

# Effects of Safety and Health Training on Work-Related Injury Among Construction Laborers

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**Objectives:** This study was designed to evaluate the effects of safety and health training on work-related injury in the construction industry. **Methods:** Union health insurance records, union training records, and workers compensation data for 1993 and 1994 were analyzed for more than 8000 construction laborers in Washington State. **Results:** After controlling for demographic factors, laborers who received safety and health training during the study period were 12% (95% confidence interval [CI] = 0.75–1.02) less likely than nontrained laborers to file for workers compensation. Among workers 16 to 24 years old, training was associated with a 42% (95% CI = 0.35–0.95) reduction in claims. **Conclusions:** These findings provide evidence of the effectiveness of safety and health training in preventing occupational injuries among construction laborers, particularly among younger workers. However, the results cover only a limited time and the long-term effects remain unclear. (J Occup Environ Med. 2004;46:1222–1228)

Construction labor is one of the most dangerous occupations in the United States. The laborer trade encompasses a wide variety of manual labor tasks, many of which involve exposure to hazardous physical and chemical agents. Studies show that laborers have an increased health risk as a result of exposure to asbestos, lead, noise, cement, carbon monoxide, and numerous other agents.<sup>1,2</sup> In addition to these hazardous exposures, laborers face an elevated risk of death or injury on the job, having an increased risk for fatal falls, electrocutions, confined space injuries, cave-ins, motor vehicle accidents, and other work-related injury events.<sup>3–8</sup> According to the Bureau of Labor Statistics (BLS),<sup>9</sup> in 2001, 344 construction laborers died of occupational injuries, a rate of almost one death per day. In the same year, approximately 120 construction laborers per day suffered nonfatal work-related injuries.<sup>10</sup> Death rates and nonfatal injury and illness rates for construction laborers are consistently higher than those for many other construction trades,<sup>2,3,5,11</sup> and one study suggests that laborers' injuries might also be more serious and more likely to require hospitalization.<sup>12</sup> These injuries place an enormous social and financial burden on workers and their families, the construction industry, and the public.

In recent decades, advancement in the systematic evaluation of construction hazards has given rise to a variety of safety and health training programs aimed at construction la-

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borers. Support for these programs is based on the assumption that raising laborers' safety and health awareness will minimize hazardous behaviors and exposures, thereby reducing the incidence of injury. Although it may appear intuitively obvious that raising laborers' safety and health awareness will reduce their risk of injury on the job, quantitative evidence of this effect is lacking in the scientific literature. Research to date has identified a variety of worksite injury hazards and promoted the development of training interventions but failed to systematically assess the effect of training on either the number or severity of construction worker injuries. A recent study of 45 open-shop (nonunion) construction companies showed that although a majority of contractors surveyed provided some type of employee safety training, most did not quantitatively evaluate their training programs in terms of accident reduction or changes in workers compensation rates.<sup>13</sup>

The lack of research linking safety and health training to construction worker injury represents a gap in the injury prevention process and a barrier to informed decision-making among occupational health professionals and construction industry stakeholders. Occupational health professionals and policymakers at the national, state, and local levels need scientific evidence of training's injury prevention effect to confidently promote training interventions, develop standards, and set funding priorities. Likewise, reliable information on the impact of training on injury rates can help construction contractors and healthcare payers evaluate the cost-effectiveness of training programs and compare the relative benefits of alternate injury prevention approaches.

The purpose of this study is to assess the effectiveness of safety and health training in reducing the incidence of work-related injury in a cohort of construction laborers in Washington State. Combined admin-

istrative datasets were used to identify union hours worked, safety and health training received, and workers compensation claims for each member of the cohort during the two-year period 1993 to 1994. It was hypothesized that workers who received safety and health training during the study period would have significantly fewer workers' compensation claims than nontrained workers, and that workers' compensation claim rates would vary according to age, gender, and the number of training hours received.

### Summary of the Literature

A review of the literature revealed only two published studies of the impact of safety and health training on injury outcomes in the construction industry. Kinn et al. assessed the injury prevention effect of safety orientation and training among plumbers and pipefitters in northwestern Ohio.<sup>14</sup> Matching training records for six employers with the Occupational Safety and Health Administration's "recordable" injury data for 1996 to 1998, Kinn et al. reported that employee safety orientations were significantly associated with a reduction in injuries (odds ratio [OR] = 0.23, 95% confidence interval [CI] = 0.15–0.35). Only 3% of workers who had received orientations experienced injuries, compared with 11% of workers without orientations. Among injured workers, 58% lacked the appropriate safety education and training level.

Johnson and Ruppe<sup>15</sup> reported a reduction in injury and lost workdays associated with comprehensive tool box training sessions in a construction company in Hawaii. Approximately 50 male union construction workers involved in carpentry and drywall work attended weekly, mandatory safety and health workshops with an emphasis on improving employee relations and morale. Results showed a reduction in reported injuries, lost workdays, observed safety hazards, and levels of perceived stress for a majority of workers dur-

ing each of the two years after implementation of the weekly training session. The internal validity of this study is limited, however, by the small sample size and the lack of a control group.

The remaining published studies to evaluate the effectiveness of construction safety and health training rely on change in workplace safety practices, rather than injury outcomes, to measure training effect. Results of these studies are mixed. Lingard and Rowlinson<sup>16</sup> evaluated the effects of a motivational safety management program on the observed safety behavior of workers at seven construction sites in Hong Kong. Worksite observations showed highly significant improvements in site housekeeping, but only moderate improvements in access to heights and no significant effect on safety performance relating to the use of bamboo scaffolding.

In a similar study, Lingard<sup>17</sup> assessed the effects of first aid training on observed safety practice among 22 employees of small construction companies in Australia. Before-and-after measurements of worker safety performance showed significant improvement in use of personal protective equipment, but only moderate improvement in use of tools and no significant change in two other individual safety performance categories. Results of interviews conducted before and after the training intervention suggested that training made participants more aware of the importance of their own behavior in avoiding injury and reduced their willingness to accept prevailing levels of occupational injury risk. Based on the combined results of these interviews and the behavioral observations, the author concluded that first aid training can have an important positive injury prevention effect. However, study findings were limited by the small sample size and inability to complete all planned observations as a result of variability in worksite activity.

Other studies rely on self-reports of behavioral outcomes. Lusk et al.<sup>18</sup> reported that a theory-based intervention consisting of a video, pamphlets, and a guided practice session significantly increased self-reported use of hearing protection devices (HPDs) in a group of over 800 construction workers but did not significantly improve intention to use HPDs in the future. Materna et al.<sup>19</sup> evaluated an educational intervention to improve self-reported lead safety practices among 21 painting contractors and their employees. Analyzing the results of pre- and postintervention interviews as well as postintervention employer focus groups, the authors found only modest improvements in reported lead-safe practices, with 15 of 27 employees and three of 12 employees meeting target work practice objectives. Finally, Albers et al.<sup>20</sup> evaluated the influence of a 16-hour ergonomics awareness training curriculum on the self-reported work behavior of 18 apprentice carpenters. In response to questions on the final course evaluation, more than half of apprentices reported using course information on a jobsite, and 43% of trainees said they had changed the way they work because of the training. Additionally, trainees were asked to select two ergonomic problems they encountered on the job and that they believed could be improved within six months. During follow up three to six months later, six of 14 trainees reported success in changing at least one problem.

Effectiveness evaluations based on observed or self-reported behavioral measures outnumber studies based on health outcomes for obvious reasons; injury and illness are statistically rare events requiring large samples and/or lengthy follow-up periods to detect statistically significant improvements. Despite their practical advantages, however, evaluations based on behavioral and worksite outcomes are weaker types of evidence than studies that include a measure of injury incidence. Because none of these behavior-based

training evaluations measured injury outcomes, whether the training programs ultimately had a significant positive injury prevention effect remains unknown. We attempted to bridge this gap in the current literature by linking training records to workers compensation claims for over 8000 construction laborers.

## Materials and Methods

Zenith Administrators, managers of the health insurance plan for the Northwest Laborers' Health and Security Trust, supplied records for all members of the Northwest Laborers who were eligible for union health insurance from 1990 to 1994. This dataset was used to identify an initial cohort of 11,652 construction laborers (Fig. 1). Cohort members were defined as laborers who were eligible for union health insurance at least one month during the five-year period, showed union hours worked in at least one month, and were residents of Washington State.

Cohort data generated from the union health insurance records were then matched with union training records provided by the Northwest Laborers' Training Trust Fund. Individual health insurance and training records were matched on the basis of social security numbers. The training dataset included attendance records for 34 different training courses offered to union members on a rotating basis from 1993 to 2000. Courses ranged from one to 40 hours in duration and covered a wide variety of topics from pipe fusion and sandblasting to cardiopulmonary resuscitation. To focus on the impact of safety and health training, the number of hours of safety and health instruction included in each course was obtained from the Laborers' Health and Safety Fund of North America, and courses with zero hours of safety and health content were excluded from the study.

Because the health insurance dataset from which the cohort data were extracted was limited to the period 1990 to 1994, and training data were

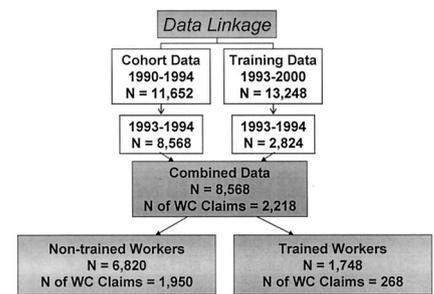


Fig. 1. Linkage of cohort, training, and workers compensation (WC) datasets.

unavailable before 1993, the two datasets could be matched for the years 1993 and 1994 only. With the observation period thus limited to two years, the study cohort was reduced from 11,652 to 8568 workers.

Next, to evaluate the impact of safety and health training on work-related injury among cohort members, the combined health insurance and training data for 1993 to 1994 were further linked to workers compensation data for the same period. Workers' compensation claims files were obtained from the Washington State Department of Labor and Industries (L&I), the principal insurer for occupational injuries in that state. Social security numbers were used to match health insurance and training data with workers compensation claims. Claims were excluded if they had been rejected for workers compensation coverage or if they pertained to injuries that occurred outside of the two-year observation period. Also excluded were claims pertaining to injuries that occurred in a month when the laborer showed no union hours worked. These injuries, which most likely occurred while the laborer was working for a nonunion employer, were excluded from analysis because the number of hours worked at nonunion jobs, and thus the laborers' exposure to risk of injury on such jobs, was unavailable.

Because many laborers filed multiple workers compensation claims during their tenure in the cohort, workers compensation claim rates were based on the total number of claims filed rather than the total

number of workers with claims. To control for variation in the length of exposure to worksite risks, person-years adjusted for the number of union hours worked during the workers' tenure in the cohort were used as the denominator. One person-year was defined as 2000 union hours worked per person per year. A post-training workers compensation claim rate was calculated for members who received safety and health training during the study period. In calculating this rate, workers compensation claims pertaining to pretraining injuries were excluded, and each worker's time at risk (person-years) was calculated from the starting date of his or her earliest training course with safety and health content.

Finally, logistic regression was used to control for age and gender in analyzing the effects of training on the incidence of workers compensation claims. Age, gender, and number of safety and health training hours received were also analyzed as independent variables in describing the workers compensation data. Information on race and ethnicity was not available in the cohort data set. SAS version 8.1 was used for all data analysis.

**Results**

The 8568 cohort members worked a total of 16,813,095 union hours, or 8406 person-years, during the two-year study period. Twenty percent of the workers received one or more hours of union safety and health training during the same period. Cohort members had an average age of 37.4 years, with nearly 64% of workers for whom age was available falling between the ages of 25 and 44. Among workers for whom both age and gender were recorded, nearly 90% were male.

Female workers were more likely to have received training than were males. Thirty-two percent of females in the cohort received safety and health training during the study period, compared with only 20% of males, a statistically significant dif-

ference (OR = 1.89, 95% CI = 1.61–2.22). Females made up 16% of trained workers for whom gender was available, but only 9% of the nontrained group. Somewhat surprisingly, trained and nontrained workers were not significantly different in age, and older workers accounted for a substantial proportion of training recipients. Workers aged 35 to 44 made up 36% of trained workers, compared with only 31% of the nontrained group. Although it is not known for certain, the relatively large number of older workers who participated in the union training program may reflect the number of "refresher" courses included in the curriculum.

Whether a worker received union safety and health training during the two-year study period was an important predictor of workers compensation claims during that same period, with trained workers being less likely to file a claim. Nontrained laborers filed a total of 1950 workers compensation claims, with a total of 6708 person-years on the job. This resulted in a claims rate of 29%. By comparison, trained laborers filed 268 posttraining workers compensation claims, with a total of 1015 posttraining person-years, resulting in a claims rate of 26%. After controlling for age and gender, training recipients were approximately 12% (95% CI = 0.75–1.02) less likely than workers without training to have filed a workers compensation claim during the study period.

The association between training and a reduction in workers compensation claims was most pronounced among younger workers (Fig. 2). Among workers aged 16 to 24, those who received training during the study period were 42% (95% CI = 0.35–0.95) less likely than those without training to file for workers compensation, a statistically significant reduction in claims. Claim rates also were lower for trained workers than for nontrained workers in the age groups 25 to 34, 35 to 44, and 55 to 65, but not significantly so.

Among workers aged 45 to 54, the claim rate was slightly lower among those without training. When claim rates were analyzed by gender, training was associated with a reduction in claims among both males and females (Fig. 3).

As illustrated in Fig. 4, age and gender were significant predictors of claim rates when analyzed as independent variables. Workers under age 40 were 17% (95% CI = 1.05–1.31) more likely to have filed a workers compensation claim than were workers aged 40 or above. Male workers were approximately 1.67 times (95% CI = 1.37–2.03) as likely as females to have filed a

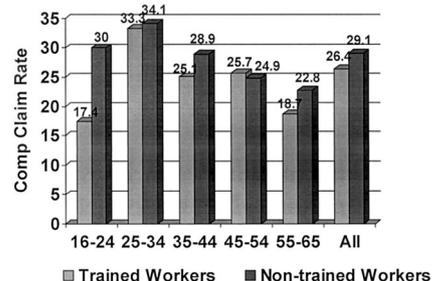


Fig. 2. Workers compensation claim rates by age and training status.

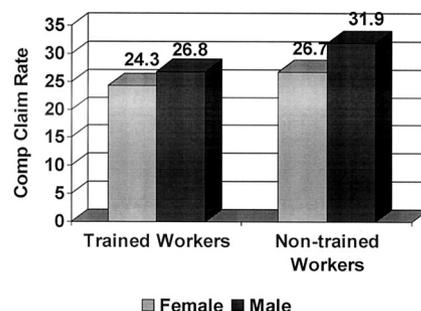


Fig. 3. Workers compensation claim rates by gender and training status.

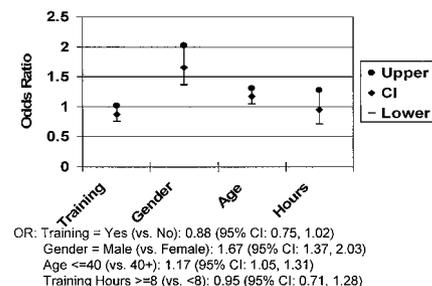


Fig. 4. Predictors for workers compensation claims.

claim. However, no significant association was found between claim rates and the number of training hours received (OR = 0.95, 95% CI = 0.71–1.28). The distribution of workers compensation claims by safety and health training hours received is displayed in Table 1.

## Discussion and Conclusions

This study demonstrates an association between safety and health training and a reduction in workers compensation claims in a large cohort of union construction laborers. Among younger laborers (aged 16–24), this association was significant. Workers aged 16 to 24 who completed at least one hour of safety and health training during the study period were 42% less likely than workers of the same age without training to file a workers compensation claim. Overall, after controlling for age and gender, cohort members who received training were 12% less likely than nontrained workers to file a claim. Although this 12% reduction was not statistically significant (95% CI = 0.75–1.02), the narrow inclusion of one in the confidence interval most likely reflects imprecision inherent in the study design, which was based on a two-year period. Based on this finding, we would expect to see a statistically significant reduction in workers compensation claims among trained workers were this study extended over a longer period of time.

By linking safety and health training to a reduction in workers compensation rates, this study provides important evidence of the effectiveness of training in reducing the incidence of work-related injury among

construction laborers, in general, and among younger laborers, in particular. Younger workers, who lag in informal (on-the-job) training, appear to have derived greater injury prevention benefit from union training courses than did their older, more experienced coworkers. This finding suggests that younger laborers are an especially appropriate target for training interventions aimed at preventing injuries on the job.

It is possible that the association between training and workers compensation claim rates detected in this study is attributable to differences in trained and nontrained workers' tendencies to file for workers compensation rather than any real difference in injury rates. That is to say, compared with the nontrained group, workers who participated in the union training program during the study period may have had better knowledge of the drawbacks and limitations of the workers compensation system, making them less likely than nontrained workers to file a claim when injured. By this same logic, however, it is also conceivable that workers who attended training were more likely than nontrained workers to be aware of the *availability* of workers compensation, making them *more* likely to pursue recovery. In the absence of quantitative evidence to support either of these two contradictory hypotheses, we have assumed that trained and nontrained union members were equally likely to pursue workers compensation remedies.

In addition to linking safety and health training with a reduction in workers compensation claims, the

present study underscores patterns in construction laborers' occupational injury experience. Results show that workers compensation claim rates varied significantly by age and gender, with younger and male construction laborers having the greatest risk of work-related injury. These findings are consistent with prior descriptive studies of occupational injury within the laborer trade. In their study of proportionate mortality among over 11,000 union construction laborers, Stern et al.<sup>1</sup> found that fatal injury rates were significantly higher for workers who were younger and had the shortest length of time in the union. With respect to gender differences, Ore and Stout's<sup>7</sup> study of occupational fatalities among all U.S. construction laborers from 1980 to 1992 showed male laborers to have a mortality rate approximately twice that of females, although female laborers had a higher risk for fatal motor vehicle injuries. The increased risk of injury among younger and male workers no doubt reflects a variety of factors, including differences in job tasks and experience, as noted in previous studies.<sup>21,22</sup> The present study indicates, however, that differences in safety and health awareness also may help to explain females laborers' lower injury risk; female workers were not only less likely to file for workers compensation, but also more likely to have received safety and health training during the two-year study period. Further research is needed to determine whether these two findings are causally related or merely artifacts of other factors not considered here such as gender-

**TABLE 1**  
Workers' Compensation Claim Rates by Hours of Safety and Health Training

Hours of Safety & Health Training	Workers' Comp Claims (post-training)	Number of Workers	Person-years (post-training)	Workers' Comp Claim Rate
1	138	736	574	24.0
2–10	78	602	259	30.1
>10	52	367	182	28.6
Total	268	1,748	1,015	26.4

based differences in safety and health attitudes or risk-taking behavior.

Although results of this study indicate that workers with safety and health training had lower workers compensation claim rates compared with nontrained workers, the data provide no evidence that training had a dose-response effect. Among trained workers, there was no significant association between the number of training hours received and workers compensation claim rates. These findings are limited, however, by the short study period and the small sample size when claims were analyzed by the number of training hours received.

The major limitation of the present study is its possible selection bias. As a result of the retrospective nature of the study and limitations in the administrative data sources, a number of potentially confounding or interacting factors could not be considered. Most notably, because training data were unavailable before 1993, we were unable to control for safety and health training that cohort members received before the two-year observation period. Also, this abbreviated training history, which was extracted from union training records, did not include safety and health education received from employers, technical schools, or other nonunion sources. Because enrollment in the union training courses offered during the study period was voluntary, selection bias may be inherent in the training program itself. The training rosters may have included a disproportionate number of workers whose employers encouraged safety and health awareness through training pay or other incentives.

Limitations in the cohort data set include a lack of information on work history, job tasks, hours worked at nonunion jobs, and individual health status. In the absence of such data, we were unable to control for workers' length of work experience, performance of high-risk tasks,

time at risk at nonunion jobs, or underlying health conditions. Lack of information on workers' personal characteristics also precluded consideration of individual factors such as race and ethnicity, safety and health awareness, or risk-taking behavior.

A final limitation of the study is its inability to evaluate the effectiveness of particular safety and health training programs on reducing specific types of injury. Because laborers in the cohort were involved in many different types of work and data were not available to accurately characterize the job tasks of individual workers, we did not attempt to match training on a particular task with injuries associated with that task or otherwise consider the content of individual safety and health training courses.

Many of these limitations are typical of retrospective evaluation studies and could be avoided in studies with prospective designs. In the future, trainers and researchers in the construction industry must close the loop in the prevention process by conducting prospective evaluation studies simultaneously with training interventions. In particular, there is a need for effectiveness evaluations with experimental or quasiexperimental designs, including randomized, controlled trials, with individual workers, groups, or companies serving as the unit of randomization. Also, if the purpose of the training program is to ultimately affect injury incidence by targeting attitudes and behaviors, it would be beneficial to include a measure of injury incidence in addition to behavioral outcomes. Finally, future training programs for construction laborers should draw on theory-based models for program development and evaluation, such as PRECEDE [The PRECEDE (Predisposing, Reinforcing and Enabling Constructs in Ecosystem Diagnosis and Evaluation) model is a framework for the process of systematic development of health and education programs], which di-

rects initial attention to outcomes rather than inputs.<sup>23</sup> More rigorous evaluation of the effectiveness of training programs in reducing work-related injury among construction laborers will help identify successful interventions and promote their rapid dissemination throughout the construction industry.

In conclusion, the present study is one of the first studies to quantitatively evaluate the effectiveness of safety and health training in reducing work-related injuries among construction laborers. Results show workers with safety and health training to be less likely than nontrained workers to file workers compensation claims, suggesting that training may be an effective intervention against work-related injury. The association between training and a reduction in workers compensation claims was strongest among workers aged 16 to 24, suggesting that training's injury prevention effect can be maximized by targeting this group. Further prospective studies are needed to evaluate the effectiveness of specific training programs in reducing particular types of injury.

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