

Work-Related Falls Among Union Carpenters in Washington State Before and After the Vertical Fall Arrest Standard

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Background Washington State enacted a change in their fall standard for the construction industry in 1991, preceding the Safety Standard for Fall Protection in the Construction Industry promulgated by Federal OSHA in 1994.

Methods We evaluated changes in the rate of falls from elevations and measures of severity among a large cohort of union carpenters after the fall standard change in Washington State, taking into account the temporal trends in their overall injury rates.

Results There was a significant decrease in the rate of falls from height after the standard went into effect, even after adjusting for the overall decrease in work-related injuries among this cohort. Much of the decrease was immediate, likely representing the publicity surrounding fatal falls and subsequent promulgation of the standard. The greatest decrease was seen between 3 and 3½ years after the standard went into effect. There was a significant reduction in mean paid lost days per event after the standard change and there was a significant reduction in mean cost per fall when adjusting for age and the temporal trend for costs among non-fall injuries.

Conclusions Through the use of observational methods we have demonstrated significant effects of the Washington State Vertical Fall Arrest Standard among carpenters in the absence of a control or comparison group. Without controlling for the temporal trend in overall injury rates, the rate of decline in falls appeared significantly greater, but the more pronounced, but delayed, decline was not seen. The analyses demonstrate potential error in failing to account for temporal patterns or assuming that a decline after an intervention is related to the intervention. *Am. J. Ind. Med.* 44:157–165, 2003.

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KEY WORDS: construction work; carpenters; falls; intervention evaluation; fall protection; evaluation methods; OSHA regulations

INTRODUCTION

Work-related falls are a significant public health problem for individuals employed in the construction trades, and the enormous costs of occupational falls, financially and in work lost time, are well documented [Sorock et al., 1993; Kisner and Fosbroke, 1994; Leamon and Murphy, 1995]. Despite the documentation of the problem, very little is known about the effect of interventions in preventing these injuries and lessening their severity. A recent systematic

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review of the effectiveness of prevention of falls in construction revealed very little data to support the effectiveness of current programs; only three studies were identified for review [Rivara and Thompson, 2000]. The authors noted the lack of evaluation of the effect of the OSHA standard designed to protect construction workers. Two studies on educational efforts, outside the US, suggested that educational programs may decrease falls, but methodological limitations restricted conclusions which could be drawn [Saarela, 1989; Lingard and Rowlinson, 1997]. Only one study evaluated the effect of a policy change or standard [Nelson et al., 1997]. Since that review, a report of fatal falls in construction 1990–1999 has been conducted using the Occupational Safety and Health Administration's (OSHA) Integrated Management Information System (IMIS) database [Derr et al., 2001]. No effect of the federal OSHA Fall Protection Standard, promulgated in 1994, was demonstrated; however, the authors felt lack of power may have contributed to their inability to detect significant changes.

The work by Nelson et al. [1997], attempted to evaluate differences in fall rates of construction employers who were inspected shortly after the Washington State standard went into effect compared to a control group of employers who were not inspected. The work was hampered by the need to exclude over two-thirds of construction employers (and self-insured employers) because they did not submit employee work hours for the full eight quarters of the study to the Department of Labor and Industries. Despite the limitations, their analyses support the role of regulatory inspections in reducing injuries and suggest that fall injury rates might be expected to decrease if more employers were inspected; cited employers were 2.3 times as likely to experience a reduction in claims for falls as control employers, after adjustment for employer size and type of business.

The 25 states and territories, which operate their own occupational safety programs are expected to provide programs at least as effective in protecting workers as federal standards would mandate. Washington State enacted a dramatic change in their fall standard for the construction industry and its enforcement in February 1991 based on the report of an advisory task force established after a record loss of 22 lives due to falls in 1988. This action preceded the Safety Standard for Fall Protection in the Construction Industry promulgated by OSHA in 1994. The Washington standard (Washington Administrative Code 296-155) requires, among other things, personal protective equipment and a fall protection plan identifying workers at risk of a fall of 6 ft or more (10 ft prior to 1994 federal ruling). The Washington provisions have included residential construction. The standard, which is similar to the later promulgated Federal standard, includes activities that should reduce the risk of falling (appropriate cover for openings and leading edge warnings, by example) as well as use of equipment and safety planning to reduce the impact of falls should they

occur and provisions for rapid evacuation of the worker in the event of injury. As such, potential measures of effect of the standard would include not only the rates at which falls from elevations occur, but also measures of the severity of falls sustained.

We describe analyses of the workers' compensation experience of a large cohort of union carpenters in Washington State between 1989 and 1998 to evaluate the effect of this standard on this group of high risk workers.

METHODS

Data Sources

Using data from the Carpenters Trusts of Western Washington, the United Brotherhood of Carpenters and Joiners, and the Washington State Department of Labor and Industries (L&I) we identified a cohort of union carpenters who worked in the State of Washington between 1989 and 1998, their hours of union work each month, and their workers' compensation claims. The compensation claims data included the date of injury, American National Standards Institute (ANSI) codes describing the events in terms of body part injured, the nature of the injury, the type of event causing the injury, the amount of lost work time associated with each injury, and the costs associated with lost time, medical care, and permanent impairment. The records of workers' compensation claims filed by these individuals included medical only claims as well as those, which resulted in lost work time. Detailed information about the data sources and the merging of these records on an individual basis without the use of personal identifiers has been previously reported [Lipscomb et al., 1997; Lipscomb et al., 2000]. Analyses were limited to individuals who worked at least 3 months of union hours during this 10-year period.

Events of Interest and Time at Risk

These combined data were used to create event histories for each individual. Person-hours of work as a union carpenter were used as the measurement of time at risk. The carpenters were considered to be at risk of injury at any time they were working union hours. The occurrence of one injury did not remove the worker from the risk set for a new event as long as he/she was still working. Although person-hours were used as the measurement of time at risk, the person-month was effectively the unit of analysis since we do not know when the hours in any given month were accumulated. All hours in months, in which an injury occurred, were counted as time at risk for that injury. Only injuries, which occurred in a month that the individual worked union hours were counted so that events and time at risk were counted on the same basis for rate calculations.

Analyses

Using the coded compensation records, injuries resulting from falls from elevations were identified and rates of injury were calculated per 200,000 hr of union work for each quarter over this 10-year period. Rates of all non-fall injuries were calculated in a similar manner, excluding claims for occupational illnesses. The percentages of change from baseline in the rates of falls from height and other injuries were calculated for each quarter; changes were plotted to allow a basic understanding of the temporal trends.

Time at risk and events were stratified by time before and after the fall arrest standard in 3-month intervals of calendar time as well as by gender, categories of age and time in the union for multivariate analyses using Poisson regression [Nizim, 1998]. Age and time in the union were both treated as time-varying variables with time at risk accumulating in the appropriate strata over the 10-year period. Dummy variables were created for the categories of gender, age, union time, and calendar time before and after the intervention. The percentages of change in non-fall injury rates for each 3-month period were entered into the model as a quasi-continuous offset variable, allowing us to assess the rates of falls before and after the fall arrest standard adjusting for the makeup of the dynamic cohort and the temporal trend in overall injury rates over the 10-year period.

A series of models were run comparing rate ratios before and after the standard went into effect that were lagged at 6-month intervals, essentially excluding increasing amounts of time at risk and events after the standard went into effect in the analyses. This was done because it was expected that the standard would have increasing effectiveness over a period of time and this technique would allow us to identify periods of time when it appeared that the standard may have had maximal effect. These analyses were repeated separately for injuries that resulted in paid lost time from work.

Since the standard includes measures which are designed to decrease severity of falls, as well as their occurrences, we also compared potential indicators of injury severity before and after the standard including paid lost days and direct payments for medical care, indemnity, and permanent impairment. Payments were adjusted to 2002 dollar values based on Consumer Price Index conversion factors for each year [Sahr, 2003]. All analyses were done using SAS Version 8 [SAS Institute, Inc., 1999].

RESULTS

From the union eligibility files, 16,215 carpenters were identified who worked at least 3 months of union hours between 1989 and 1998. The cohort included 15,762 men (97.2%) and 453 women (2.8%). Age at entry into the study cohort (not union initiation) ranged from the age of 17 to 75 years, with a mean of 35 years and a median of 34 years.

Time in the union ranged from less than 1 year to 49 years. Mean time in the union was 6.9 years; median was 1 year. Over this 10-year period of time the cohort worked a total of 102,144,049 hours. Rates of falls from elevations ranged from a high of 4.4 per 200,000 hours in the last quarter of 1989 to a low of 1.2 per 200,000 hours in 1998. Over this same period of time, the overall rates of non-fall related injuries decreased from 45.0 per 200,000 hours in 1989 to 24.9 per 200,000 hours in 1998. In Figure 1A the percentages of change in the rates of falls from elevations and non-fall injuries are plotted over this 10-year period of time. Figure 1B demonstrates these same changes for injuries that resulted in paid lost time from work, which occurs in Washington State after the third lost day. There was a marked drop in the rate of falls, overall and of more serious ones resulting in paid lost time, before the fall standard went into effect in February 1991, with a continued decline through 1998. There is a similar pattern of declining rates of other injuries as well, but without the marked drop before 1991.

In Figure 2A,B the ratios comparing rates before and after the standard based on Poisson regression analyses, with variable lagging lengths applied, are depicted. For all falls, and those resulting in paid lost time, we present modeling results with and without correcting for the overall decline in injury rates among the cohort. Without correction, the most pronounced decline overall occurred before the standard went into effect (months lagged = 0). When correcting for the overall pattern of decline, there is a much less dramatic decline in the rates of falls, particularly in the first 36 months after the standard went into effect. The most significant drop occurs between 36 and 42 months after the standard went into effect and that drop is sustained through 72 months of follow-up. When looking only at paid lost time claims the same pattern is seen with the greatest drop between 36 and 42 months.

In Table I, mean measures of severity before and after the standard went into effect are shown for paid lost time claims. Injuries that result in no lost time, obviously, have no lost days or costs associated and rarely result in permanent impairment so these analyses were limited to paid lost time injuries. These measures were plotted by calendar year for falls from height and non-fall injuries to document temporal trends. Graphs depicting changes over the 10-year period demonstrate marked declines in these measures before the standard went into effect (Fig. 3A,B). When looking at the pattern of paid lost days compared to non-fall injuries the changes are more pronounced for falls after 1991 when the standard went into effect. Over the 10-year period there was a 64% reduction in the proportion of falls from height that required hospitalization, compared to a 42% reduction in other injuries requiring hospitalization.

Using log transformed outcome measures to normalize the distributions, linear modeling was used to evaluate the effect of the intervention (coded as a dummy variable) on



FIGURE 1. Percentages of change in injury rates over time, 1989–1998, Union Carpenters Washington State. **A:** All injuries. **B:** Paid lost time injuries.

paid lost days and payments. Initially models were run for each cost measure separately. However, results were similar and payments were combined and only presented as a total. These models were adjusted for age, which is a significant predictor of costs associated with falls [Lipscomb et al., 2003 (this issue)]. There was a significant effect of the intervention on paid lost days ($P = 0.0003$; parameter estimate -181.6 , $SE = 50.2$). In contrast, there was no significant effect on total direct payments ($P = 0.11$; parameter estimate -0.30 , $SE = 0.19$).

Additional analyses were done to take into consideration the temporal increase in direct payments that were associated with non-fall injuries, that might be expected due to

increasing costs of medical care and wage replacement. Mean payments per claim were calculated and stratified for periods of time before or after the standard by type of injury (fall or non-fall) and 10-year age groups. The percent change in costs for each stratum of age was calculated for non-fall injuries and applied to the cost of each fall in the appropriate strata; calculating an expected mean cost if falls had the same changes in percent cost over time as non-fall injuries. A paired t -test, weighted by the number of injuries in the age strata, was used to assess the differences in observed and expected costs, demonstrating a significant reduction in total costs for falls after the standard ($P < 0.0001$, $t = -19.7$). In Table II, the observed and expected mean total costs are

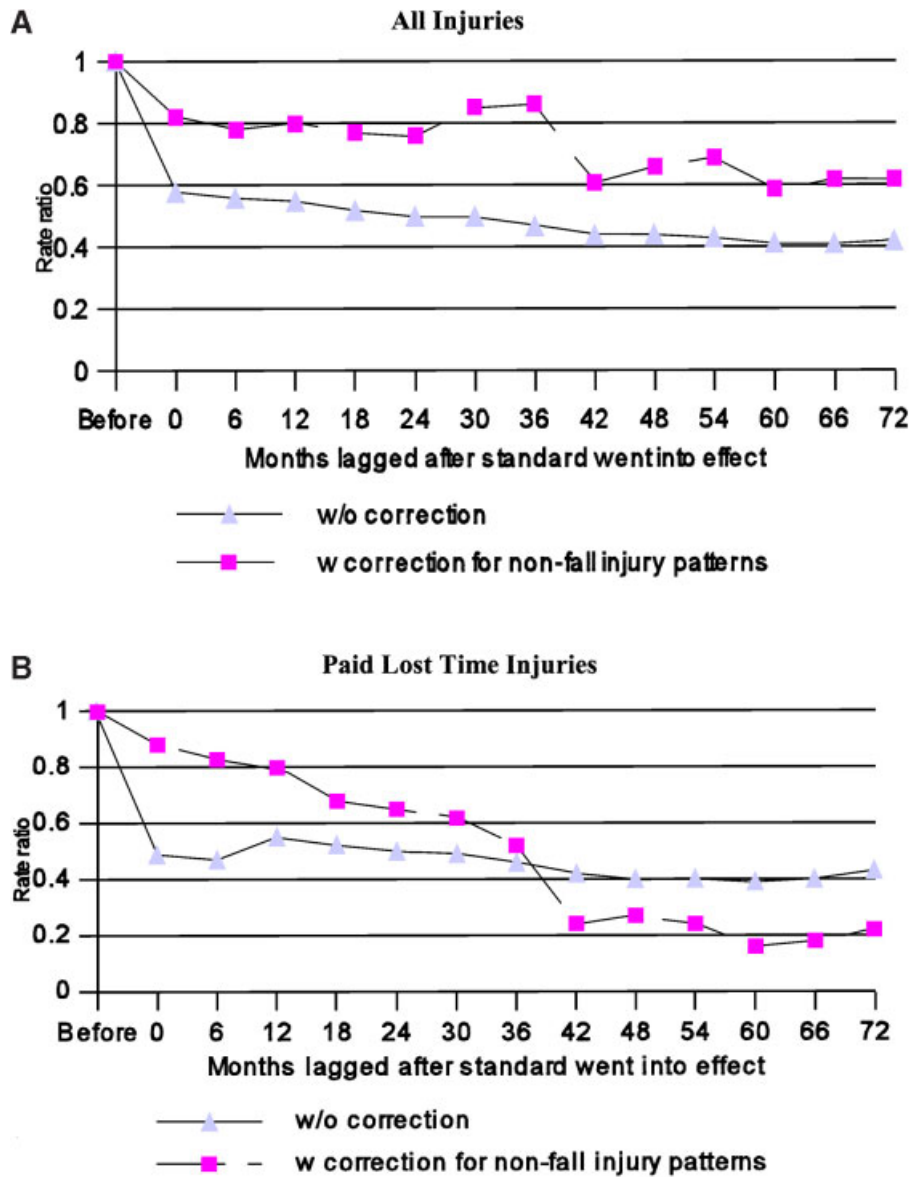


FIGURE 2. Rate ratios for (A) all falls, (B) paid lost time falls with progressive months of lagging after the fall standard.

TABLE I. Changes in Severity Measures: Falls From Heights That Resulted in Paid Lost Time, Washington Carpenters, 1989–1998

	Mean per injury before standard	Mean per injury after standard	Difference (P-value)
Number of paid lost days	399	240	-159 (<0.001)
Amount paid for lost days (\$)	29,995	20,289	-9,506 (<0.0001)
Amount paid for medical care (\$)	14,986	11,664	-3,322 (<0.0001)
Amount paid for impairment (\$)	5,368	5,060	-308 (=0.49)
Total amount paid (\$)	50,349	37,213	-13,136 (<0.0001)

Payments adjusted to 2002 dollar value.

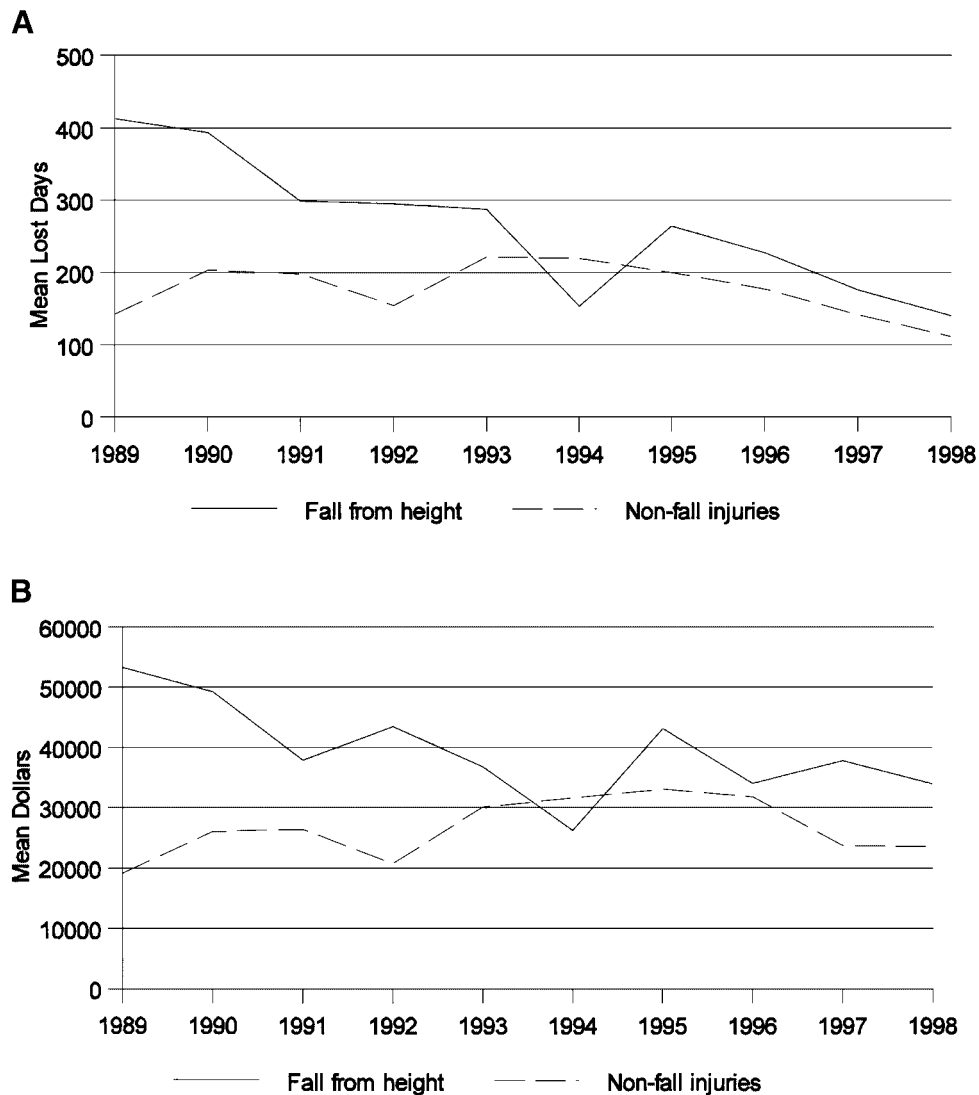


FIGURE 3. A: Mean paid lost days per claim for injuries resulting from falls from elevations and non-falls. **B:** Mean direct payments per claim for falls from elevations and non-falls. Union Carpenters Washington State, 1989–1998.

presented by age strata. Only total costs are presented for simplicity, although significant differences were seen for each cost parameter using this methodology.

DISCUSSION

In our analyses we observed a 20% reduction in the rate of falls from elevations comparing rates before and after the 1991 standard change, using no time lagging, but taking into account the overall trend in injury rates among these union carpenters. This pattern was sustained until 3 years after the standard went into effect at which point the most significant decline was seen. Without controlling for the temporal trend in overall injury rates, the rate of decline appears significantly greater, but the more pronounced, but delayed decline is not

seen. Results are similar, but more dramatic, for paid lost time claims. There was also a significant decline after the standard on potential measures of severity (including mean number of lost days and costs for medical, indemnity, and impairment).

We believe the early changes in rates and severity are likely due to the publicity surrounding the need for a standard and anticipation of the change. The Department of Labor and Industries undertook a widespread informational campaign and education program for employees and employers at the time the standard was developed including providing written materials and holding local workshops [Nelson et al., 1997]. It is possible that activities surrounding the fall standard increased awareness and attention to other safety issues on job sites that somehow influenced the overall decline, but we

TABLE II. Mean Direct Payments for Falls From Heights That Resulted in Paid Lost Time Before and After Standard Change Adjusting for Payment Changes in Non-Fall Injuries, Washington Carpenters, 1989–1998

Age category	Mean direct payments ^a (\$)			
	Before standard	After standard		
	Observed	Observed	Expected ^b	Difference
<20	2,755	6,339	9,074	-2,735
20-<30	26,936	23,413	26,504	-3,091
30-<40	43,701	29,676	46,258	-16,582
40-<50	57,046	43,703	73,868	-30,165
50-<60	102,398	63,275	150,793	-87,518
60+	104,276	49,703	143,509	-93,806
Overall	50,349	37,213	62,106	-24,893

^aPayments include medical, indemnity (wage replacement), and permanent impairment; payments adjusted to 2002 dollar value.

^bExpected = observed age-specific percent change in non-fall injury costs.

think the standard is unlikely to have been responsible for the pattern of non-fall injuries over this 10-year period. The greatest decline in rates occurred between 3 and 3½ years after the standard went into effect; with about a 60% decline sustained through the next 3 years. The progressive lagging by calendar time substantially decreases the data that are available for analyses and was not reasonable beyond this 72-month period. Severity of falls also declined, and appeared to be related to the standard, while there was not a corresponding magnitude of decline in severity measures for non-fall injuries.

The effect of a standard such as this can be difficult to assess with the regulation change applying to the entire industry at the same point in time. We were interested in using observational techniques to evaluate changes in incidence density rates before and after the change among a well-defined occupational cohort. We were also interested in what periods of time the effects of the standard might be most pronounced. Our approach was to evaluate changes in fall rates accounting for the temporal trends in overall injury rates over the 10-year observation period among these carpenters, as opposed to using trends for falls before the intervention to predict expected fall rates after the intervention. We felt this was a more appropriate approach for our data because of the relatively limited amount of observation before the standard change went into effect (just over 2 years) and the marked decline in the fall rates in the year prior to the standard. The trust fund, from which we obtained our data, did not have electronic data available before 1989 from which we could define the cohort and their time at risk. We were also faced with the dilemma of limited observation time before the standard went into effect and decreasing overall injury rates,

obviously, not related to the standard change for which we wanted to account.

We used Poisson regression for multivariate analyses, since it is particularly useful in the analyses of longitudinal data for a dynamic cohort, such as this one, allowing maximal use of available data for each individual [Checkoway et al., 1989]. Through our analyses we were able to adjust for age, time in the union, and predominant type of carpentry work, which are known to be associated with risk of injury [Lipscomb et al., 1997; Lipscomb et al., 2000], including falls [Lipscomb et al., 2003 (this issue)], among this cohort; while also adjusting for temporal trends in overall injuries. The methods we used were similar to those described by Kuhn et al. [1994] in evaluating changes over time in rates of childhood injuries following a prevention program, providing estimates similar to those obtained in time series analyses. The approach allowed us to use observational data to evaluate the effect of this standard on a large cohort of workers taking into account the overall pattern of injury decline during this time period. The findings point out the potential for error in failing to account for overall patterns or assuming that a decline after an intervention is related to the intervention. It is interesting that for all falls from heights, when adjusting for the temporal decline, the rate ratios are always of a lesser magnitude with this correction. However, for paid lost time claims, the magnitude of effect is more pronounced after 42 months than without the correction; suggesting that failing to correct overestimates the effect of the standard in the early years after the standard went into effect and underestimates its effect later. We had no information on the height from which these carpenters fell and consequently whether they should have been protected by the standard. Based on severity, the paid lost time claims were more likely to have been the result of a fall from 6 ft or greater, and the analyses of those claims may more accurately reflect the affect of the standard change. In addition, employers who self-insure are not required to report injuries that do not result in paid lost time to the Department of Labor and Industries, perhaps making the paid lost time claims analyses more representative of the experience of this large cohort.

We did not have information about the effect of the standard on contractors that were inspected or cited, which was the focus of the evaluation of the analyses by Nelson et al. [1997]. Her work was consistent with study of manufacturing plants, where a 22% reduction in injury rates was seen after employers were inspected by OSHA [Gray and Scholz, 1993]. These authors pointed out that although injuries decreased after inspection, the overall effect of enforcement is small because only a small proportion of employers are inspected by OSHA. The Oregon Department of Consumer and Business Services reported an 85% reduction in citable hazards upon subsequent industrial inspections and a reduction in disabling injuries of 18% in the 2 years following the

consultation visit [Oregon Dept. of Consumer and Business Services, 1994a,b]. All of these findings support the principal of specific deterrence in which employers are more likely to respond if their company is likely to be inspected versus general deterrence, where the likelihood of inspection of any employer would deter employers throughout the industry.

Our findings certainly do not counter these reports with increasing numbers of contractors visited by safety inspectors overtime; in the first year of the standard 5.6% ($n = 1,609$) of construction employers insured by Washington's State Fund were visited by plan safety inspectors and cited for violating the standard [Nelson et al., 1997]. While changes may be more pronounced among contractors who were inspected, our analyses focused on a very dynamic work cohort—not on a contractor level. Using these methods, we still saw a substantial decline in the rate, and the severity, of falls among this large, and diverse, cohort of carpenters. The most pronounced decline occurred 3 to 3½ years after the standard and is consistent with an increasing effect of the standard over time. Although costs were not the major focus of this study, we did use direct payments as a surrogate for injury severity. We did not have access to complete data for econometric models and chose a fairly simple observed-to-expected comparison of total direct payments recognizing that there are more complex models available for cost analyses.

In reality, construction workers work for many contractors as they constantly work themselves out of their jobs as building projects are completed. Their job sites can be small, with the number of workers at any given site likely to be small. There are no permanent job sites, as in an industrial setting, in which to place environmental controls or to easily regulate or reinforce safety practices. Because of the dynamic nature of their work, very small gains would be expected from changes at any given work site—particularly in some segments of the trade. “In construction it is not enough to think about what needs to be done in individual workplaces. In construction, we must think industry-wide, because that is how workers are employed [Ringen and Seegal, 1995].”

Construction workers may have an advantage over industrial workers in that they structure their work environment on a daily basis, making decisions that have great potential to affect their health and safety. Because their job sites change frequently and they potentially are involved in those changes, they have the capacity to have a positive impact on the safety environment. This is an aspect of construction that can be viewed as an opportunity—but application of a fall standard requires more than worker desire. Equipment and safety practices must be part of the work environment and are the responsibility of the contractor for whom the worker is employed. While, there is still much to be learned about effects of different types of interventions aimed at reducing workplace injuries and how these interventions can be applied most effectively on an industry wide basis,

particularly among a very mobile workforce, these analyses demonstrate observational methods that can be used to evaluate the effect of an intervention on a large workforce in the absence of a control group.

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