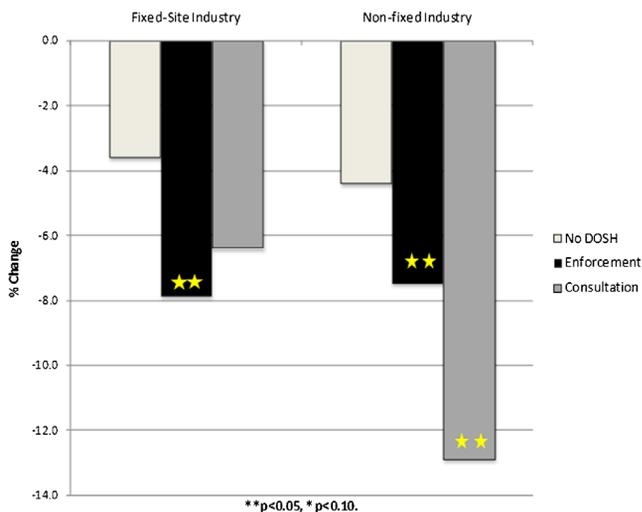
DOSH activity year	Years compared	No. of accounts	Fixed-site industry (% change)			Non-fixed industry (% change)		
			No DOSH activity (n = 67,615)	Enforcement (n = 2,656)	Consultation (n = 849)	No DOSH activity (n = 13,286)	Enforcement (n = 1,329)	Consultation (n = 290)
1999	1999–2000	8,658	-6.7	-21.2*	-6.6	-7.1	-15.5	-10.5
2000	2000–2001	8,239	-0.8	-1.7	11.5	-3.2	-6.6	8.7
2001	2001–2002	8,367	-6.7	-25.5**	-22.9	-1.8	-13.3	9.1
2002	2002–2003	8,572	-4.0	-9.3	-5.9	6.4	0.8	-23.3*
2003	2003–2004	8,572	-0.3	-9.9	-5.8	-1.9	0.5	2.2
2004	2004–2005	8,670	0.4	-9.5	8.3	-9.7	-16.2	23.1
2005	2005–2006	8,790	-3.2	-22.4**	-26.6*	-5.2	-20.3	-27.7
2006	2006–2007	8,902	-4.1	-0.9	-10.2	-3.2	1.4	-7.1
2007	2007–2008	8,993	-4.2	-10.4	3.4	-5.4	-11.5	-43.7*
2008	2008–2009	8,551	-8.7	0.8	-1.8	-3.6	4.2	-51.9
Pooled 1999–2008	DOSH activity year vs. 1-year after	86,314	-3.6	-7.9**	-6.4	-4.4	-7.5**	-12.9**

Annual and pooled results from multivariate model (adjusted for size and claims incidence rate history). Poisson modeling excluded 289 accounts that had both consultation and enforcement visits during the DOSH activity year.  
 \**P* < 0.10.  
 \*\**P* < 0.05.

results suggest that while enforcement activity has significant impact in all industries, it is slightly greater in fixed-site workplaces while the impact of consultation may be greater in non-fixed-site workplaces such as in the construction industry.

The outcome measure used thus far to track the impact of DOSH activity is CIRs for injuries of all types. However, a large proportion of these injuries are non-traumatic musculoskeletal (MSD) disorders. Since these arise

from hazards for which there is no specific DOSH regulation, the focus of DOSH inspections is more likely to be on finding hazards subject to specific occupational safety and health regulations in the Washington Administrative Code such as unguarded machinery, lockout/tagout practices and fall hazards which are related to non-MSD injuries. We broke out changes in CIRs by whether the claims were for MSDs or not. The expectation is that DOSH emphasis on compliance with specific regulations will result in employers fixing hazards related to non-MSD injuries primarily. The results shown in Table II bear this out. Non-MSD medical-only CIRs in fixed-site workplaces show a 4.9% greater decrease (CIR -9.5%, *P* < 0.001) than that in NO DOSH workplaces where CIRs fell by 4.6%. On the other hand, MSD medical-only CIRs showed a slightly smaller decrease than that for NO DOSH (CIR -1.5% vs. -4.3%, *P* = 0.64). Similarly, non-MSD compensable CIRs show a 7.4% greater decrease (CIR -9.5% vs. -2.1%, *P* = 0.03) than that for NO DOSH, while the decline in CIRs for compensable MSDs is not statistically significantly different from that for NO DOSH workplaces (CIR -6.7% vs. -2.0%, *P* = 0.14). Among non-fixed-site workplaces there was not as strong an association between DOSH enforcement and CIR changes. However, even within this weaker association the contrast between results for non-MSDs versus MSDs is similar: non-MSD medical-only CIRs fell by 4.4% while the MSD medical-only CIR actually increased slightly following the DOSH enforcement visits. The contrast in CIR changes between MSD and non-MSD injuries following DOSH consultation



**FIGURE 2.** Changes in lost work-day claims incidence rate: Enforcement and consultation visits compared to no DOSH activity. [Color figure can be seen in the online version of this article, available at <http://wileyonlinelibrary.com/journal/ajim>]

**TABLE II.** Association Between DOSH Activity and Various Claims Incidence Rate (CIR) Measures, 1999–2008

Outcome measure (CIR)	Fixed-site industry						Non-fixed industry					
	No DOSH activity (n = 66,615)		Enforcement (n = 2,588)		Consultation (n = 829)		No DOSH activity (n = 12,663)		Enforcement (n = 1,289)		Consultation (n = 278)	
	Percent change	P-value	Percent change	P-value	Percent change	P-value	Percent change	P-value	Percent change	P-value	Percent change	P-value
All medical-only claims	-4.4	<0.0001	-7.7	<0.0001	-4.8	0.083	-5.3	<0.0001	-3.0	0.195	-13.5	0.006
All lost-workday claims	-3.6	<0.0001	-7.9	0.017	-6.4	0.18	-4.4	<0.0001	-7.5	0.031	-12.9	0.043
Non-MSD medical claims	-4.6	<0.0001	-9.5	<0.0001	-4.8	0.151	-5.5	<0.0001	-4.4	0.080	-13.4	0.018
Non-MSD lost-workday claims	-2.1	0.072	-9.5	0.033	-26.9	0.001	-1.8	<0.0001	-3.0	0.506	-11.2	0.081
MSD medical claims	-4.3	<0.0001	-1.5	0.634	-5.7	0.235	-4.8	<0.0001	1.9	0.666	-15.4	0.073
MSD lost-workday claims	-2.0	<0.0001	-6.7	0.136	6.7	0.316	-3.7	0.001	1.2	0.827	1.6	0.880

Pooled results from multivariate model (adjusted for size and claims incidence rate history).

P-values for no DOSH activity column reflect probability that effect of No DOSH is zero. Other P-values reflect probability that effect is the same as No DOSH.

visits parallels that for enforcement. CIRs for non-MSD compensable claims fell substantially more than those for MSD claims. In fixed-site workplaces non-MSD compensable CIRs fell by 24.8% more than NO DOSH workplaces (CIR -26.9% vs. -2.1%,  $P < 0.001$ ), while MSD compensable CIRs actually rose (CIR +6.7% vs. -2.0%,  $P = 0.32$ ). In non-fixed-site workplaces, non-MSD compensable CIRs fell by 9.4% more than that for NO DOSH workplaces (CIR -11.2% vs. -1.8%,  $P = 0.08$ ), while the MSD compensable CIR rose by 1.6% (CIR +1.6% vs. -3.7%,  $P = 0.88$ ). The medical-only CIR for MSDs following consultation visits deviates from the overall pattern: following DOSH consultation there is a slightly greater decrease among medical-only MSDs than for non-MSDs. In fact, there is some evidence that consultation visits in non-fixed workplaces are associated with a significant decrease in medical-only MSD CIRs. However, there is no association between DOSH activity—either enforcement or consultation—and compensable MSD claims.

Any hazard reduction activity following a DOSH visit is likely to not have as immediate an effect on MSDs as they do on non-MSDs since many workers will already have been harmed by previous exposures. In addition, there may be a more significant reporting effect of DOSH activity on MSDs than on non-MSDs, which may be masking the rate-decreasing effect from the DOSH activity. Because of these concerns, we re-estimated the pooled study for the effect of DOSH activity on MSD claims rates while allowing for a 2-year follow-up period for measuring changes in claims rates. Because of the additional requirement that this imposes on business survival (5 years instead of 4), this analysis excludes an additional 16% of the previously eligible business accounts from the estimate. The results show that there is no effect of DOSH

activities on MSD claims rates when measuring over a 2-year follow-up. However, on the theory that musculoskeletal injuries may exhibit an “inertial” property and may only decline with a lag following a reduction in hazards, we also tried this analysis with a 1-year measurement period consisting only of the second follow-up year. We find that DOSH enforcement visits among fixed-site workplaces were associated with a statistically significant decline in claim rates when we examined only the second measurement year (-11.5%,  $P = 0.016$ ). This effect was not found, however, in non-fixed-site workplaces and it was not found for consultation visits.

It is expected that the threat of financial penalties may induce employers to correct hazards cited and also perhaps to place greater emphasis on safety subsequent to DOSH enforcement. To test this hypothesis, we restricted our analysis of DOSH enforcement visits and estimated the association with changes in medical-only non-MSD CIRs and compensable non-MSD CIRs. We restrict this analysis to non-MSD injuries on the theory that, since citations are related to violations of specific occupational safety and health regulations, and since these regulations do not address musculoskeletal hazards, the imposition of these penalties will induce greater change in hazards for non-MSD injuries. Table III presents results of this analysis. In fixed-site industry those workplaces having an enforcement visit without a citation for violating occupational safety and health rules saw their non-MSD medical-only CIR fall by 23.2%. This is an 18.1% greater decrease than at workplaces without a DOSH visit, and this difference is statistically significant (CIR -23.2% vs. -5.1%,  $P < 0.001$ ). But at workplaces where DOSH enforcement found violations and issued one or more citations, overall CIRs fell by 25.8%, a statistically significant 20.7%

**TABLE III.** Association Between DOSH Enforcement, With and Without Citations, and CIRs, 1999–2008

Outcome measure (CIR)	Fixed-site industry (% change)						Non-fixed industry (% change)					
	No DOSH activity (n = 68,692)		Without citation (n = 2,089)		With citation (n = 500)		No DOSH activity (n = 13,387)		Without citation (n = 949)		With citation (n = 364)	
	Percent change	P-value	Percent change	P-value	Percent change	P-value	Percent change	P-value	Percent change	P-value	Percent change	P-value
Non-MSD medical-only claims	-5.1	<0.001	-23.2**	<0.001	-25.8**	<0.001	-6.0	<0.001	-12.9	0.121	-16.8**	<0.001
Non-MSD lost-workday claims	-1.8	0.089	-6.8	0.571	-22.1**	<0.001	-2.1	0.075	-5.2	0.690	-21.2**	<0.001

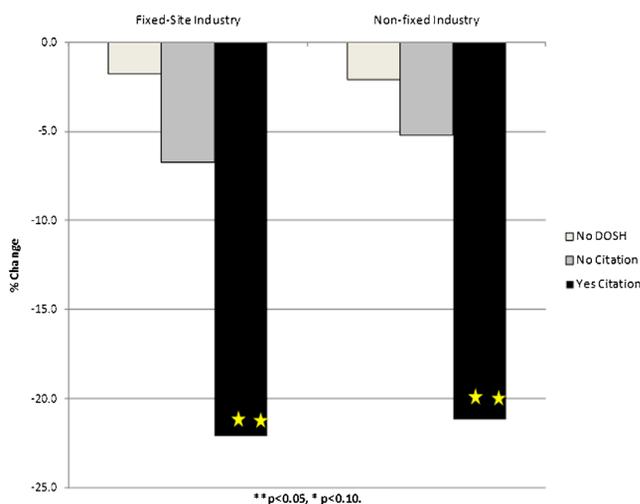
Pooled Results from Multivariate Model (adjusted for size and CIR history).  
 \*\*  $P < 0.05$ .

greater decrease than at NO DOSH workplaces (CIR -25.8% vs. -5.1%,  $P < 0.001$ ).

Compensable claims are typically more costly than medical-only claims, and represent a greater burden both to the injured worker and to employers. When we focus only on non-MSD compensable claims (see also Fig. 3), we find the citation effect is even more pronounced. The citation group had a statistically significant 20.3% greater decrease (CIR -22.1% vs. -1.8%,  $P < 0.001$ ) in non-MSD compensable CIR than did the NO DOSH group, whereas the no citation group saw only a non-significant 5% greater decrease (CIR -6.8% vs. -1.8%,  $P = 0.57$ ). The same pattern was found at non-fixed industry workplaces. The enforcement without citation group had a 6.9% greater decrease in non-MSD medical-only CIRs

relative to the NO DOSH group (CIR -12.9% vs. -6.0%,  $P = 0.12$ ). But the enforcement with citation group had a statistically significant 10.8% greater decrease in non-MSD medical-only CIRs relative to the NO DOSH group (CIR -16.8% vs. -6.0%,  $P < 0.001$ ). For compensable non-MSD claims, the no-citation group had only a 3.1% greater decrease in non-MSD CIRs relative to NO DOSH, and this difference was not statistically significant (CIR -5.2% vs. -2.1%,  $P = 0.69$ ). The citation group had a statistically significant 19.1% greater decrease in non-MSD compensable CIRs relative to the NO DOSH group (CIR -21.2% vs. -2.1%,  $P < 0.001$ ). These results suggest that inspections that issue citations for violations of specific DOSH regulations, which currently only address hazards connected to non-MSD injuries, may have played a significant role in non-MSD injury prevention.

In cases where claims are averted as a result of DOSH activity there is a direct cost savings from averted medical and wage replacement costs. These direct cost savings are a lower bound estimate of the total cost savings from averting the worker injury. Other costs averted include interruption of production, accident investigation costs and recruitment and training costs for replacement workers. Also there is the savings from avoiding the long-run loss of earning power which can affect workers for several years following serious injury and can lead to a need for public assistance funds. It should also be recognized that even if an injury incident is not averted, there may be a decrease in claims costs at workplaces which receive an occupational safety and health inspection or consultation. Using our 10-year pooled set of data, we modeled medical costs of all claim types as a function of DOSH activity status, industry grouping, size of employer and CIR history. We then repeated this model with wage replacement costs as the outcome measure. The results, broken out by industry grouping and DOSH activity status, are presented in Table IV. DOSH enforcement inspections in fixed-site workplaces which met the selection



**FIGURE 3.** Changes in non-MSD lost-workday claims incidence rate: no DOSH activity compared to enforcement without citation and with citation. [Color figure can be seen in the online version of this article, available at <http://wileyonlinelibrary.com/journal/ajim>]

**TABLE IV.** Association Between DOSH Activity and Claims Costs, 1999–2008

Claims cost	Fixed-site industry (relative to no DOSH activity)		Non-fixed industry (relative to no DOSH activity)	
	Enforcement	Consultation	Enforcement	Consultation
Medical costs	–\$558,783*	+\$82,680	–\$762,066	–\$294,641*
Wage replacement costs	–\$1,596,690**	+\$261,992	–\$1,096,234	–\$493,442

Pooled results from multivariate model (adjusted for size and claims cost history).

\* $P < 0.10$ .

\*\* $P < 0.05$ .

criteria were associated with a reduction of approximately \$2.1 million in total claims costs relative to employers with no DOSH activity. This is comprised of a savings of \$0.5 million in medical costs ( $P = 0.08$ ), and a savings of \$1.6 million in wage replacement costs ( $P < 0.001$ ). DOSH consultation visits at fixed-site workplaces were associated with an increase of \$0.3 million in claims costs relative to employers with no DOSH activity, although this was not statistically significant. In non-fixed-site workplaces, we found DOSH enforcement inspections were associated with a decrease of approximately \$1.8 million in claims costs relative to NO DOSH workplaces. However, this difference was not statistically significant ( $P = 0.12$ ). DOSH consultation visits were associated with a statistically significant \$0.3 million decrease in medical costs ( $P = 0.07$ ), but not wage replacement costs, relative to NO DOSH workplaces.

As with claims, we expect that the impact of a DOSH citation would be a stronger signal for employers to reduce hazards and therefore would reduce costs by more than at workplaces either receiving a DOSH inspection without citation or, especially, workplaces with no DOSH activity at all. Again, we modeled medical and wage replacement costs for all claim types separately as a function of DOSH activity status (citation—yes; citation—no; NO DOSH), industry grouping, employer size, and CIR history. The results are presented in Table V. In fixed-site industry, we find DOSH inspections without citation are

associated with a reduction in claims costs of \$0.3 million relative to workplaces without DOSH activity. However, this difference is not statistically significant. By contrast, DOSH inspections resulting in citations were associated with a statistically significant savings of \$1.8 million in both medical and wage replacement costs relative to both workplaces with inspections but no citations and workplaces without DOSH activity. In non-fixed industry the pattern was quite different, however. DOSH inspections, both with and without citations, were associated with lower claims costs than workplaces without DOSH activity, but this difference was not statistically significant.

## DISCUSSION

This study measures the impact of the specific form of deterrence arising from the event of an OHS inspection or consultation visit. It does not account for the general deterrence effect whereby all firms reduce hazards because they believe that failure to do so may be detected and penalized, nor does it account for the effect which OHS standards and educational outreach may have on the pace of technological change in safety or on the level of safety awareness among managers or workers. This means that the impact shown by the study probably understates the full effect that OHS standards and enforcement mechanisms have on the incidence of injuries and illnesses.

**TABLE V.** Association Between DOSH Enforcement, With and Without Citations, and Claims Costs, 1999–2008

Claims cost	Fixed-site industry (relative to no DOSH activity)		Non-fixed industry (relative to no DOSH activity)	
	Enforcement without citation	Enforcement with citation	Enforcement without citation	Enforcement with citation
Medical costs	–\$23,007	–\$533,784**	–\$432,554	–\$321,200
Wage replacement costs	–\$290,242	–\$1,305,097*	–\$714,507	–\$365,615

Pooled results from multivariate model (adjusted for size and claims cost history).

\* $P < 0.10$ .

\*\* $P < 0.05$ .

We address the more narrow issue of specific deterrence by examining the percentage change in workers compensation CIRs in Washington State at individual workplaces visited by DOSH inspectors or receiving a DOSH consultation in the years 1999 through 2008 relative to that of workplaces receiving no DOSH activity. This approach differs from that taken in several previous studies in that it uses workers compensation claims as the outcome measure, extends the scope to include all industries and all sizes of workplaces down to 10 FTEs. It also evaluates not only inspections, with and without penalties, but also consultation activities within the same analytical framework. This allows a direct comparison to be made between these two strategies at a time when there is debate as to the proper mix of strategies to be taken in different workplaces. Because we use workers compensation claims as the outcome measure we are able to evaluate the impact DOSH activity has on costs for medical and wage replacement benefits. Finally, by pulling together 10 years of OHS regulatory activity, we are able to probe further into issues such as how the impact varies by type of industry and by injury type. The latter relates to the question of whether OHS activity is primarily centered on rule compliance or whether impacts can be seen beyond injuries related to cited standards.

We identify a consistent association between DOSH enforcement and consultation activities and decreases in workers compensation CIRs relative to those of workplaces receiving no DOSH activity. This association was stronger for time-loss claims involving at least four lost workdays and it was stronger still for injury types related to hazards associated with regulatory standards in the year immediately following DOSH activity. At workplaces where inspections resulted in citations we found that non-MSD time-loss injuries fell by about 20% relative to workplaces not having any DOSH activity. This reduction is similar in scale to that found by Gray and Scholz [1993] using a 3-year measurement period. Where inspections did not result in citations, a smaller non-significant decrease in CIRs was observed. Consultation visits were also associated with a significant decline in CIRs relative to workplaces with no DOSH activity. The effect was particularly evident in non-fixed-site workplaces as in the construction and transportation industries. One reason may be that a construction firm requesting a consultation may use the results to improve safety across all of its worksites. As with enforcement, we found the effect of consultation activities to be greater on time-loss claims for such non-MSD injuries as fractures and cuts than for time-loss MSDs. Although this is the first controlled study to show a significant effect for consultation activities, this result should be treated cautiously. Because firms initiate the consultation activity by voluntary request, the cohort

available for analysis is necessarily self-selected and may not be representative.

The percentage decline in claims costs was also greater for workplaces which received enforcement visits. In fixed-site industries, if the visit resulted in a citation, the effect strengthened. The results were weaker for consultation and even reversed for fixed-site industries. This reflects the results seen in CIRs—consultation activities appear to have more impact on injuries in the non-fixed-site industries such as construction. The reasons for this are not clear, though the focus of consultation is on smaller businesses which are more typical of the construction industry than of manufacturing. The claims cost reductions observed among the DOSH-inspected workplaces in fixed-site industries which met the selection criteria of our study amounted to \$2.1 million per year. If the cost savings per FTE of this effect is typical of all DOSH-inspected workplaces in this sector we can estimate the cost savings resulting from all DOSH inspections by multiplying the savings per FTE by the total FTEs at all DOSH-inspected workplaces. This would translate into a reduction in claim costs of about \$20 million per year. If the savings of \$0.3 million observed at DOSH-consulted workplaces in non-fixed industries is scaled up to all such workplaces visited by consultation the cost reduction would be about \$4 million per year. If the non-significant cost changes in DOSH-inspected non-fixed-site workplaces and DOSH-consulted fixed-site workplaces are typical, this would add another \$6–\$7 million in cost savings. The combined cost savings of about \$30 million per year is roughly equivalent to the annual budget for the entire state OHS regulatory program. This does not include any indirect cost savings reaped by employers by avoiding production interruptions or having to hire replacement workers. Nor does it include losses borne by the injured worker such as uncompensated earnings losses while on time-loss, and long-term effects of injury on their productivity and income. Depending upon the type of injury and the length of time until return to work these losses can be substantial and long-lasting [Boden and Galizzi, 1999; Foley et al., 2007].

Among the strengths of this study are that it is able to examine the impact of a particular DOSH enforcement or consultation visit at workplaces that have not had any DOSH activities in the previous 2 years; that it follows each workplace's CIR for 2 years prior to the event and for 1 year after the year of the intervention; and that it controls for the effects of general industry category and workplace size. By examining a closed cohort with full survival throughout each of ten 4-year study periods, we are able to exclude the influence of changes in cohort membership and avoid survivorship bias. The model also adjusts for CIR history. Because DOSH bases its inspection targeting partly on CIRs, there is a concern that any

measured decrease in CIRs may simply be a result of regression to the mean and incorrectly ascribed to the DOSH visit. To minimize this risk, we include CIR history in the model as a predictor, and track percentage changes in CIRs rather than absolute changes<sup>4</sup>. Each workplace's claims rate history serves as its own control. In this was any atypical spike in claims rates in a baseline year for an otherwise low-claims rate workplace would not lead to the erroneous attribution of the subsequent regression to the mean to the DOSH activity.

Since we can only control for industry at the aggregate level (fixed-site vs. non-fixed), our study leaves open the possibility that uncontrolled variation within these large industry groupings may result in some residual confounding by industry. We should note that in Washington State inspection scheduling is driven more by industry membership and time elapsed since the previous inspection, as well as complaints, than it is by experience rating or claims rate relative to industry averages.

The selection criteria of this study were designed to allow a test of the impact of a new DOSH activity on CIRs at the same workplace. This required the exclusion of multiple location businesses. In addition, the high variability of CIRs for very small employers (<10 FTEs) made it difficult to detect the impact of DOSH visits. These exclusions mean that 15% of all DOSH visits that occurred in the baseline years are represented in this study. Those populations not represented in this study include very large self-insured firms, large State Fund-insured firms with multiple business locations, and small firms with sporadic periods of employment. Due to constraints in the L&I claims databases, the focus of this study is on stable, small to medium-sized, State Fund-insured firms with a single business location. Since the firms selected for this study differ from excluded firms on such factors as long-term stability, the number of business locations, size, and self-insured status, these results may not be typical of DOSH activity overall.

Since businesses must invite DOSH to conduct a consultation visit, the consultation cohort may be self-selected to have a relatively lower CIR. The concern would be that to the extent that regression to the mean effects survive even after controlling for claims rate history, we would tend to see claims rate increases following a consultation visit, possibly obscuring the effect of the visit. In fact, however, we find that businesses that invite consultations tend to have higher claims rates than those who do not. For example, the consultation cohort in non-fixed NAICS had time-loss claims rates 22–72% higher than the No

DOSH cohort in the 3 years up to and including the year of the visit. Among fixed-site NAICS the same pattern holds with even greater force. Any regression to the mean effects would tend to bring rates down, though this is addressed by using each workplace's 2-year pre-visit claims rate as a predictor in the multivariate analysis. However, another way in which self-selection may affect the consultation results is of more concern. Requests for consultation may be an indicator of an employer who is already concerned enough about OSH performance that, in addition to requesting the consultation, they may also be taking steps to correct hazards. In this case, it would be a mistake to attribute all of the subsequent reduction in injury rate to the consultation alone. Without a random assignment of firms to consultation and control cohorts it is not possible to separate the impact of the consultation from that of already-occurring employer actions to reduce hazards.

Due to the workplace level basis of our study design, and due to the need for claims rates specific to the workplaces actually visited by DOSH inspectors and consultants, our study had to exclude both very small workplaces and some of the largest multiple location firms in the state. We also had to exclude a large number of firms (mostly very small), which did not employ workers for a consecutive sixteen quarters. Although these exclusions were made necessary by the limitations of the workers' compensation database and by the requirements of our study design, these exclusions raise the question of whether the effects found in our study would also be seen at other workplaces visited by DOSH. It is possible, for example, that effects at workplaces belonging to firms on the brink of extinction may differ from those found amongst our case group because the management is too distracted with business survival. We compared the distributions of firm size and industries between the pooled data in our study and that of all Washington State workers' compensation accounts during the same period of time. Apart from the exclusion of the very small businesses (1–9 FTEs), the size distribution of firms in our study generally tracks that of all covered accounts. The difference is mainly a small over-representation of accounts in the 10–49 FTE range and a small under-representation of accounts in the very large category (over 500 FTE). The distribution of our study accounts by industry is also comparable to that of all covered accounts, except for higher proportions in manufacturing (5% in all vs. 9% in our study) and lower proportions in construction (15% in all vs. 12% in our study). The discrepancy is likely due to the relative stability of accounts in manufacturing and the instability of accounts in construction.

The associations between DOSH activity and decreasing CIRs identified in this study do not provide sufficient evidence for a causal relationship. While CIR decreases

<sup>4</sup> When the effects of DOSH enforcement were stratified by average pre-inspection claims incidence rate, the association between DOSH enforcement and decreasing claims incidence rate was found in all strata.

are believed to flow from a decrease in hazards following citation, as found by Gray and Jones [1991], it is also possible that inspections lead to the suppression of claims. Our finding that there is a greater decrease in the incidence rate of more severe lost workday claims following DOSH inspections is evidence against this interpretation, however.

The results of this study are evidence that OHS regulatory interventions in the workplace are having an impact on worker injuries. It is shown that the 1-year impact strengthens when we exclude injuries not related to specific standards. The impact strengthens even further when enforcement visits are accompanied by financial sanctions. We also find some evidence for injury reduction impacts following voluntary consultation activities, particularly in the non-fixed-site industries such as construction. Finally, we find evidence of DOSH activities having a significant impact on reducing workers compensation claims costs.

The magnitude of the decline in claims rates following inspections with penalties is evidence that specific deterrence does lead to a refocusing of management priorities and to improved OHS effort beyond merely coming into compliance with standards. These effects are larger than would result from the incremental, narrowly focused safety improvements predicted by the theory of fully informed rational choice. But the increased safety effort does not manifest itself in equivalent injury reduction effects across all hazards in the workplace over the same time interval. In Washington State, MSDs account for over 40% of all claims and costs in State Fund-insured workplaces. This study finds no evidence of MSD injury reduction following DOSH activity in the workplace in the year following the DOSH activity year. However, we did find mixed evidence for reduction of MSD injuries beginning in the second year following the DOSH activity year. This suggests that even though the hazards being addressed during both enforcement and consultation activities are those related to acute traumatic injuries such as fractures, burns and amputations, management response is not limited to cited hazards alone but may extend to hazards across a broader front. These results suggest two conclusions: (1) the measured effect of inspection on claims rates is dependent on the length and timing of the measurement period; and (2) MSD claims react more slowly to the intervention and need a longer and more delayed period of follow-up measurement than that for non-MSD claims.

These results are evidence that an expansion of both enforcement and consultation activities would bring substantial improvement in injury outcomes through the specific deterrence mechanism explored in this study. For hazards lacking a specific standard, such as MSDs, the evidence suggests either that regulation should be extended in some form to cover these hazards as

well, or that other strategies on the part of workers compensation insurers, such as loss-control programs focusing on primary prevention, should be explored and strengthened.

## CONCLUSION

The results of the pooled analysis show that DOSH enforcement activities make a significant contribution to reducing CIRs and costs in the period following the visit. Evidence of claims rate and cost reductions following consultation was also found but is to be treated with caution due to the self-selected nature of the consultation cohort. Results also suggest that while enforcement has a similar impact in both fixed and non-fixed-site industries, consultation may be having stronger effects in the non-fixed establishments. When we exclude musculoskeletal injuries and focus on those arising from hazards for which there are specific regulations, we find that the 1-year DOSH effect strengthens substantially for fixed-site industries. There is some evidence, however, that the impact on MSD injuries appears with a delay relative to that on non-MSD injuries. Citations for non-compliance have a powerful impact on non-MSD CIRs in the following year: CIRs fall by more than triple the amount seen at businesses having a DOSH enforcement visit with no citation. DOSH enforcement and consultation activity is shown to result in substantial savings in total claims costs in the year following a visit. Evidence of a delayed effect on MSD injuries suggests that a 1-year measurement period may not be sufficient to capture the full impact of DOSH visits on injury claims and costs. Studies of the impact of OHS inspections and consultations with lagged and longer measurement periods should be the focus of future work.

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