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The re-occurrence of violations in occupational safety and health administration inspections

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Abstract

How well do firms in the United States maintain compliance with occupational safety and health administration (OSHA) standards after being cited for a violation? How and why does this vary among standards? This paper identifies serious violations of 91 frequently cited standards at manufacturing plants during 1992–2002 and tracks compliance with that standard in later inspections over 10 years. While formal measures of Repeat violations are quite low, we find considerably higher re-violation rates for some standards once we look separately at how often health standards are cited in later health inspections and safety standards cited in later safety inspections. Characteristics of the standards affect re-violation rates, but not always in the expected direction. Standards whose violations are rated as more hazardous or which received higher initial penalties tend to have more re-violations. These findings could reflect inspector behavior, with those standards getting more attention and thus being cited more frequently. When, as in the case of OSHA and other enforcement agencies, we know about violations only when inspectors cite them, we need to consider bureaucratic behavior as well as employers' incentives.

Keywords: compliance, enforcement, occupational safety and health administration, occupational safety and health standards, regulation.

1. Introduction

The occupational safety and health administration (OSHA) was established "to ensure a safe and healthy workplace" for all workers. It pursues this goal by setting and enforcing standards designed to reduce or eliminate hazards, conducting inspections and imposing penalties for violations. This paper focuses on understanding the difficulty that firms have in maintaining compliance with OSHA standards. For reasons explained below, our sample is based on 23,499 inspections of manufacturing establishments from 1992 to 2002 that cited a serious violation of any of 91 frequently cited OSHA standards. We follow all inspections of these establishments for 10 years following their initial violation to see if the same standard was cited again.

Our first objective in this paper is to understand the frequency of what we call "re-violations" and how it varies among OSHA standards over a 10-year period. Second, we try to explain some of that variation by looking at characteristics of (i) the standards, (ii) the establishments, (iii) the expected penalties imposed by inspections, and (iv) the types of inspections that investigate them. The second and third of these have been the focus of a number

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of studies that looked at factors like establishment size and the presence of unions, and the size of penalties. While this paper provides new data about establishment characteristics and the role of penalties, it goes beyond other studies in looking at variations in compliance for different standards. This is important because studies often fail to explore "compliance with what?" (Hopkins 1994). Lastly, the attention to types of inspections allows us to suggest some important points about how to measure compliance. Findings on compliance also need to be interpreted in light of enforcement procedures. While employer noncompliance is a necessary condition for re-violations, they also require that inspectors re-visit the workplace, identify the violations, and cite them.

In the remainder of the paper, Section 2 discusses the theoretical frameworks for compliance; Section 3 provides a literature review; Section 4 provides the institutional background; Section 5 describes the data and methods; Section 6 presents the findings, first of the descriptive analysis and then of the regression results; and Section 7 discusses the conceptual and policy implications.

2. Discussion of theoretical frameworks

Motivations for an employer's behavior can include a wide variety of factors. As business organizations, it is natural to assume that economic concerns play a large role. Without profits, firms die. Yet economic constraints are not always binding, providing opportunity for organizational pressures and personal concerns, including views about the morality of behavior and the legitimacy of legal authority.

We begin with economic motives. The standard economic model of regulatory compliance was developed by Becker (1968) who identified the benefits of compliance as reducing the expected value of the penalties that would be imposed for noncompliance, combining the probability of being inspected, the probability of the violation being detected, and the amount of the penalty. These must be weighed against the costs of compliance, both capital costs to purchase and install new safety equipment and operating costs to maintain the equipment, and properly train and monitor the workers.

This model would lead us to predict that employer compliance with OSHA regulations would be better:

- When employers believe that compliance with a standard would reduce injury costs.
- When employers believe that the costs of compliance with the standard would be low.
- When employers perceive a high probability of inspection by OSHA.
- When employers anticipate high penalties for violations.
- At larger firms, because smaller firms have poorer information and have less incentive to reduce injuries in order to reduce their workers' compensation premiums.
- At unionized workplaces, because unions may be an alternative source of information about violations and a source of pressure for compliance.

The factors above apply to all compliance decisions. The changes after an employer has been cited for a standard are that (i) noncompliance due to ignorance is no longer an issue and (ii) the employer may face a higher penalty if OSHA cites the same standard again. We examine these predictions in this paper, although we note that the costs and benefits of compliance are difficult to measure.

Employers usually have substantial economic incentives to improve safety apart from regulation. As workers become wealthier and better educated, their demand for safety will increase. Employer incentives can include avoiding higher wages paid for riskier jobs, higher workers' compensation premiums, higher rates of turnover, fears of liability, reputational loss in the marketplace, and lower worker morale (Viscusi 1983).

Socio-legal scholars have emphasized that business decisions are influenced by personal and social perspectives about what sort of behavior is appropriate and desirable as well as by organizational rules and procedures (Paternoster & Simpson 1993).[1] These norms, often embedded in legal rules, can conflict with short-run profit maximization. Blanc (2018) has proposed one useful way of categorizing the "different foundations of compliance" in four groups:

- "enabling conditions: knowledge and understanding of rules, financial and technical ability to comply without putting the business viability in jeopardy;

- economic incentives: deterrence (probability of detection primarily, amount of potential sanctions as a secondary aspect – and also risk of reputation loss), improved market position, or compliance investments resulting in higher productivity, reduced losses etc.);
- social and cultural drivers: group conformity (other group members or models behave in a compliant way), group ethical values (ethical values aligned with the values of the regulation and/or posit legal compliance as an absolute good);
- legitimacy and interactions – individual psychological drivers: legitimacy of authorities (influenced by social and cultural drivers, but also directly by individual experience), procedural justice (or lack thereof) experienced in interactions with authorities, regulators."

Our view is that different motivations spur compliance and that their relative role varies depending on the economic environment, the social relations in the workplace, values of leaders, and the leaders' interactions with the regulatory authorities, particularly the assessment of their competence, reasonableness, and fairness. However, information on most of these factors is difficult to obtain for large samples that also include valid information about compliance status. As a result, we focus here on some economic variables, the technologies required by the individual standards (which have received little attention) and the incentives of inspectors.

3. Literature review

Because we are tracking compliance over time, it is relevant to note other studies that have examined how the number of violations cited in inspections of the same workplace changes over time. Gray and Jones (1991a, 1991b) examined federal OSHA inspections in manufacturing from 1972 to 1983 and found that the second inspection cited only about half the number of safety and health violations cited in the first inspection. The number did not decline much after the second inspection. The same authors also tracked overexposures to toxic substances and health standard violations for the same period and again found by far the biggest improvement between the first and second inspections. Ko *et al.* (2010) replicated the safety study but looked at four different sub-periods from 1972 to 2006 and found that the sequence pattern remained very similar in all four.

Weil (1996) looked at inspections in the custom woodworking industry from 1972 to 1991 and also found that the number of violations cited dropped most sharply after the first inspection and then leveled off. Like the other studies above, he also found that OSHA was more likely to re-inspect those establishments which had more violations in the first inspections. Weil (2001) also studied construction industry inspections from 1987 to 1993 at over 2,000 large construction firms' projects and found much smaller effects of inspection sequence both for contractors and for individual construction projects than he had found in the woodworking industry.

Weil (1996) has argued that there are stronger incentives to correct violations after they are initially cited, either from OSHA's potentially high penalties for willful or repeated violations or from external pressures such as litigation or workers' compensation costs if an accident results from the violation. The impression one gains from these papers is that after an OSHA inspection identifies violations at a workplace, the violations get fixed, making the workplace safer and leaving fewer hazards to be found on future inspections, though there might be some slippage over time. Prior research looked at total numbers of violations over a sequence of inspections, not the re-violation rates for specific standards, which is the focus of this paper.

Other studies provide more perspective on the reasons behind noncompliance. Sims (1988) analyzed a large survey of firms in the mid-1980s that provides insights into the reasons why small firms perform worse. Their leaders are less likely to believe that they have safety problems and less likely to believe that safety measures will be effective. Based on interviews with safety directors at about a dozen firms, Bardach and Kagan (1982) observed that the legalistic style of inspectors often led firms to adopt more adversarial positions.

Coglianese and Kagan (2007) also recognize the importance of both deterrence and social norms, identifying multiple examples where a sense of duty to comply with regulatory norms is more compelling than the fear of regulatory fines. For example, Braithwaite and Makkai (1991) found that nurses in nursing homes emphasized their professional responsibility and moral standards rather than any economic incentive to provide good care.

In work on environmental protection, Gunningham *et al.* (2003) advanced the concept that firms require a "social license" to operate. To obtain this, firms must avoid the perception that the harms they cause are so great that they undermine the legitimacy they normally enjoy. "Sustained inspection and enforcement activity seem to have inculcated a 'culture of compliance.' Consequently, *the regulations themselves*, not the fear of enforcement action, currently have the strongest impact on behavior. Rather than simply providing a threat, regulations and inspections acted as a reminder or guide to enterprises as to what was required of them." Even here, we can wonder whether a "culture of compliance" emerges independently of the belief that resistance would be unproductive.

4. OSHA enforcement and measuring re-violations

Federal OSHA has been conducting inspections of workplaces since 1971. In 21 states, it has delegated its authority for inspections in the private sector to state OSHA programs. Since those 21 states can each follow their own enforcement strategies and sometimes use different coding systems for their standards, we limit our study to the 29 "federal OSHA" states.

OSHA inspections take several forms. As Table 1 shows, "Programmed" inspections, which are targeted according to an OSHA plan, are the most common. The second most common are inspections in response to complaints, usually from workers or their representatives.[2] Other major types of inspections are referrals (from another OSHA inspector or another agency), accident investigations (almost all for fatal accidents), and follow-up inspections. These last are conducted in a small percentage of cases, visiting an establishment inspected earlier to determine whether the employer actually abated the violations cited on the earlier inspection.

The primary job of OSHA inspectors is to detect violations of standards, which then usually lead to fines. Fines are required for violations labeled as "Serious." In 212,397 inspections over 1992–2012, OSHA cited 942,193 violations, over 70 percent of which were cited as Serious. Other violation types include "Other than Serious," (which often have no fines), Repeat, Willful and Unclassified.[3] Table 2 shows the number of violations cited in each type.

We are interested in examining re-violations, where a standard that had been cited on one inspection is then cited again on a later inspection. This could happen either because the employer never fixed the violation or because the problem occurred again after being initially fixed. OSHA labels the former a "Failure to Abate"

Table 1 Number of inspections by type, 1992–2012, manufacturing sector, federal occupational safety and health administration states

Type	Frequency	%
Accident	4,811	2.3
Complaint	65,435	30.8
Referral	18,973	8.9
Follow-up	9,387	4.4
Programmed	103,850	48.9
Seven other types	9,941	4.7
Total	212,397	100

Table 2 Number of violations cited, by severity, 1992–2012, manufacturing sector, federal occupational safety and health administration states

Type of violation	Frequency	%	FTA
Other than serious	257,202	27.3	787
Serious	661,745	70.2	2,719
Repeat	14,020	1.5	87
Unclassified	3,608	0.4	6
Willful	5,618	0.6	37
Total	942,193	100	3,636

FTA is the number of violations of that type which were designated as failure to abate cases, indicating there were additional penalties for not fixing a previously cited problem.

(FTA) violation, while the latter is a "Repeat" violation. Repeat violations can be cited when the same standard is cited again at an establishment within three years of the initial violation.[4] (In 2008, the "look-back period" was raised to five years.). As seen in Table 2, any violation type if unabated could trigger an FTA violation. There were only 3,636 FTA violations cited during our 1992–2012 sample period, so FTA violations are quite rare, representing only about 1 in 250 violations. Repeat violations are more common, with about 14,000 cited over the period, still only 1.5 percent of the total.

When a violation is cited, the employer is required to post the citation, which includes the date for the completion of abatement, at the workplace near where the violation occurred. In addition, employers must report to OSHA when they have abated the violation; those who fail to report are prime candidates for a follow-up inspection. Because of these procedures, it seems plausible that firms would choose to abate the violation in the great majority of cases. The fact that only 1 in 250 violations was for "failure to abate" is consistent with that assumption. Of course, other failures to abate may not have been detected.

Two veteran OSHA administrators[5] noted, however, that since proving an FTA violation requires showing that it had *never* been corrected, inspectors may decide instead to cite the employer for a Repeat violation, which does not require that demonstration. This is consistent with the finding that 30 percent of the Repeat violations were cited in follow-up inspections and that about 15 percent of all follow-up inspections cited at least one Repeat violation, compared to only two percent of programmed inspections and three percent of complaint inspections.[6] However, because many follow-up inspections are targeted at firms that failed to comply with the requirement to report their abatement progress, this 15 percent re-violation figure considerably overstates the rate of re-violation among all firms.

Based on the information presented above, one could conclude that a very great majority of firms come into compliance after being cited for an OSHA violation, and most firms manage to maintain compliance for at least a few years. However, we are interested in extending the analysis of re-violations along three dimensions. First, we follow each inspected establishment for 10 years after the "initial" violation to see what happens beyond the period covered by Repeat violations. Second, we look at many different standards to see whether they exhibit differences in their re-violation rates, indicating difficulties in achieving or maintaining compliance. Third, we examine how characteristics of inspections and the standards themselves affect the probability of observing a re-violation.

For a re-violation to be observed, the inspection needs to cover that part of the establishment, and not all inspections cover everything. Programmed inspections are more likely to be "comprehensive" in scope (71 percent) than complaint (10 percent) or follow-up inspections (six percent). In addition, complaint inspections focus on the hazards mentioned by the complainant while follow-up inspections focus on the hazards identified in the earlier inspection. Thus, programmed inspections provide stronger and more consistent evidence about whether previously violated standards are still being violated. Programmed inspections also randomly select establishments to inspect, although the random selection is made from targeted categories like "establishments in high-rate industries," or "industries where amputations are a risk." [7]

Another important characteristic of the inspection is the training of the inspector. Because of differences in the skills needed to identify violations, health standards are primarily cited in health inspections conducted by industrial hygienists, while safety standards are primarily cited in safety inspections conducted by safety specialists. As a result, it would be misleading to look at the percentage of *all* inspections that observed a re-violation of a health standard; instead it would make sense to focus on *health* inspections, similarly for safety standards and safety inspections. We expand on the importance of this distinction below. We combine this distinction with the inspection type to generate six distinct sets of inspections for our analyses: programmed safety and programmed health, complaint safety and complaint health, and follow-up safety and follow-up health.

We also considered characteristics of the OSHA standard in our analyses. Because OSHA inspectors review the files on previous inspections of the establishment before they visit, they are aware which standards had been previously cited. However, they have limited time to conduct their inspection, so time pressures are likely to lead inspectors to focus on what they view as the most important problems. This could depend on the hazardousness of a violation, and we obtained an assessment of the hazardousness of violations of each standard from a panel of three former high-ranking OSHA officials.[8] Standards may also differ in the difficulty of achieving compliance or maintaining that compliance over time. Finally, the likelihood that a re-violation of a standard will be cited depends on its detectability. An earlier study measured this by asking a panel of inspectors whether a violation of a given standard would have been detected if there had an inspection of the workplace the day before an accident involving a violation of that standard. For machine guarding violations, the estimates were over 80 percent while, for most others, the estimates varied between 20 and 50 percent (Mendeloff 1984).

5. Data and methods

5.1. Creating the data file

In this paper, we limit our analysis to the 29 "federal OSHA" states, as discussed earlier. To analyze re-violations, we need to be able to identify multiple inspections of the same establishment over time. As part of another project, we had linked together all OSHA inspections in federal OSHA states from 1992 to 2012 in the manufacturing sector. The OSHA inspection and violation data were obtained from the Department of Labor enforcement data webpage.[9] Following a technique developed by Fellegi and Sunter (1969) that calculates the probability of two records matching based on agreement or disagreement on their characteristics, the records were linked based on the information reported in OSHA inspection records, using name, address, industry, employment size, and other characteristics to identify records that referred to the same establishment. The matching methodology is explained in more detail in Gray (1996).

The first step in defining our analysis sample was identifying the set of standards to examine. There are hundreds of OSHA standards to consider at the eight-digit level (e.g. 1910.0212 refers to all machine and machinery guarding), but if one includes all the subparts of individual standards there are thousands (e.g. 1910.0212(a)(5) refers to guarding the blades of fans). We identified standards that were cited at least 1,000 times in our sample, using the most detailed subparts with at least 1,000 citations. This resulted in a total of 91 standards.[10]

For our 91 standards, we identified all inspections in our sample where those standards had been cited for serious, willful, or repeat (SRW) violations from 1992 to 2002. We created a separate "initial citation" observation for each plant and standard violated. We linked each of these initial citations to the data from all programmed, complaint, and follow-up inspections that occurred at the establishment through the 10 years following the initial inspection. We then identified all the violations found during each of those later inspections. If there was any SRW violation of the same standard that had been cited on the initial inspection, that counted as a re-violation. Thus, our unit of observation is defined as a pair of inspections – initial and later – and an initially violated standard, which may or may not have been re-violated on the later inspection. If the initial inspection found violations of three different standards and the plant was inspected two more times in the next 10 years, it would generate a total of six observations in our dataset.

Summary statistics for our analysis dataset are presented in Table 3. We have a total of 181,040 paired inspection-standard observations in the dataset. They are based on 84,827 initial citation records from 23,499 inspections, so on average each initial inspection cited 3.6 different standards and each citation linked to 2.1 later inspections within 10 years.

5.2. Descriptive analysis of re-violation rates

Our descriptive analysis is based on calculating the average re-violation rates for different standards and different types of later inspections. In addition to full-sample results, we examine re-violation rates separately for:

- safety standards in programmed safety inspections
- health standards in programmed health inspections
- safety standards in complaint safety inspections
- health standards in complaint health inspections
- safety standards in safety follow-up inspections
- health standards in health follow-up inspections

In the descriptive material, we also examined how re-violation rates vary depending on the length of time since the initial inspection. Finally, we looked at the distribution of average re-violation rates across our 91 standards and identify standards with especially high re-violation rates. Although this approach does not control for

Table 3 Summary statistics (181,040 observations)

Variable Name	Mean	SD	Description
Re-violated dummy	0.069	0.254	Initial standard was cited on later inspection
Inspection category for later inspection			
Health complaint	0.177	0.382	
Health followup	0.061	0.240	
Health programmed	0.152	0.359	
Safety complaint	0.264	0.441	
Safety followup	0.102	0.302	
Safety programmed	0.243	0.429	
Characteristics of inspected establishment			
Unionized plant	0.416	0.493	
Establishment size	399	1,487	Number of employees in establishment
Dummies: 1–10 employees	0.042	0.200	
11–19 employees	0.063	0.243	
20–49 employees	0.171	0.376	
50–99 employees	0.194	0.395	
100–249 employees	0.241	0.428	
250+ employees	0.290	0.454	
Characteristics of initial standard violated			
Standard hazardousness	6.057	1.810	Expert ranking, 3 (least) to 9 (most)
Initial abatement period	46.2	96.6	Days allowed for initial abatement
log(initial abatement period)	3.112	1.161	Version used in logit analysis
Current Own penalty for initial violation	1,860	6,062	(2012 $)
Current Other penalties in initial inspection	24,653	93,583	Total for all other standards (2012 $)
Standard classification dummies			
Training	0.093	0.291	
Design	0.076	0.265	
Engineering controls	0.029	0.168	
Guarding	0.290	0.454	
Hazard analysis	0.032	0.177	
Housekeeping/maintenance	0.044	0.204	
Monitoring/medical	0.058	0.235	
Provide equipment	0.128	0.334	
Provide information	0.054	0.226	
Safe storage	0.021	0.144	
Written plan	0.056	0.229	
Work practices	0.119	0.324	

any characteristics of the standard or workplace, it provides an initial summary of our data, and raises some issues for further examination.

5.3. Econometric analysis of re-violation rates

Next, we carried out logistic regression analyses, allowing us to control for a variety of other factors which may affect re-violations. This analysis is based on the sample of observations described above – initial inspections with a violation of one of our 91 standards connected to a later inspection of that establishment, which may or may not show a violation of the initial standard. The OSHA inspection records provide information on the establishment's number of employees, whether there is a union present, and its four-digit SIC industry. The characteristics of the standard initially cited include its average abatement time, its hazardousness, and the type of activity needed to achieve compliance (e.g. does it require employee training or machine guarding). Given the importance of penalties in the economic model of compliance, we include information about the size of the penalties assessed on the initial inspection, both the penalty for the standard being cited and the total of the penalties for other standards cited on that inspection.

5.3.1. Establishment size

We include dummies for five size categories – 1–10 employees, 11–19, 20–49, 100–249, and 250 or over (50–99 being the omitted group) – allowing for nonlinear effects of establishment size on compliance. Our sample averages about 400 employees; only about a quarter have fewer than 50. We expect that larger establishments will have lower re-violation rates. One reason is that managers there are more likely to have in-house expertise about the standards. Another is that, because larger establishments tend to be part of larger firms, the injury prevention incentives provided by experience rating in workers' compensation insurance will usually be greater. Concerns about reputation are also likely to be larger. Although we expect larger establishments to have better compliance, they also have more opportunities for violations to be re-cited. Consider, for example, a machine guarding violation. An establishment with one machine could be expected to have fewer problems than an establishment with 100 such machines. Finally, inspections may be less comprehensive at larger workplaces, since the number of hours spent on-site is not proportional to the number of employees. For federal OSHA programmed safety inspections, the median hours on-site are 3 for establishments with under 10 employees, increasing to 4, 5, 6, and 7.5 for those with 10–19, 20–49, 50–99, and 100–249 employees.

5.3.2. Unions

Over 40 percent of our sample is unionized. Unions can provide information to workers about workplace hazards and provide a mechanism for workers to address hazards collectively. If firms fail to abate hazards or fall out of compliance, workers in unionized firms are more likely to submit complaints to OSHA than are workers at non-union workplaces (Weil 2004). There is also evidence that, in programmed inspections, having a worker accompany the inspector (rarely done in nonunion workplaces) increases the number of violations cited (Huber 2007). Thus, although unions may improve compliance, they could be associated with more re-violations being cited during programmed inspections as well an increase in the frequency of complaint inspections.

5.3.3. Industry

There could be a variety of differences across industries in terms of their ability or willingness to achieve or maintain compliance with standards over time. We include industry dummies at the two-digit SIC level to control for such differences. Another important role this variable plays is in controlling for differences in inspection frequency across industries. Although frequency may not affect the percentage of inspections finding violations, it will affect the number of violations found.

5.3.4. Average abatement time for the standard

OSHA's violation records include the number of days that OSHA gave the employers to abate the violation. According to the 2011 OSHA Field Operations Manual (page 5–4), the abatement time is supposed to be based on the "shortest period in which the employer can reasonably be expected to correct the violation…" Our interpretation is that the length of this period reflects OSHA's judgment about the difficulty and cost of achieving compliance. If longer abatement periods are associated with major capital expenditures, perhaps they reduce the need for other requirements – for example, wearing respirators or hearing protection – that can lead to re-violations. However, perhaps the initial difficulty in compliance foretells later problems as well. OSHA's standard abatement period is 30 days and the mean abatement period in our sample is 46 days. Appendix I shows the median abatement periods for our 91 standards. Only five are longer than 45 days, all health standards, three of which have median abatement periods exceeding 100 days.

5.3.5. Degree of hazard

To develop a measure of hazardousness for each standard, we empaneled three recently retired senior OSHA officials and asked them "If there were a violation of this standard that was not corrected, what would be the frequency of injuries as a result during the following year?" They assigned ratings of high, medium, or low; we assigned scores of 3, 2, and 1 to the responses and summed them across the panelists, resulting in a hazard rating from 3 to 9, with higher scores indicating greater hazards.[11] Our sample averages about six. The hazard ratings for each standard are shown in Appendix I. Our expectation is that more dangerous hazards cause more losses to the firm – so employers would have a greater incentive, all else equal, to stay in compliance with high-hazard standards. In a countervailing effect, OSHA inspectors may scrutinize compliance with the high-hazard standards more closely, making any re-violations more likely to be observed.

5.3.6. Category of compliance activity

OSHA's regulations categorize standards in terms like "walking and working surfaces," welding, machines, electrical. Here we try to create categories that come closer to cross-cutting activities or conditions that the standard either mandates or proscribes. For example, two of the most common categories are standards requiring worker training and requirements for machine guarding. We came up with the following 12 categories based on this approach; an example follows each.

D: Design – anchor fixed machinery-212(b)
EC: Engineering controls – use these controls, when feasible, to reduce exposures-1000(a)
G: Machine guarding – point of operation guarding-212(a)(3)
HA: Hazard analysis – assess need for personal protective equipment-132(d)(1)
HM: Housekeeping/maintenance – keep floors clean and dry-22(a)(2)
ME: Monitoring and medical exams – at least annual inspections of equipment-147(c)(6)
PE: Provide equipment – provide eye and face protection-133(a)(1)
PI: Provide information – label hazardous chemicals-1200(f)(5)
SS: Safe storage of hazardous materials – oxygen storage-253(b)(4)
T: Training – training on confined space standard-146(g)(1)
W: Have a written plan – written Respiratory Protection Program required-134(c)(1)
WP: Work practices – take defective trucks out of service-178(p)(1)

As seen in Table 3, machine guarding standards are the most frequently cited, with over one-quarter of our sample, while providing equipment and work practices are also relatively common. Information on which standards are assigned to which category is found in Appendix I. Some categories seem more like one-time fixes (design, engineering controls, written plan) while others seem to require ongoing efforts (housekeeping, monitoring, and training) where re-violations might be more likely.

5.3.7. Penalties on the initial inspection

If OSHA levies bigger penalties, deterrence theory implies that future compliance will improve if employers believe that the cost of future noncompliance would be larger. OSHA's rules on setting penalties call for consideration of the gravity of the hazard as the starting point. Then this amount can be adjusted downward for smaller firm sizes (up to a 60 percent reduction), for the "good faith" demonstrated by the employer (up to a 35 percent reduction) and for a good inspection history (up to 10 percent).[12] We can observe and control for establishment size in this study, but not for "good faith" or inspection history.

We employ two penalty measures that attempt to separate these different facets of penalties. *Ownpen* is the penalty from the initial violation of the standard, intended to measure the employers' expected penalties due to future noncompliance with the standard. *Otherpen*, in contrast, measures the total penalties from violations of all other standards during the initial inspection. We expect *otherpen* to measure the overall culture of compliance and thus identify establishments with a higher future likelihood of noncompliance. To some degree, higher values of *ownpen* may also reflect a culture of noncompliance, but we at least expect that the *ownpen* coefficient will be less strongly positive than *otherpen*. Sample averages were about \$2,000 for *ownpen* and over \$20,000 for *otherpen* (deflated to 2012 dollars). Since the penalty amounts were highly skewed, we grouped them into quintiles based on the initial inspection year, measuring whether a given penalty amount is high or low relative to the other observations from the same year. While the actual dollar cutoffs vary year by year, the cutoffs for the quintiles of *ownpen* are approximately \$50, \$500, \$1,000, and \$2,000 while the cutoffs for the quintiles of *otherpen* are approximately \$2,000, \$5,000, \$10,000, and \$20,000.

5.3.8. Year of later inspection

We include dummies for the year when the later inspection was conducted as a way to control for shifts in OSHA enforcement policy over time. A number of authors have argued that OSHA enforcement is quite responsive to political direction (Scholz *et al*. 1991; Jung & Makowsky 2014; Wood & Waterman 1994). It is true that President

Reagan slashed the OSHA enforcement budget when he took office. However, other scholars (e.g. Huber 2007) argue that these changes could reflect bottom-up variations in the demand for regulation (varying with, e.g. local union strength) rather than top-down pressures on OSHA. Schell-Busey (2017) also found no evidence of partisan effects in the way that employer appeals were handled. Still, the coefficients on the year dummies in our model could capture changes in enforcement intensity across different Presidential administrations, as well as any other unmeasured factors that were changing over time.

6. Results

6.1. Descriptive analysis

How frequently are the same standards cited by OSHA in a later inspection during a 10-year follow-up period? Table 4 provides information on this point, showing the impact of focusing on different sets of inspections when defining re-violations. We start by considering all inspections in our sample: both health and safety and all types (programmed, complaint and follow-up). We then calculate re-violation rates for each of our 91 standards. Table 4 shows both the mean and median of the 91 re-violation rates. When we consider all inspections, the median re-violation rate is 4.0 percent. Thus for nearly half the standards, fewer than 4 out of 100 initial violations would be cited again. The mean is higher, at 4.8 percent, since some standards are re-violated much more often than average, but only five standards were cited again on more than 10 percent of the later inspections:

- The general machine guarding standard [1910.0212(A)1]—17.9 percent.
- Guarding point of operation for punch presses [1910.0217(C)2]—13.1 percent.
- The general machine guarding standard for guarding the point of operation [1910.0212(A)3]—12.7 percent.
- Requirement to keep dust levels (including silica dust) below the permissible exposure limit (PEL) [1910.1000(c)]—12.4 percent.
- Mechanical power presses – requires regular inspection procedure [1910.0217(E)1] – 11.2 percent.

The high re-violation rate for the general machine guarding standards requires some discussion. They were frequently cited along with more specific machine guarding violations. Suppose that one inspection cites a violation for poor guarding of a woodworking machine and a later inspection cites a violation for poor guarding of a punch press. These involve two different standards; however, if the general machine guarding standard was also cited in both cases, we would see a re-violation of that standard.[13] Also, as mentioned earlier, violations of machine guarding standards are among the easiest to identify.

Table 4 Percentage of following inspections with re-violations of the standard

	Mean (%)	Median (%)
1. All inspection types, all standards	4.8	4.0
2. Only programmed inspections, all standards	6.2	5.0
3. All inspection types, matched to S/H standards	6.8	5.5
4. Programmed inspections, matched to S/H standards	9.5	7.6
Programmed safety inspections, safety standards	9.4	7.9
Programmed health inspections, health standards	9.7	7.5
Complaint safety inspections, safety standards	6.0	4.7
Complaint health inspections, health standards	5.6	5.0
Followup safety inspections, safety standards	3.1	2.4
Followup health inspections, health standards	4.7	4.2

Starting with all inspections with SWR violations of selected standards during 1992–2002, the re-violation rate is the percentage of all inspections of the same establishment in the next 10 years that had a violation of that standard. The inspection type is based on the later inspection, not the initial one. Re-violation rates were calculated separately for each of the 91 standards; the means and medians reported here are based on those 91 numbers.

A median re-violation rate of 4.0 percent over 10 years is certainly consistent with the view that re-violations are unusual and rarely pose a significant problem. However, we get a somewhat different picture if we change the set of inspections included in the calculation. The initial calculation included all types of inspections, including complaint and follow-up inspections which tend to be limited in scope, as well as the programmed inspections that are more likely to be comprehensive. When we limit the calculation to programmed inspections only (line 2), the median re-violation rate rises by one-quarter, to 5.0 percent, while the mean rises to 6.2 percent. The initial calculation also did not constrain the inspection to those that fit the health or safety orientation of the standard. When we impose this constraint but allow all inspection types (line 3) the median re-violation rate rises to 5.5 percent, and when we limit the inspections to programmed ones that matched the standard's health or safety orientation (line 4), the median re-violation rate is 7.6 percent, nearly double our initial rate. The last section of Table 4 reports re-violation rates for health and safety standards for each inspection type, showing that follow-up inspections have the lowest re-violation rate, especially for safety standards, while the rates for both health and safety programmed inspections are consistently higher than the other categories.

We now look in more detail at the re-violation rates for particular standards, using the most targeted set of inspections, programmed safety inspections that look at safety standards and programmed health inspections that look at health standards. Table 5 shows that we now have 21 safety standards and 12 health standards where the re-violation rate exceeds 10 percent.[14]

6.1.1. Do re-violation rates of the same standard change over time?

Do the annual rates of re-violation of standards change over the 10-year period following their initial violation? In other work, we have found that the total number of violations cited increases as the length of time between inspections increased (Ko et al. 2010). Whatever deterrent effect the earlier penalties had could erode over time. On the other hand, it may take some time for workers to adapt to changes in equipment or techniques, making the repetition of those violations more likely in the years immediately after the citation.

Figure 1 shows the annual re-violation rates for four different types of inspections. The levels of re-violation rates across the different types are consistent with what we saw in Table 4, with the highest re-violation rates among programmed inspections, both safety and health. The re-violation rates for a given inspection type tend to be fairly stable over time, after an increase in the first few years that is concentrated mostly among health inspections.

Table 6 shows the fluctuations over time for four individual standards with high overall re-violation rates, although the smaller sample sizes involved result in substantially greater year-to-year fluctuations.

While these figures still suggest that most employers stay in compliance with most standards after being cited, there is a subset of standards for which re-violations are relatively common. Figure 2 shows the full distribution of the re-violation rates for our 91 standards, based on programmed inspections matching the safety or health orientation of the standard.

6.2. Logistic regression results

We now turn to an econometric analysis of re-violation rates to see how much of the variation in re-violation rates can be explained by characteristics of the standards and how much variation is being driven by characteristics of the establishment and the inspection. Our sample is the 181,040 paired inspection-standard observations. Since our dependent variable, "Re-violated," is a binary variable, we use a logistic regression model. The results of the analysis are shown in Table 7. The first column shows the analysis on the full sample, including all six inspection categories, using dummies for each inspection category to account for the sizable differences in re-violation rates across the six categories. In the remaining columns of Table 7, we see the results of the model being run separately on each inspection category. In all analyses, we clustered the error terms based on the later inspection to allow for unobserved differences across either the establishments at the time they were being re-inspected or across the re-inspections themselves.

The dummy variables describing the inspection categories in the full sample model 1 show the pattern we expected from the earlier descriptive analysis. Health complaint inspections are the base group, and they have relatively low re-violation rates, similar to safety and health follow-up inspections. In contrast, both health and safety programmed inspections have significantly higher probabilities of re-violation. The one minor surprise is

Table 5 Standards which are re-cited in more than 10% of programmed inspections in the 10 years following the initial violation

Safety standards		Safety programmed inspections	
Description	Standard	Re-violation %	# Insp.
Machine guarding – general	19100212 A01	35.9	3,412
Machine guarding – guard point of operation	19100212 A03	24.1	2,318
Power press – guard point of operation	19100217 C02	22.9	746
Log-out tag-out – do periodic inspections	19100147 C06	21.3	917
Railings required for >4' elevation	19100023 C01	18.8	1,471
Power press – inspection procedures	19100217 E01	18.0	560
Guard pulleys <7 feet from the floor	19100219 D01	16.8	1,441
Log-out tag-out – energy control procedures	19100147 C04	15.0	2,105
Abrasive wheel machinery – adjust peripheral	19100215 B09	14.8	1,653
Enclose sprockets <7 feet from the floor	19100219 F03	14.3	899
Power press – design of foot pedals	19100217 B04	12.5	336
Log-out tag-out – device application	19100147 D04	12.5	401
Electric equipment – install and use as labeled	19100303 B01	12.2	394
Woodworking machinery – kickback protection	19100213 C03	12.2	148
Power press-guard point of operation	19100217 C01	12.0	616
Guard horizontal shafting	19100219 C02	11.8	473
Guard vertical and inclined belts	19100219 E03	11.8	771
Keep floors clean and dry	19100022 A02	11.8	246
Guard projection shaft ends	19100219 C04	11.7	273
Woodworking machinery – guard the blade	19100213 H01	10.8	502
Log-out tag-out – training and communication	19100147 C07	10.6	1,466
Health standards		Health programmed inspections	
Description	Standard	Re-violation %	# Insp.
Comply with exposure limits – dusts	19101000 C	30.9	194
Use engineering controls for toxics	19101000 E	29.9	288
Training for lead-exposed workers	19101025 L01	20.8	101
Label hazardous chemicals	19101200 F05	18.9	502
Have facility for quick drenching of eyes	19100151 C	18.4	729
Med. evaluation prior to respirator use	19100134 E01	16.2	142
Noise – use engineering controls to meet PEL	19100095 B01	15.1	146
Have a written hazard communication program	19101200 E01	13.4	704
Provide information and training before job starts	19101200 H01	13.0	230
Spray painting – remove combustible residues	19100107 G02	12.7	150
Fit test required for tight respirators	19100134 F02	12.4	121
Chemicals – comply with exposure limits	19101000 A	11.8	144

that safety complaint inspections have higher re-violation rates, making them look more like the programmed inspections than like the health complaint inspections.

6.2.1. Establishment size

Most of the coefficients related to establishment size in our full-sample model accord with our expectations, including having the patterns differ between programmed and complaint inspections. Table 7 shows that re-violation rates in safety programmed inspections, which usually inspect the entire workplace, do not vary greatly with size, but the largest establishments have the highest rate, 1.7 percentage points above the rate in the base category. Since the safety programmed subsample has an average re-violation rate of 11.75 percent, the 1.7 percentage point increase represents 14 percent of the average rate. Those results indicate a higher re-violation rate at bigger establishments, but this only holds for programmed inspections, and could be driven by the greater likelihood of

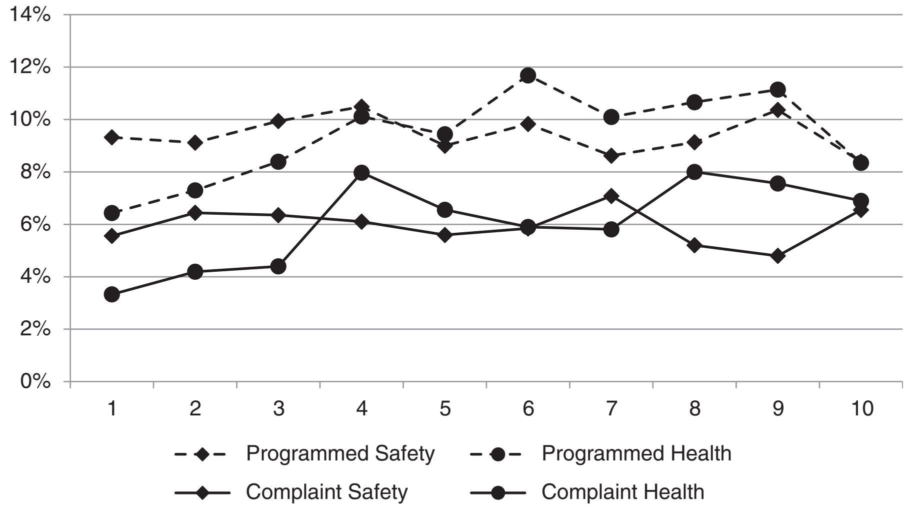

Figure 1 Percentage of inspections citing re-violations by year after initial citation, by inspection type. Note: The numbers in Figure 1 are the average re-violation percentages for that inspection type across all the relevant standards (57 safety or 34 health standards) for later inspections occurring that many years after the initial citation.

Table 6 Percentage of inspections with re-violations, by year after initial violation—selected standards

Standard	Year: 1	2	3	4	5	6	7	8	9	10
19101000C exposure limits – dusts	44	0	34	13	34	35	38	36	23	26
19101000E engineering controls for toxics	31	27	26	11	29	49	30	31	33	32
1910147C6 lockout-tagout periodic inspection	8	22	9	24	22	22	28	20	25	20
1910217C2 power press-guard point of operation	10	29	24	28	26	22	28	17	18	19

These figures are the percentages of inspections in each year after the initial violation that have a re-violation of that standard. For the first two standards, the percentages are based on programmed health inspections; for the latter two, on programmed safety inspections. The observed variability is at least partly due to small samples (the zero in the first row is based on only three inspections; other cells in the table are generally based on ten or more inspections).

finding something wrong in a larger workplace. For complaint inspections, where the chief issue is whether there is a re-violation of the *particular* standard initially cited and the inspection is usually limited in scope, the percentage with re-violations is significantly *smaller* for the biggest establishments, up to 90 percent smaller in the case of health complaint inspections (the reduction of 3.4 percentage points is very large compared to the average re-violation rate of only 3.73 percent). In this case, the likelihood of a given violation may be closely tied to the overall quality of compliance and, as noted above, we expect larger establishments (with their greater knowledge and resources) to have better compliance on average.

6.2.2. Unions

We find that the presence of unions, like establishment size, has a different relationship with re-violations depending on the inspection category. In the full sample, we see a small but significant negative association between unions and re-violation rates, but this is the result of very different coefficients across inspection types. In programmed safety inspections, the re-violation rate at unionized workplaces was 14 percent higher than at nonunionized, while for complaint safety inspections, the rates were 25 percent lower. The pattern of signs for health inspections was similar, but the coefficients were substantially smaller.[15]

The difference in union coefficients across inspection types is consistent with Huber's (2007) finding that OSHA cited more violations in programmed inspections when a worker accompanied the inspector, a practice limited almost totally to union workplaces. In contrast, accompanying the inspector did not play that role for complaint inspections because the inspectors had a good sense of what they were looking for.

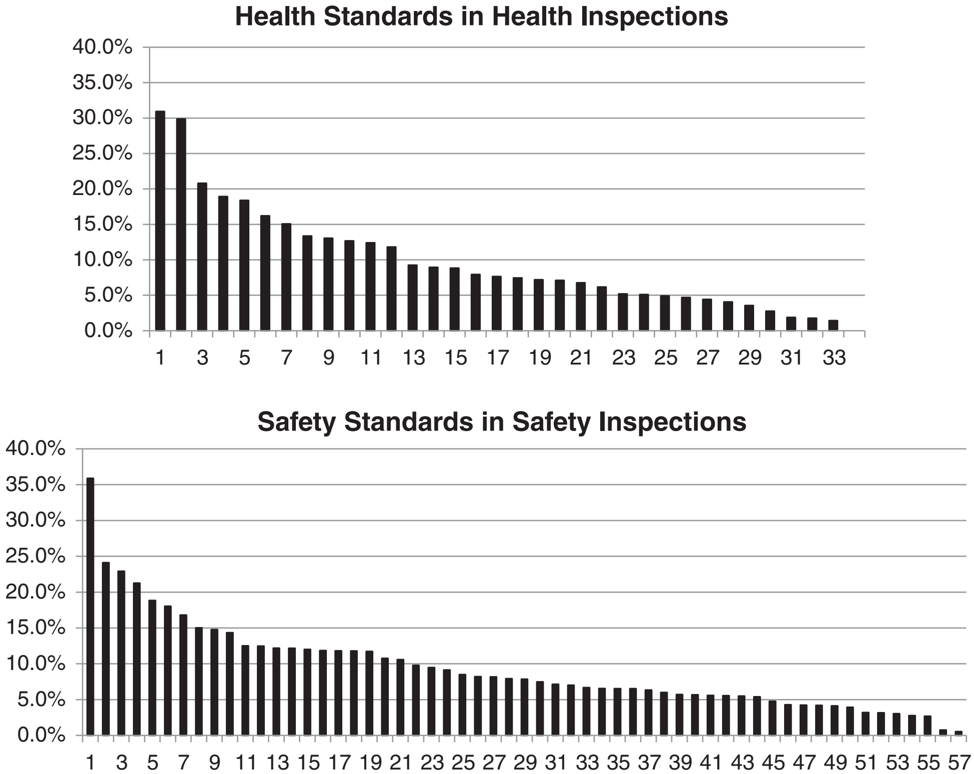

Figure 2 The Percentage of Programmed Safety and Health Inspections Re-citing the Same Standard over 10 years (34 health standards and 57 safety standards).

The lower percentage of re-violations in complaint inspections at unionized workplaces could reflect other factors as well. Perhaps hazards at unionized workplaces are better controlled – leading to the lower percentages of re-violations in complaint inspections – but unions help inspectors find more violations in programmed inspections, fully or partially offsetting the better compliance (Huber 2007). Complaint inspections are more common at unionized workplaces. As others have noted, belonging to a union can protect a complaining worker from retaliation and unions may have strategic reasons to trigger inspections if the firm is not being cooperative in other areas (Weil 1991). This may result in complaint inspections at union workplaces getting triggered for less hazardous situations than complaint inspections at nonunion workplaces.

6.2.3. Industry

We don't see very strong patterns in the industry coefficients across the models. Relative to the base group of food (SIC 20), only furniture (SIC 25) and chemicals (SIC 28) show significant differences in the full sample, with both showing lower re-violation rates, though this difference is not consistent for them across all six inspection categories. None of the other industry dummies show significant coefficients that are consistent across any of the subsamples, and few of the industry coefficients are significant overall. Because inspection rates vary considerably across industries, the absence of many significant industry coefficients suggests that inspection rates did not have much impact on re-violation rates.

6.2.4. Abatement time

As noted earlier, the abatement period allowed by OSHA reflects the difficulty and cost of abating the initial violation. We believed that greater difficulty would usually be linked to engineering controls and that these might actually reduce compliance problems in the long run. However, we find that violations which were given longer abatement times have higher re-violation rates, an effect that is significant in all of the models. The coefficients predict that a doubling of the abatement period is associated with an increase in re-violation rates of about 5–10

Table 7 Likelihood of re-violation, given an inspection, federal occupational safety and health administration manufacturing (logistic regression – marginal effects)

	(1) All Inspections	(2) Safety Program	(3) Health Program	(4) Safety Complain	(5) Health Complain	(6) Safety Followup	(7) Health Followup
Re-violated mean	6.93%	11.75%	5.91%	7.11%	3.73%	3.83%	4.01%
Later inspection type (base = HC)							
Health followup	0.001 (0.17)						
Health programmed	0.025*** (6.95)						
Safety complaint	0.042*** (13.33)						
Safety followup	−0.004 (−0.72)						
Safety programmed	0.07*** (20.83)						
Establishment size (base = 50_99)							
1–10 employees	0.025*** (4.89)	−0.016 (−0.87)	0.004 (0.33)	0.036*** (3.53)	0.015** (2.23)	0.02** (2.32)	−0.009 (−0.85)
11–19 emp	0.009** (2.09)	−0.01 (−1.03)	−0.01 (−1.06)	0.033*** (3.03)	0.009 (1.39)	0.013 (1.60)	−0.002 (−0.18)
20–49 emp	0.001 (0.31)	−0.006 (−1.06)	−0.006 (−0.93)	0.008 (1.23)	0.009** (1.98)	−0.002 (−0.31)	−0.004 (−0.51)
100–249 emp	−0.002 (−0.86)	0.006 (1.08)	−0.004 (−0.74)	−0.001 (−0.21)	−0.014*** (−3.13)	−0.004 (−0.46)	−0.018** (−2.00)
250plus emp	−0.014*** (−4.82)	0.017** (2.31)	0.005 (0.73)	−0.022*** (−3.92)	−0.034*** (−6.77)	−0.001 (−0.10)	−0.022** (−2.06)
Union	−0.004* (−1.96)	0.016*** (3.16)	0.007* (1.65)	−0.018*** (−4.31)	−0.002 (−0.74)	−0.011* (−1.77)	−0.01 (−1.43)

	(1) All Inspections	(2) Safety Program	(3) Health Program	(4) Safety Complain	(5) Health Complain	(6) Safety Followup	(7) Health Followup
Log (initial abatement)	0.006*** (8.65)	0.007*** (3.75)	0.005*** (3.03)	0.005*** (4.26)	0.004*** (3.59)	0.005*** (5.05)	0.004** (2.14)
Standard hazardousness	0.009*** (20.62)	0.017*** (16.36)	0.004*** (3.80)	0.011*** (12.05)	0.004*** (4.39)	0.006*** (3.71)	0.0001 (-0.04)
Standard category (base = training)							
Design	0.033*** (8.77)	0.095*** (10.15)	0.018** (2.04)	0.011 (1.38)	0.002 (0.23)	0.009 (1.09)	0.007 (0.58)
Engineering controls	0.038*** (6.87)	−0.252*** (−4.39)	0.107*** (11.30)	−0.273*** (−4.26)	0.049*** (7.75)	~	0.052*** (4.92)
Guarding	0.042*** (14.09)	0.101*** (13.01)	0.009 (1.22)	0.039*** (7.18)	0.001 (0.21)	0.007 (1.03)	−0.006 (−0.60)
Hazard analysis	−0.003 (−0.48)	0.003 (0.25)	0.015 (1.41)	−0.023** (−2.23)	0.011 (1.35)	−0.015 (−1.15)	−0.022 (−1.32)
Housekeeping/maintenance	0.043*** (9.62)	0.023 (1.54)	0.039*** (3.75)	0.051*** (6.64)	0.038*** (6.09)	0.023** (2.50)	0.001 (0.11)
Monitoring/Medical exams	0.036*** (10.13)	0.09*** (10.25)	0.029*** (3.33)	0.019*** (2.76)	0.015** (2.50)	0.011 (1.31)	0.003 (0.20)

(*Continues*)

Table 7 Continued

	(1) All Inspections	(2) Safety Program	(3) Health Program	(4) Safety Complain	(5) Health Complain	(6) Safety Followup	(7) Health Followup
Provide equipment	0.028*** (8.97)	0.045*** (5.48)	0.047*** (6.70)	0.011* (1.96)	0.021*** (4.14)	0.006 (0.88)	0.011 (1.13)
Provide information	0.046*** (12.50)	−0.009 (−0.75)	0.089*** (11.42)	−0.012 (−1.37)	0.055*** (10.46)	0.017** (2.09)	0.027*** (2.99)
Safe storage	0.011 (1.49)	0.023 (1.28)	−0.004 (−0.28)	0.019 (1.44)	−0.03* (−1.83)	0.003 (0.24)	0.024 (1.52)
Written plan	−0.014*** (−3.53)	−0.026** (−2.40)	0.013 (1.46)	−0.048*** (−5.60)	0.005 (0.77)	−0.018** (−1.98)	0.007 (0.75)
Work practices	0.012*** (3.86)	0.029*** (3.65)	0.004 (0.45)	0.01* (1.95)	0.004 (0.70)	0.008 (1.34)	−0.015 (−1.31)
	(1) All Inspections	(2) Safety Program	(3) Health Program	(4) Safety Complain	(5) Health Complain	(6) Safety Followup	(7) Health Followup
Own penalty quintiles (base= lowest quintile)							
Own penalty Q2	0.012*** (5.38)	0.032*** (5.77)	0.003 (0.64)	0.014*** (2.97)	0.001 (0.19)	0.005 (0.84)	0.012** (2.03)
Own penalty Q3	0.01*** (5.10)	0.029*** (5.96)	0.005 (1.19)	0.007 (1.62)	−0.001 (−0.18)	0.003 (0.58)	0.015** (2.38)
Own penalty Q4	0.013*** (6.47)	0.034*** (6.54)	0.001 (0.29)	0.013*** (3.38)	0.003 (0.87)	0.008 (1.51)	0.011* (1.67)
Own penalty Q5 (highest)	0.016*** (7.19)	0.036*** (6.08)	0.004 (0.73)	0.02*** (4.70)	0.002 (0.55)	0.015** (2.35)	0.014** (1.99)
Other penalty quintiles (base = lowest quintile)							
Other pen Q2	−0.001 (−0.35)	0.004 (0.75)	−0.006 (−1.21)	0.003 (0.63)	−0.009** (−2.46)	−0.008 (−1.29)	0.006 (0.81)
Other pen Q3	0.0004 (0.16)	0.001 (0.25)	−0.015*** (−3.01)	0.006 (1.47)	−0.001 (−0.25)	−0.006 (−1.04)	0.009 (1.19)
Other pen Q4	−0.001 (−0.23)	0.004 (0.66)	−0.012** (−2.37)	−0.001 (−0.20)	−0.002 (−0.48)	0.004 (0.62)	−0.006 (−0.78)
Other pen Q5 (highest)	−0.012*** (−3.78)	0.005 (0.59)	−0.027*** (−3.99)	−0.017*** (−3.09)	−0.03*** (−5.78)	−0.003 (−0.37)	−0.008 (−0.97)
Number obs	181,040	43,974	27,593	47,796	32,123	18,196	11,110
Pseudo R^2	0.056	0.071	0.059	0.069	0.093	0.050	0.080
Log-likelihood	−43,033.6	−14,786.7	−5,830.9	−11,417.3	−4,637.5	−2,840.2	−1,721.2

t statistics in parentheses; $*P < 0.10$, $**P < 0.05$, $***P < 0.01$.

~ = coefficient dropped - variable perfectly predicts the outcome. The regression also includes dummies for two-digit SIC industries and the year of the following inspection (complete results available in Table S1 in the online appendix).

percent. Thus, violations that are more difficult to abate initially also seem to be somewhat more difficult to maintain compliance with over time.

6.2.5. Degree of hazard

We had expected to find that re-violations are less common for those standards whose violations are expected to be more hazardous, but that is not what we found. The benefits of compliance with a standard presumably increase with the dangers resulting from violating it. Nonetheless, we find that an increase of one unit in the hazard index (which runs from 3 to 9) increases the re-violation rates from 9 to 15 percent in different inspection samples. The effects are significant for the full sample and all inspection categories except for health follow-up inspections.

A possible interpretation of these coefficients is that OSHA inspectors look more carefully for violations that present larger hazards, making those violations more likely to be cited on later inspections. In this context, the positive hazard coefficients would suggest that re-violation rates are driven more by OSHA inspector behavior than by employer behavior.

6.2.6. Categories of standards

We see substantial and frequently significant differences in re-violation rates across categories of standards in Table 7, but the effects (and even the signs) vary considerably between health and safety inspections. This is not surprising, since we saw considerable differences in re-violation rates across standards in our descriptive analysis. We chose our base group, "Training" standards, with these concerns in mind, because it included multiple standards for both safety and health.

Relative to Training standards, other categories mostly showed significantly higher re-violation rates, which seems surprising given the need for repeating the training at regular intervals. The only category that shows significantly lower re-violation rates is the requirement for having a written plan (W), which seems logical. For programmed safety inspections, the standards with much higher re-violation rates (about 80 percent higher than the base rate) were those for Design standards, machine guarding standards, and standards calling for periodic inspections (ME).

Given the ongoing nature of those tasks, we expected the housekeeping/maintenance standards (HM) to be frequently re-violated and, except in safety programmed inspections, they were: compared to training, 72 percent more frequent for health programmed inspections, 65 percent more frequent for safety complaint inspections and 102 percent more frequent for health complaint inspections. The three standards in the Providing Information (PI) category were all health standards. Providing information might seem like a one-time task, but the detailed and somewhat complicated rules of the Hazard Communication Standard led to many re-violations in health standards.

As noted earlier, the detectability of violations could be another source of variation across standards. While Mendeloff (1984) provides information for only a few types of standards, machine guarding had the highest detectability and work practices the lowest, consistent with their relative re-violation rates found here.

6.2.7. Penalties

As noted earlier, we expected the size of the penalty imposed on the initial violation (*own penalty*) to be negatively associated with re-violation rates, driven by the usual deterrence argument. We thought we might see a more positive relationship with the amount the establishment was penalized for all of its other violations (*other penalties*), reflecting an overall lack of compliance effort. Neither of these hypotheses were supported by our results. For programmed and complaint safety inspections, higher penalties on the target violation were associated with re-violation rates 20 to 30 percent *higher* than the lowest penalty category; for health inspections, there was no relation. In contrast, for penalties imposed for the other violations cited in that inspection, higher penalties were linked to *lower* re-violations rates (25 to 80 percent lower) especially for the highest penalty quintile (roughly equivalent to total penalties exceeding $20,000). The exception was the programmed safety inspections, whose re-violations rates were unaffected. Many of these results could reflect inspector behavior, if a standard that gets a high penalty on the initial inspection receives more attention on later inspections.

6.2.8. Year of later inspection

The year dummies did not show a strong year-to-year trend over time, although there is some tendency for them to be negative in the earlier years of the sample, with the largest negative coefficients for the full-sample model in 1992 and 1995, while the largest positive coefficients were in 2004 and 2005. This could reflect the tendency noted in the descriptive analysis of Figure 1 for somewhat lower re-violation rates in the first few years after the initial inspection, since by definition any "later" inspection occurring in 1992 must be less than a year after the initial inspection. With this effect being concentrated in the first few years after the initial inspection and relatively stable afterwards, it does not result in a continuing trend of higher re-violations in the later years of our sample.

Although never significant, the year dummy variables for the "all inspection types" category were generally negative from 1992 to 2000 (Clinton years), positive from 2001 to 2008 (Bush2 years), then negative again from 2009 to 2012 (Obama years). Finding fewer re-violations under Democratic administrations could reflect an expectation by businesses of tougher OSHA enforcement practices, leading to a greater deterrence effect in those years. Still, it is surprising that any such deterrence effect would outweigh the tendency for tougher enforcement to lead to more (rather than fewer) violations being cited overall.

Although not included in the analyses we show here, we also examined whether the employer had contested the citation for the specific standard. Our assumption was that going to the trouble of contesting a violation, which imposes some legal costs on the employer but also puts a hold on their obligation to comply, could be linked to an increase in future noncompliance. We found no evidence that contesting a citation made re-violating that standard more likely. In fact, the coefficients on the contest variable were negative and significant at the 0.10 level for both programmed safety and health complaint inspections.

7. Discussion

We have examined the frequency of re-violations of OSHA standards, using two types of analysis. The first analysis examines the extent of noncompliance with previously cited OSHA standards. The second analysis uses logit models to examine a set of factors that might help explain variation in re-violation patterns, mostly factors related to the benefits and costs to employers of maintaining compliance with those standards. Below, we first discuss the methodological insights the study provides and then turn to substantive findings and their implications.

7.1. Methodological insights

We observed that Repeat violations comprise less than 3 percent of all violations in manufacturing in Federal OSHA states and that FTA violations are well under one percent. This creates the impression that violations are corrected after they are cited and re-violations are a minor problem. The implication is that almost all of the violations found in re-inspections are new ones.

We have shown that a different measure of re-violation rates, at least in federal OSHA inspections in manufacturing, is considerably higher than portrayed by the figures above. Our measures of re-violations focus on programmed inspections, which tend to be more comprehensive and provide a fuller picture of compliance. We further limit the re-violation measures to those inspections designed to address the particular standards, that is, looking at health standards cited in health inspections and safety standards cited in safety inspections.

These adjustments lead to re-violation rates that exceed 10 percent for a third of the 91 standards, exceed 20 percent for 7 of them, and exceed 30 percent for 2. Yet, although we no longer are looking at 3 percent rates, employers continue to comply in the great majority of cases.

The other methodological point that we highlight is one that bedevils all uses of violation data to assess compliance. Changes in enforcement policy and variations in inspectors' effort can affect whether violations are cited and how they are cited. During most of our sample period, the average number of serious violations cited per inspection remained fairly constant, increasing about one percent per year over the 15 years from 1995 to 2010. To the extent that this is an overall measure of enforcement stringency, its lack of variation over time suggests that the relationship between observed violations and underlying compliance was not systematically changing during our sample period.

7.2. Substantive findings

The measures we have developed indicate that re-violations of standards are more common than usually portrayed. This result derives partly from the longer time period we follow. Figure 2 showed that the percentage of re-violations did not change much in the 10 years following the initial violation, which certainly supports the change OSHA made in 2008 to extend the follow-back period for Repeat violations from 3 to 5 years.

We were surprised, as were some of the OSHA officials we spoke with, about the 30 percent frequency of re-violations for two of the toxic substance exposure standards shown in Table 5.[16] And even if we ignore the general machine guarding standard, the large number of machine guarding standards with 10 to 24 percent re-violations is disturbing.

7.3. Factors affecting re-violations

Earlier, we laid out predictions about re-violations based on the assumption that a major factor driving re-violations was employer behavior based on benefit-cost calculations. How well do our findings conform to those predictions? We predicted that re-violations would be less frequent:

1 When employers believe that compliance with a standard would reduce injury costs.
2 When employers believe that the costs of compliance with the standard would be low.
3 When employers perceive a high probability of inspection by OSHA.
4 When employers anticipate high penalties for violations.
5 At larger firms, because smaller firms have poorer information and have less incentive to reduce injuries in order to reduce their workers' compensation premiums.
6 At unionized workplaces, because unions may be an alternative source of information about violations and a source of pressure for compliance.

1. Reducing risks: We have no direct evidence of employer beliefs about the efficacy or worthwhileness of different standards. Instead, we have a measure of the "hazardousness" of violations provided by OSHA experts. If employers' beliefs were similar, then, other things equal, they should make greater efforts to maintain compliance with those standards with higher hazard ratings. As we saw, however, higher hazard ratings were regularly associated with higher, not lower, re-violation rates.

2. Costs of compliance: We expected that higher initial costs of compliance would be associated with lower re-violation rates, assuming that on-going compliance with those standards would be cheap relative to the initial investment. Our proxy for abatement costs is the length of abatement time allowed for the initial violation. We found that longer abatement periods were linked to higher, not lower, re-violation rates, which does not support the prediction we made.

3. Inspection probability: We did not include a variable for an inspection rate. If we had, it would have relied on the inspection rate for the establishments' industry. However, we did include industry dummy variables and found very few with significant effects on re-violations. No sample had more than two significant industry coefficients and no industry was significant in more than one sample. Thus we think it is unlikely that variations in inspection rates had a sizable impact on re-violations. However, we acknowledge that Industry dummy variables may reflect more than differences in inspection rates.

4. Penalties: We did not find that larger penalties for the specific standard we were following were associated with lower re-violation rates, as deterrence theory would suggest. In contrast, the measure of the penalties for all other violations cited in the initial inspection did have negative coefficients, which grew to significance when they reached the top penalty quintile (roughly those over $20,000). For that highest quintile, the re-violation rates, compared to the lowest penalty quintile (roughly those under $1,000), were 45 percent lower for health programmed inspections, 24 percent lower for safety complaint inspections, and 80 percent lower for health complaint inspections. For health programmed inspections, even lower levels of *other penalties* were linked to a decline in re-violation rates. While this is not exactly the standard-specific deterrence effect we were expecting, the results suggest than when the overall penalties in an inspection become "high enough," re-violations of standards become less likely.

5. Establishment size: The effects of establishment size in programmed inspections were small, likely due to the expected better compliance at larger workplaces counter-balancing the more numerous opportunities for re-violations there. In complaint inspections, where the focus was on a specific standard, the smallest workplaces had higher re-violation rates and the largest had lower re-violation rates (relative to the excluded category, 50–99 workers), including a 90 percent reduction for complaint health inspections among worksites with over 250 workers.

6. Unions: Once we separated programmed and complaint inspections, we found that unionized workplaces had more re-violations than nonunion workplaces in safety programmed inspections, as predicted based on the union's role in helping inspectors find violations. However, unionized workplaces had lower re-violation rates in safety complaint inspections, indicating that compliance with a given standard was more likely there, perhaps due to the union's safety activities.

The first four of these predictions capture aspects of the economic deterrence model. They don't perform very well here. One reason could be that our measures do not capture the appropriate concepts. While acknowledging that, we think that a simple employer benefit-cost analysis omits important organizational and normative factors, particularly inspector behavior, which can explain many of our results that seem inconsistent with the deterrence model.

Some studies have examined whether partisan political influence affects the enforcement process. Here the effect is usually presumed to affect the behavior of regulators rather than the behavior of employers. We noted that there are conflicting findings about the extent and nature of any political influence on enforcement. Democrats would be assumed to enforce more strictly and cite more violations, but our results do not show any evidence that the probability of finding re-violations increases with Democratic Administrations or falls with Republicans.

An important limitation of our study is that three of our measures of the characteristics of OSHA standards – hazardousness, the difficulty of initial abatement, and the type of abatement activity required – remain in an early stage of development. Some of the activity categories are based on only two or three standards. Yet we believe that all three of these concepts are meaningful additions to a study of compliance. Another limitation is our lack of information on other characteristics of the standards, such as the average cost of complying with them, which would be difficult to collect for the wide range of standards we cover here.

Our analyses provide new information about which standards are more likely to be re-cited, given a later inspection, and how often. Since employer noncompliance is a necessary condition for a re-violation, the analysis sheds some light on employer behavior. However, as we have emphasized, our findings about re-violations depend not only on employer behavior but also on OSHA's. Therefore, inferences about employer behavior that are based on noncompliance found during inspections need to be drawn cautiously.

Overall, the evidence that some firms have difficulty maintaining compliance with important health standards seems clear. If OSHA believes that non-compliance with certain standards is especially hazardous, it should consider taking new steps to ensure continuing compliance. Any such steps need to be balanced against the ongoing need to inspect previously uninspected workplaces, since finding violations is more common on the first inspection of a workplace than on subsequent inspections. Further research is needed to clarify the possible tradeoffs between avoiding re-violations and providing incentives for initial compliance.

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Endnotes

1 Paternoster and Simpson (1993) provide another useful list of factors to consider alongside Blanc's.

2 For a large number of complaints, OSHA relies on a "phone-fax" procedure that usually avoids inspections. These are not included in our data set. On-site inspections are conducted when one or more of the following conditions is present:

1 "There is a written, signed complaint by a current employee or employee representative with enough detail to enable OSHA to determine that a violation or danger likely exists that threatens physical harm or that an *imminent danger* exists;

2 An allegation that physical harm has occurred as a result of the hazard and that it still exists;
3 A report of an *imminent danger*;
4 A complaint about a company in an industry covered by one of OSHA's local or national emphasis programs or a hazard targeted by one of these programs;
5 Inadequate response from an employer who has received information on the hazard through a phone/fax investigation;
6 A complaint against an employer with a past history of egregious, willful or failure-to-abate OSHA citations within the past three years;
7 Referral from a whistle blower investigator; or
8 Complaint at a facility scheduled for or already undergoing an OSHA inspection.

In other cases, OSHA telephones the employer, describes the alleged hazards, and then follows up with a fax or a letter. The employer must respond within five days, identifying in writing any problems found and noting corrective actions taken or planned. If the response is adequate, OSHA generally will not conduct an inspection. The employee who filed the original complaint will receive a copy of the employer's response. If still not satisfied, the complainant may then request an on-site inspection." See https://www.osha.gov/as/opa/worker/handling.html.

3 The violation category "U" for unclassified was used for a subset of quite serious violations.

4 The OSHA Field Operations Manual (2011) states, "Generally, similar workplace conditions or hazards can be demonstrated by showing that in both situations the identical standard was violated," but it cites exceptions on 4–28 and 4–29.

5 Richard Fairfax, former Director of OSHA Field Operations, and Michael Connors, former Director of OSHA's Region 5.

6 In striking contrast, only 66 FTA violations were cited in follow-up inspections, less than 2% of the total violations in those inspections. FTA violations are cited disproportionately frequently in complaint inspections, most likely because workers are reporting the employer's failure to abate the violation.

7 The way in which OSHA chooses where to carry out programmed inspections has changed over time. In some years, OSHA randomly inspected establishments with more than 40 employees in *industries* with high injury rates or known hazards. From 1997 to 2012, some programmed inspections were targeted at establishments that had reported high injury rates to OSHA two years earlier. In the last few years, programmed inspections have largely focused on workplaces containing specific hazards that are included in one of OSHA's "special emphasis" programs.

8 They included the two officials named above plus Robert Hooper, the Deputy Director of OSHA's Region 1.

9 Found at https://enforcedata.dol.gov/homePage.php.

10 There were additional criteria used to screen the standards. There was a conflict between our desire to ensure that the standard re-violated was the same exact one and the need to ensure that the standard was violated a large number of times. Therefore, we looked at all of the times that sub-provisions of the standards had been violated and included only those standards where one provision provided at least 60 percent of all violations. For example, if a standard had been cited 2,000 times as a serious violation and it had 10 sub-provisions, we included it only if one of the sub-provisions had at least 1,200 violations (60 percent of 2,000). That sub-provision would be the standard included in our analysis.

11 Since these were ordinal measures – high, medium and low probability of an accident in the next year if the violation were not corrected – we used Kendall's tau as a measure of the inter-rater reliability of the hazardousness rankings. The average of the three was +0.45, which is considered "moderately strong." See, for example, Haldun Akoglu, "User's guide to correlation coefficients," Turk J Emerg Med. 2018 Sep; 18(3): 91–93. Published online 2018 Aug 7. doi: 10.1016/j.tjem.2018.08.001.

12 We had considered using OSHA's calculation of the "gravity" of the violation as a measure of how hazardous it was. OSHA calculates "gravity" as a function of both the severity of the injury, if one occurs, and the probability that it will occur. This is a reasonable approach. However, when we looked at the data, we found that severity and probability had a high positive correlation. In other words, hazards that would cause severe injuries were also expected to have them more frequently. We found this correlation implausible since more severe injuries tend to be considerably less frequent. As a consequence, we decided to develop our own measure of "hazardousness."

13 The same argument applies to any "general" standard that may be cited along with more specific standards. The general machine guarding standard is by far the most prominent example.

14 In some respects, our measure of re-violations is too low. We limit it to cases where both the initial violation of the standard and the later one were classified as Serious, Repeat or Willful. Thus, we do not include cases where the same standard was cited, but where the initial violation or the later one or both were cited as "other than serious" violations. As

Table 2 shows, this category includes about 27 percent of all violations. We also include only programmed, complaint and follow-up inspections as candidates for later inspections, excluding categories which include about 15 percent of inspections.

15 While the marginal coefficients in the two subsamples are similar in magnitude, the much higher re-violation rate for programmed inspections yields a smaller percent impact.

16 One reason for the high rates reported for these health standards could be that they each include many different toxic substances. Thus, 1910.1000(a) could be cited again even if the earlier violation pertained to, for example, overexposures to perchloroethylene and the later violation pertained to overexposures to sulfur dioxide.

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APPENDIX I

Standards Suitable for Analysis

Standard	S/ H	Category	Hazard rating	Median abate	# of obs	Description
19100022 A01	S	HM	4	15	2,313	Keep workplace clean and orderly
19100022 A02	S	HM	7	18	1,722	Keep floors clean and dry
19100022 B	S	HM	3	19	1,109	Aisles free of obstructions
19100023 A08	S	PE	7	14	1,051	Floor holes guarded by rails or floor cover
19100023 C01	S	PE	5	19	6,928	Elevation >4’ must have railing
19100024 H	S	PE	6	18	834	Place hand rails on open side of exposed stairways
19100095 B01	H	EC	8	119	1,126	Feasible administrative or engineering controls for noise >90 db or PPE
19100095 C01	H	WP	8	47	1,858	Hearing conservation program required >85 db
19100095 D01	H	ME	6	33	732	Noise monitoring when >85 db
19100095 G01	H	ME	7	35	727	Audiometric testing program >85 db
19100095 I02	H	WP	9	12	1,048	Employers shall ensure that hearing protectors are worn
19100095 K01	H	T	3	34	938	Training when noise above 85 db
19100106 E09	S	HM	4	12	649	Housekeeping for flammable liquids
19100107 C06	H	WP	6	33	945	Wiring used in spray painting shall be spark-free
19100107 E02	H	HM	3	15	753	Minimize flammable liquids near spray painting
19100107 G02	H	HM	4	18	988	Remove combustible residues near spray painting; use no-spark cleaners
19100132 D01	H	HA	6	32	1,942	Assess need for personal protective equipment-PPE
19100132 D02	H	W	3	33	841	Certification of PPE hazard assessment
19100132 F01	H	T	6	33	857	Train each worker required to use PPE
19100133 A01	S	PE	8	12	2,863	Require eye or face protection
19100134 A	H	PE	7	33	1,046	Supply respirators; have a respiratory protection program (RPP)
19100134 C01	H	W	5	34	925	Requirements of the RPP
19100134 E01	H	ME	5	33	945	Medical evaluation prior to required respirator use
19100134 F01	H	ME	5	33	492	Fit tests required for tight-fitting respirators
19100134 F02	H	ME	5	33	758	Fit tests at least annually or when changes made
19100134 K01	H	T	5	33	407	Ensure workers know specifics of respirator use
19100138 A	S	PE	9	17	774	Provide hand protection
19100146 C01	H	HA	6	33	1,203	Assess presence of permit-required confined spaces
19100146 C02	H	PE	5	26	1,284	If they are present, post danger signs
19100146 C04	H	W	5	34	1,070	Prepare a written permit space program
19100146 G01	H	T	6	33	1,010	Provide training on confined spaces

(*Continues*)

Standard	S/ H	Category	Hazard rating	Median abate	# of obs	Description
19100147 C01	S	W	8	33	5,015	Have a program of lock-out/tag-out (LOTO) to control machine energy
19100147 C04	S	WP	7	33	8,923	Develop LOTO procedures for energy control
19100147 C06	S	ME	5	33	3,847	Inspect LOTO procedure at least annually
19100147 C07	S	T	7	33	6,429	Provide skills and knowledge for LOTO
19100147 D04	S	PE	5	20	1,939	Use logout and tagout devices
19100151 B	H	T	4	33	262	When doctor not near, have trained first aid
19100151 C	H	PE	6	26	4,588	Provide facilities for quick drenching or flushing of eyes and body
19100157 C01	S	PE	3	10	832	Provide accessible portable fire extinguishers
19100157 E03	S	HM	3	18	378	Check extinguishers at least annually; record
19100157 G01	S	T	4	33	1,323	Explain extinguisher use and hazards
19100157 G02	S	T	3	33	1,399	Training at initial employment and annually
19100176 B	S	SS	5	17	1,553	Stack materials so they are stable and secure
19100178 P01	S	WP	3	13	2,000	Forklift-terminate operation until back to safe condition
19100178 Q07	S	ME	3	18	827	Forklift-daily or more frequent examinations before service, report defects
19100179 J03	S	ME	4	33	438	Inspect cranes periodically
19100212 A01	S	G	9	25	13,356	Guard machines – general
19100212 A03	S	G	9	30	8,129	Guard point of operation for machines
19100212 A05	S	G	4	12	1,511	Guard blades <7 feet above floor or working level with openings <0.5 inch
19100212 B	S	D	3	13	759	Anchor fixed machinery to floor
19100213 B03	S	D	5	26	879	Woodworking machines-prevent automatically restarting upon restoration of power
19100213 C01	S	G	8	18	593	Guard circular hand-fed ripsaw with a hood
19100213 C02	S	PE	6	19	470	Furnish wood machine operator with a spreader
19100213 C03	S	PE	6	19	551	Provide wood machine operator with kickback fingers
19100213 D01	S	G	8	17	516	Guard circular crosscut table saw with a hood
19100213 H01	S	G	7	18	1,720	Hood must protect upper portion of radial saw
19100213 H04	S	G	5	18	1,166	Install radial saw so that front end is elevated
19100213 I01	S	G	7	18	605	Guard bandsaw blades, except cutting part
19100215 A02	S	G	4	16	979	Design for guarding abrasive wheels

(*Continues*)

Standard	S/ H	Category	Hazard rating	Median abate	# of obs	Description
19100215 A04	S	D	4	10	3,672	Design of rests for holding material for grinding
19100215 B09	S	D	4	10	6,121	Design of guards for certain types of grinders
19100217 B04	S	D	4	25	1,035	Pedal design shall prevent unintended operation – mechanical punch press
19100217 C01	S	G	9	33	1,936	Power press – general machine guarding
19100217 C02	S	G	9	32	2,084	Power press – Point of operation guarding
19100217 E01	S	ME	5	33	1,820	Program for inspections, maintenance and recordkeeping for power presses
19100219 B01	S	G	4	27	1,227	Guard flywheels less than 7 feet above floor
19100219 C02	S	G	7	25	1,853	Guard horizontal shafting-mechanical transmission
19100219 C04	S	G	6	20	1,043	Guard projection shaft ends
19100219 D01	S	G	6	19	5,319	Guard pulleys <7 feet from floor and platform
19100219 E01	S	G	6	19	2,391	Guard horizontal belts and ropes
19100219 E03	S	G	6	23	3,269	Guard vertical and inclined belts
19100219 F01	S	G	7	27	1,023	Guard gears for mechanical transmission
19100219 F03	S	G	6	19	3,757	Enclose sprockets <7 feet above floor or platform, provide protection from falling
19100242 B	S	WP	6	12	3,442	Do not use compressed air for cleaning with exceptions
19100252 B02	S	PE	8	17	1,265	Use helmets to protect eyes when welding
19100253 B04	S	SS	3	8	2,258	Safe storage of oxygen for welding
19100303 B01	S	HA	4	12	1,848	Determine safety of electrical equipment
19100303 B02	S	WP	4	13	1,694	Install and use electrical equipment as labeled
19100332 B01	S	T	6	43	1,443	Train workers in electrical safety
19100333 B02	S	WP	7	33	1,648	When electric exposure, lock-out equipment
19100334 A02	S	HA	5	10	851	Visually inspection cords and plugs before shift
19101000 A	H	EC	5	90	1,245	Toxic exposures limited to below levels in Tables Z-1
19101000 C	H	EC	5	120	958	Toxic exposures limited to below levels in Tables Z-3
19101000 E	H	EC	5	127	1,905	Use administrative or engineering controls for respiratory hazards
19101025 L01	H	W	5	33	697	Regular training for lead-exposed workers
19101030 G02	H	T	5	33	1,078	Information/training on bloodborne pathogens
19101200 E01	H	PI	4	33	4,915	Written communication program for labels and warnings for hazardous chemicals
19101200 F05	H	PI	6	17	3,874	Label, tag or mark hazardous chemicals on containers

(*Continues*)

Standard	S/ H	Category	Hazard rating	Median abate	# of obs	Description
19101200 G01	H	W	5	27	1,501	Develop safety data sheet for each hazardous chemical
19101200 G08	H	PI	4	26	969	Ensure safety data sheet available to employees
19101200 H01	H	T	8	33	1,774	Information and training at initial assignment or with new chemical hazard

Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Table S1. Likelihood of Re-violation, Given an Inspection, Federal OSHA Manufacturing (Logistic Regression – marginal effects).

