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EFFECTIVENESS OF OSHA OUTREACH TRAINING ON CONSTRUCTION WORK-RELATED INJURY RATES

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ABSTRACT

Despite the size and breadth of the Occupational Safety and Health Administration's (OSHA) Outreach Training program for the construction industry, there is limited information on its impact on rates of work-related injury. In a 9-year (2000-2008) dynamic cohort of approximately 17,000 union carpenters in Washington State, the effectiveness of OSHA Outreach Training on rates of workers' compensation injury claims and related outcomes was explored. OSHA Outreach Training resulted in a 13% (non-significant) reduction in rates of injury overall. The effect was more pronounced for carpenters in their apprenticeship years, drywall installers, and with increasing time since training. Hazard awareness and protection training, coupled with more efficient approaches to injury control, should be standard practice in the construction industry. In line with the observed effect in this study, it is unrealistic to expect OSHA Outreach Training alone to have a large effect on union construction workers' rates of work-related injury.

KEY FINDINGS

- This study demonstrates the feasibility, as well as the strengths and limitations, of using multi-source longitudinal surveillance data in the appraisal of long-term evaluations of the effectiveness of workplace safety interventions such as training.

- OSHA Outreach Training resulted in a 13% non-significant reduction in rates of workers' compensation injury claims. Though modest, this finding is in line with realistic expectations of the effect of OSHA Outreach Training alone on union carpenters' rates of injury.

- The protective effect of OSHA Outreach Training was more pronounced for carpenters in their apprenticeship years and for those with a predominant type of work of drywall installation.

- An increasingly protective effect of training was observed with increasing time since training.

- A large proportion of carpenters who completed OSHA Outreach Training through the union did not meet the study cohort entry criterion of working at least three months of union hours, likely reflective of attrition during the apprenticeship period.

- In addition to overcoming methodological challenges to understanding the effect of training on work-related injury outcomes, future studies should consider specific worker sub-groups for whom training may be particularly beneficial (e.g., apprentices).

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INTRODUCTION

Safety training is frequently recommended and prescribed for preventing work-related injury and illness. For workers in the dangerous construction industry, safety training may lead to important increases in worker knowledge and attitudes about occupational safety (Sokas et al. 2009, Williams et al. 2010, Forst et al. 2013) as well as measures of safety behavior (Trabeau et al. 2008, Kaskutas et al. 2013, Ruttenberg 2013). Though evidence supporting safety training's prevention of adverse health outcomes (e.g., injuries, illnesses) is limited (Cohen et al. 1998, Robson et al. 2010, Robson et al. 2012, Mullan et al. 2015), encouraging examples can be found among plumbers/pipefitters (Kinn et al. 2000), laborers (Dong et al. 2004, Williams et al. 2010), carpenters/drywall tapers (Johnson and Ruppe 2002), residential construction workers (Darragh et al. 2004), and railway construction workers (Bena et al. 2009).

When the Occupational Safety and Health Act of 1970 was established, the OSHA Training Institute (OTI) developed a series of short hazard awareness training courses, including 10-hour (for entry level workers) and 30-hour (for workers with safety responsibilities) courses for the construction industry. OTI trained federal occupational safety personnel to deliver the courses to federal employees in locations around the US. The training courses cover the "recognition, avoidance, abatement, and prevention of safety and health hazards in workplaces" and provide "information on workers' rights, employer responsibilities and how to file a complaint" (OSHA 2014). In the 1990s, OSHA began permitting authorized providers to offer this training in the private sector, and industry demand drove explosive growth in delivery of "OSHA-10" and "OSHA-30" for construction. Trainers had issued less than 20,000 OSHA-10 and OSHA-30 cards each year in the early 1990s; since 2010, more than 500,000 workers per year have earned an OSHA-10 or OSHA-30 card. Joint labor-management apprenticeship programs providing vocational training to North America's union-sector construction workers were among the earliest and largest adopters of OSHA Outreach Training. Today nearly all construction trade unions have incorporated OSHA-10/OSHA-30 training into their apprenticeship curricula. It may be required by an employer (Wilkins 2011), and some states mandate it prior to working on publicly-funded building projects (Sinyai et al. 2013, Taylor 2014).

Safety-forward gains in construction workers' knowledge and attitudes (Sanyang 2007, Sokas et al. 2009, Wilkins 2011) and behavior (Ruttenberg 2013) have been observed following OSHA-10 training. However, evaluations of the effect of OSHA Outreach Training in preventing adverse construction work-related outcomes are few (Taylor 2014). An understanding is called for to "strengthen and extend the reach of quality training and education" (NORA Construction Sector Council 2008) with the goal of improving construction workers' safety and health.

OBJECTIVES

Building on an existing, robust, longitudinal cohort of union carpenters in Washington (WA) State over the years 2000 through 2008, the goal of this study is to explore the effectiveness of OSHA Outreach Training on carpenters' work-related injury rates. The specific aims are:

- Link existing records of union carpenter OSHA Outreach Training to union eligibility, membership, and workers' compensation (WC) claims data for a cohort of approximately 17,000 union carpenters in WA State between 2000 and 2008.

- Describe carpenters' OSHA Outreach Training experience by calendar time, worker characteristics (i.e., gender, age, time in the union), and predominant type of work.

- Stratified by calendar time, worker characteristics, and predominant type of work, quantify rates, rate ratios (RR), and 95% confidence intervals (CI) examining the relationship between outcomes and OSHA Outreach Training. Contrast patterns in rates observed for work-related injuries overall, by paid time loss (TL) and costs, and for specific mechanisms of injury.

METHODS

As part of prior research, the researchers – with assistance from the Carpenters Trusts of Western WA (CTWW) and the WA State Department of Labor and Industries (L&I) – created a cohort of union carpenters examine patterns in work-related injury rates (McCoy et al. 2013). The cohort comprises union eligibility, membership, and WC claims data files, linked at the individual level in a de-identified manner through use of a unique member number.

- Union eligibility and membership files, from the CTWW, contain for each carpenter: a unique member number (assigned by CTWW and lacking identifying details), date of birth, gender, monthly union hours worked, data of union entry, and union local. The union membership files contained information on all union members, regardless of hours worked. However, the study cohort was limited to individuals who worked ≥3 months of union hours, with observation beginning in the month eligibility criteria were met (i.e., the 3rd month of union work). As in prior research with these data (e.g., (Lipscomb et al. 2014)), carpenters were assigned a predominant type of work based on the work most commonly performed by the union local to which they belong: residential building, light/heavy/mixed commercial, drywall installation, millwrighting, and piledriving. Some carpenters were affiliated with a union local outside of WA State for which predominant type of work information was not available.

- WC claims data files, provided by the WA State Department of L&I, contain for each claim: date of event; date of claim; open/close status; ANSI/OIICS codes describing the event nature, mechanism, body part affected, and source; TL status; number of paid TL days (with TL compensation paid after the 3rd calendar day of being medically unavailable for work, not including the day of injury, in WA State); and associated costs. A TL claim is one in which there was not approved work available for the injured worker within the medical restrictions. Cost estimates are limited to payment types reported consistently between state fund and self-insured claims, improving the consistency of costs across payers, but excluding the medical portion of claims costs. All costs are adjusted using the US Consumer Price Index to 2015 dollars and assume all dollars were paid on the date of injury. Although the claim pool was extracted April 2010 for prior research (McCoy et al. 2013), the extract was updated April 2016 to reflect L&I's current methodology and estimates of paid TL and costs.

These files were linked at the individual level to union carpenter training records. The training file, provided by the CTWW, is composed of individual-level data on the dates of completed OSHA-10, -30, and -500 level courses completed through face-to-face, in-class instruction at the Pacific Northwest Regional Council of Carpenters' (PNWRCC) affiliated training centers.

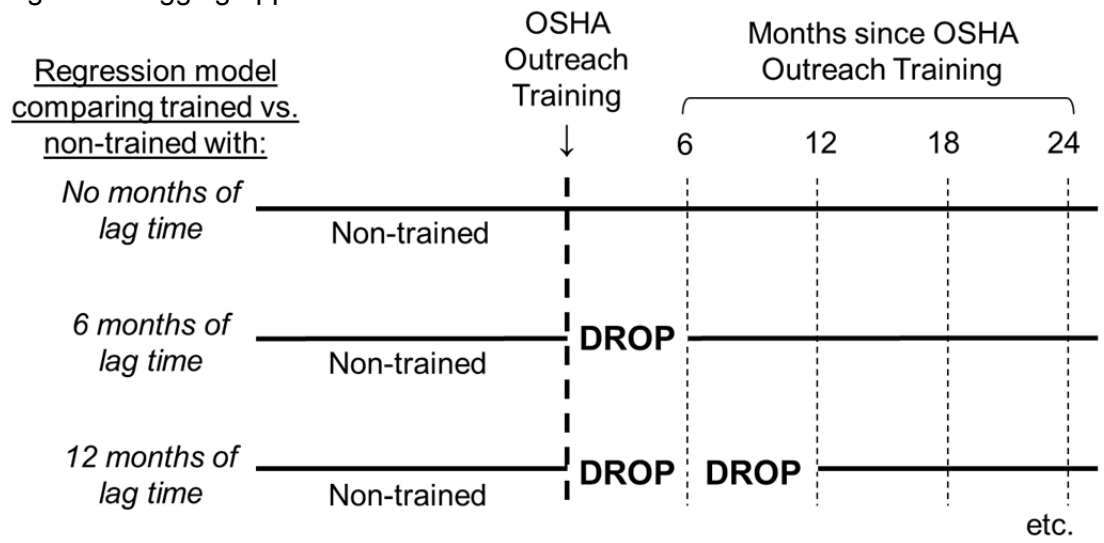
Some US states, employers, and unions require that workers re-take an OSHA Outreach Training course every 3 to 5 years. Thus, a carpenters' union work hours were categorized as "trained" if the carpenter completed an OSHA Outreach Training course within the prior 5 years. It is this definition on which the presented analyses are based. However, OSHA Outreach Training completion cards do not expire, and sensitivity analyses were conducted in which a cohort member was defined as "trained" for all time following course completion. Also, given the dynamic nature of the study cohort, a subset of the cohort was in the union prior to January 1, 2000. These "prevalent members" (who made up 52.9% of the cohort and contributed 76.8% of

the time at risk) may have completed OSHA Outreach Training prior to cohort entry. For the presented analyses, these members were categorized as "trained" when they completed an OSHA Outreach Training course during the study period, and for the 5 years following course completion. Sensitivity analyses were conducted in which prevalent members were also categorized as "trained" for the first 5 years of follow-up (January 1, 2000 - December 31, 2004).

Carpenters' characteristics and union work hours with and without OSHA Outreach Training, and by type of OSHA Outreach Training course, were described. Time at risk (union work hours) and work-related outcomes were stratified by categories of OSHA Outreach Training (yes/no), age, gender, time in the union, predominant type of work, and calendar time. Age, time in the union, and predominant type of work varied over time with union work hours and number of events accumulating in the appropriate strata over the 9-year period. Injury rates (events per 200,000 union work hours), unadjusted and adjusted RR, and 95% CI were calculated using Poisson regression, with ln(union work hours) as the offset (Nizam 2014) and scaling to correct for overdispersion (Pearson χ^2/degrees of freedom>1.5). In addition to examining the effect of training on work-related injuries overall, sub-analyses examined the effect of training on rates of "Fatal Four" injuries emphasized in OSHA Outreach Training: falls from elevation, electrocutions, struck by events, and caught in/between events. For analyses of TL days and costs - outcomes which are highly skewed - negative binomial models (Hilbe 2011) were used to examine rates, RR, and 95% CI, with generalized estimating equations (GEE) (Zeger et al. 1988) to account for within-subject correlation.

Finally, recognizing the potential for a differential OSHA Outreach Training effect by time since training, related models were constructed to examine RR before and after such training (Figure 1). In successive "lagged" models, 6-month increments of time at risk and work-related outcomes following training were removed. This approach allowed assessment of time periods in which the effect of training was most pronounced. For this training intervention, it is plausible to assume an enhanced effect immediately following the training class. It is also plausible to observe a gradually increased effect over time as trained workers spend more time in the field gaining experience applying training-based knowledge.

Figure 1. Lagging approach



RESULTS AND DISCUSSION

The study cohort is composed of 17,106 carpenters who worked 99,411,000 union hours in WA State between 2000 and 2008. Carpenters' average age increased from 41.3 years in 2000 to 44.9 in 2005, and down to 42.0 in 2008 (McCoy et al. 2013), and nearly all are male (97.7%). A total of 9,894 WC claims were reported and accepted for the cohort, and 15.3% (n=1,514) resulted in paid TL. The rate of injuries overall and with paid TL declined 42% and 54%, respectively, over the study period. Patterns in rates across categories of worker demographic and work-related characteristics are similar to those reported previously (McCoy et al. 2013); adjusted rates of injury were higher among females, increased with increasing age, decreased with increasing time in the union, and were higher among residential carpenters and drywall installers. A total of 2,910 (29.4%) injuries were characterized as a Fatal Four mechanism: fall from elevation (5.0%), electrocutions (0.3%), struck by (21.3%), and caught in/between (2.8%).

During the study period, 1,017 cohort members took 1,089 OSHA Outreach Training courses through PNWRCC-affiliated training centers, and 7% (n=67) took more than one OSHA Outreach Training course. Most of the courses taken were "OSHA-10 Construction" (85%), followed by "OSHA-30 Construction" (10%) and "OSHA-500 (or OSHA-502) Construction" (3%). When individual-level training data were merged to the study cohort of members who contributed ≥3 months of union hours, 57.5% (n=585) of union carpenters who took OSHA Outreach Training during 2000-2008 did not link to the study cohort. Similar linkage patterns have been observed in the authors' prior work with these data and are not surprising given the literature on construction apprentice attrition and retention (Bilginsoy 2003, Byrd and Weinstein 2005, Glover and Bilginsoy 2005). Analyses related to the characteristics of workers taking OSHA Outreach Training, as well as those related to OSHA Outreach Training effectiveness, are based on training data from the 432 carpenters who linked to the study cohort. They completed 464 OSHA Outreach Training courses.

Most OSHA Outreach Training took place in carpenters' early years in the union, and particularly in the first year for carpenters completing OSHA-10 training (Table 1). As expected, the average number of years in the union was lower among union members who completed OSHA-10 training (3.4, 95% CI 2.7-4.1) compared to those who completed OSHA-30 training (7.2, 95% CI 5.1-9.4). Nearly 80% of OSHA-10 training was among carpenters likely in an apprenticeship period (i.e., <4 years in union). No difference was observed in the average age of members completing OSHA-10 compared to OSHA-30 training. Carpenters doing light/heavy commercial work had a higher proportion of trained hours compared to carpenters in other trades, and drywall installers had a lower proportion of trained hours.

Table 1. Stratified by years in the union, OSHA training courses completed by union carpenters through the PNWRCC training centers, 2000-2008

	OSHA-10		OSHA-30	
Years in the union	n	%	n	%
<1	250	(66.3)	26	(34.2)
1 to <2	31	(8.2)	4	(5.3)
2 to <4	15	(4.0)	6	(7.9)
4 to <6	16	(4.2)	7	(9.2)
6 to <8	9	(2.4)	7	(9.2)
8 to <10	14	(3.7)	3	(3.9)
10 to <20	24	(6.4)	12	(15.8)
20+	18	(4.8)	11	(14.5)

Participation in OSHA Outreach Training was associated with a 13% reduction in rates of reported and accepted WC injury claims ($RR_{Trained\ vs.\ Non\text{-}Trained}$ 0.87, 95% CI 0.72-1.06) (Table 2). This relative difference did not vary significantly across categories of age or calendar time, and it was similar for Fatal Four injuries (RR 0.81, 95% CI 0.55-1.18). The effect was more pronounced, however, among workers during their apprenticeship years (<4 years in the union). Although findings were not statistically significant and were attenuated in adjusted analyses, they bore similarities to patterns observed by Dong et al. (2004) who evaluated the effect of safety training on rates of work-related injury among union laborers in WA State over two years in the mid-1990s. The authors observed 12% lower injury rates among trained versus untrained workers. This effect was greater among younger workers – a finding the authors attributed to less informal on-the-job training and a greater propensity of younger and less experienced workers to benefit from injury prevention training material (Dong et al. 2004). Findings from both studies suggest that workers with the least experience receive the most benefit from safety training. Appropriately, the Carpenters' construction apprenticeship program mandates OSHA-10 Outreach Training for incoming apprentices, and first-year union members accounted for a majority of the OSHA-10 students during the period under study.

A protective, significant effect of training was observed among carpenters whose predominant type of work was drywall installation (RR 0.34, 95% CI 0.15-0.75). Drywall installers have high rates of work-related injury compared to workers in other construction trades, including in this cohort of union carpenters (Lipscomb et al. 2000, Lipscomb et al. 2003, Schoenfisch et al. 2013, Schoenfisch et al. 2014, Schoenfisch et al. 2014, Lipscomb et al. 2015, Lipscomb et al. 2015), perhaps allowing more of an effect of OSHA Outreach Training to be observed. Carpenters who receive OSHA Outreach Training may also be more likely to work for safer contractors; this pattern may be particularly true for carpenters in the drywall trade.

No significant difference was observed in the proportion of injuries resulting in paid TL days (trained: 21.2%; non-trained: 18.6%), the median number of paid TL days per TL injury (trained: 105; non-trained: 92), or the rate of TL injury by training status (RR 1.00, 95% CI 0.65-1.53). However, the number of paid TL days per 200,000 hours worked was lower among trained carpenters (trained: 547 per 200,000 union hours worked; non-trained: 1,752 per 200,000 union hours worked). Similar patterns were observed for cost rates (trained: $0.79 per union work hour; non-trained: $1.92 per union work hour). OSHA Outreach Training may indeed effectively reduce rates of severe work-related injury events. However, the data were not robust enough to allow exploration of this finding beyond a comparison of simple rates.

In lagged analyses, an increasingly protective effect of training was observed with increasing time since training, though results are statistically non-significant (e.g., $RR_{36\text{-}month\ lag}$ 0.66, 95% CI 0.35-1.25) (Figure 2). This protective effect was greater among carpenters with <4 years in the union, compared to their more experienced counterparts. This finding may be attributable to improved application of classroom knowledge with increased on-the-job experience, safer firms seeking out safety-trained workers (and vice versa), or some combination of these and/or other unidentified factors.

Sensitivity analyses were conducted to compare the presented findings to those obtained when removing the 5-year expiration on carpenters' training. Thus, a member who completed OSHA Outreach Training remained categorized as "trained" any time following training. With this change, no meaningful differences were observed in the effect of training, including on rates of work-related injury overall (RR 0.92, 95% CI 0.78-1.10) and those with paid TL (RR 0.93, 95% CI 0.60-1.44). Analyses were also conducted in which prevalent members were included and assumed to be trained at the start of study follow-up, only being categorized as "not trained" if

Table 2. Injury frequencies, time at risk, rates, rate ratios, and 95% CI of WC claims for injury by OSHA Outreach Training, overall and by worker age, time in the union, type of work, and calendar year

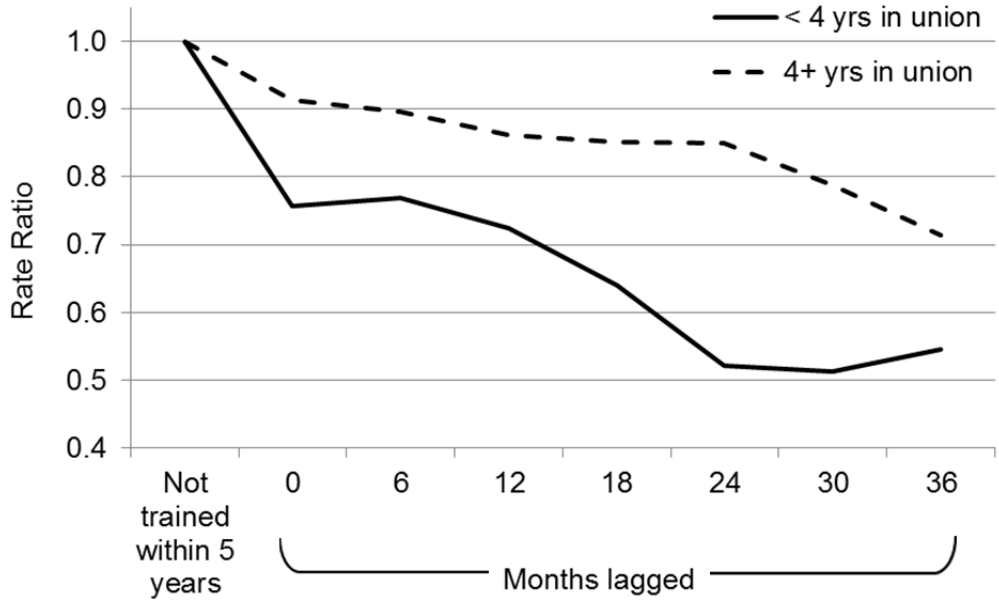
	OSHA Outreach Training through PNWRCC in past 5 years						
	Yes			No			
	Hours	# injuries	Rate[a] (95% CI)	Hours	# injuries	Rate[a] (95% CI)	Rate ratio[b] (95% CI)
Injuries, Overall	1,138,147	99	17.4 (14.3-21.2)	98,272,853	9,787	19.9 (19.5-20.3)	0.87 (0.72-1.06)
By carpenter age							
<30 years	269,493	26	19.3 (13.1-28.3)	16,423,237	1,820	22.2 (21.2-23.2)	0.87 (0.59-1.28)
30 to <40 years	356,751	27	15.1 (10.4-22.1)	28,177,004	2,960	21.0 (20.3-21.8)	0.72 (0.49-1.05)
40+ years	506,276	45	17.8 (13.3-23.8)	53,538,101	4,999	18.7 (18.2-19.2)	0.95 (0.71-1.28)
By time in the union							
Apprentices (<4 years)	355,427	33	18.6 (13.2-26.1)	23,586,374	2,890	24.5 (23.6-25.4)	0.76 (0.54-1.07)
Journeymen (≥4 years)	782,720	66	16.9 (13.3-21.5)	74,686,479	6,897	18.5 (18.0-18.9)	0.91 (0.72-1.16)
By predominant type of work							
Commercial	676,655	70	20.7 (16.4-26.2)	51,217,796	4,911	19.2 (18.7-19.7)	1.08 (0.85-1.37)
Drywall	155,565	6	7.7 (3.5-17.2)	21,141,980	2,418	22.9 (22.0-23.8)	0.34 (0.15-0.75)
Other[c]	300,541	20	13.3 (9.0-20.6)	24,871,732	2,282	18.4 (17.6-19.1)	0.73 (0.47-1.13)
By calendar year							
2000-2002	74,999	13	34.7 (20.1-59.7)	31,806,516	3,806	23.9 (23.2-24.7)	1.45 (0.84-2.50)
2003-2005	347,504	29	16.7 (11.6-24.0)	27,597,535	2,713	19.7 (19.0-20.4)	0.85 (0.59-1.22)
2006-2008	715,644	57	15.9 (12.3-20.7)	38,868,803	3,268	16.8 (16.3-17.4)	0.95 (0.73-1.23)

[a] Injuries per 200,000 work hours

[b] Compares rate of injury among trained versus rate of injury among non-trained. Unadjusted and adjusted analyses yielded similar findings; the unadjusted estimates are presented.

[c] Includes residential, piledriving, millwrighting, and work out of WA State

Figure 2. Rate ratios comparing work-related injury rates surrounding OSHA Outreach Training, lagged by increasing amounts of time post-training and stratified by years in the union



they did not complete OSHA Outreach Training within 5 years. With this categorization and adjusting for potential confounders, change was observed in the effect estimate related to rates of work-related injury overall (RR 1.12, 95% CI 1.03-1.22), but not for that of rates of paid TL injuries (RR 0.93, 95% CI 0.65-1.33).

The true benefits of training and strength of effectiveness are not fully apparent through use of WC claims data alone; there are important practices that cannot be explored in these data. The effect of safety training on injury prevention through improved hazard awareness and control may "spill-over" to non-trained workers (Dong et al. 2004, Williams et al. 2010, Forst et al. 2013, Ruttenberg 2013). Further, training may influence reporting practices by educating workers on their rights to a safe workplace and providing instruction on *how* to report a work-related injury (Dong et al. 2004, Williams et al. 2010, Forst et al. 2013, Ruttenberg 2013).

Limitations and Strengths

There are well-known limitations inherent in the cohort data of relevance to the research questions. No direct measures of job tasks or work-related exposures are available in this cohort, although predominant type of work provides a meaningful categorization for analyses. Also, the data do not include ethnicity or language spoken. In some construction trades in the Pacific Northwest, high-risk, high-priority minority populations are prevalent, and efforts are needed (NORA Construction Sector Council 2008) to deliver targeted safety training (Williams et al. 2010, Wilkins 2011, Forst et al. 2013). Additionally, we recognize that we are gathering data from union carpenters who are part of an apprenticeship program, limiting the generalizability of findings (Roelofs 2012, Amick III et al. 2015). However, focusing on the union segment of the industry, with existing union apprenticeship programs, labor-management relations, and (in this case) a longstanding collaborative partnership with an academic research team, allowed the research questions to be addressed to carry out this work with the resources available through CPWR's Small Study funding mechanism.

Our statistical analysis reflected carpenters with OSHA Outreach Training that we were able to identify. Presumably a substantial number of journeyman carpenters in this cohort received OSHA Outreach Training prior to the period under study, but records for that time were unavailable. Additionally, data on carpenters' OSHA Outreach Training through other means (e.g., online) were not available. Though training records indicated that 1,017 workers received OSHA Outreach Training during the period, fewer than half met the cohort requirement of ≥3 months of union work - likely a consequence of apprentice attrition (Bilginsoy 2003, Byrd and Weinstein 2005, Glover and Bilginsoy 2005).

Finally, measuring WC claims activity is not the same as measuring occupational injuries. It is well-documented that a large number of work-related injuries are not reported to WC (Azaroff et al. 2002, Shannon and Lowe 2002, Leigh et al. 2004, Fan et al. 2006, Rosenman et al. 2006, Friedman and Forst 2007, Welch et al. 2007, Government Accountability Office 2009, Lipscomb et al. 2013, Wuellner and Bonauto 2014, Lipscomb et al. 2015). Firms with high-quality safety and health programs may encourage reporting of all workplace injuries. OSHA Outreach Training includes instruction on injury reporting and on workers' legal protections under OSHA. Such incentives may increase the propensity of workers to report minor injuries, in which case the 13% reduction in WC claims associated with OSHA Outreach Training observed in this study would be an underestimate of the true relative difference.

This study demonstrates both the utility and importance of robust, longitudinal surveillance data in the appraisal of long-term evaluations of the effectiveness of workplace safety interventions, as well as challenges in clearly evaluating training effects in this dangerous industry. Similar exploration of construction workers' training and injury experience outside of this dynamic cohort is unrealistic, if not impossible, in the open shop environment or otherwise. Time at risk and reported injuries were well defined, allowing for the calculation of injury rates and their examination over time surrounding documented training. This study also demonstrates the complexity of occupational safety training effectiveness evaluations and the related importance of framing an analytical approach and interpreting results in context. Although statistical power was limited to address all of the planned analyses, the framework presented provides a guide for future research considerations.

Relevance and Practical Application

Recent systematic reviews point to the paucity of research demonstrating that occupational safety training can improve health outcomes, as well as a lack of well-designed controlled studies (Cohen et al. 1998, Robson et al. 2010, Robson et al. 2012). Yet training is not delivered in a randomized controlled manner, and it never happens in isolation. Even OSHA-10 training can be variable depending on the instructor's points of emphasis, delivery method, and learners' characteristics. Studies must consider the time needed for an intervention effect to be observed, the potential "spill-over" of a training intervention to non-trained workers, and the mobility of construction workers from project to project and employer to employer. In addition to working to address known methodological needs, future studies should focus on improving the accessibility, quality, and relevance of training, as well as its application in practice. Regardless of the study design, evaluations that focus on outcomes alone will be inherently limited without information on intervention fidelity; the effect of OSHA Outreach Training on rates of work-related injury will reflect, in part, the effectiveness of teaching methods (Wilkins 2011) and trainees' ability to apply well-learned material on worksites (Williams et al. 2010).

Construction worker training in hazard awareness, injury prevention and mitigation, workers' rights, and how to report adverse work-related events should be standard practice. Yet, such training alone cannot be expected to prevent work-related injuries to a significant degree in this dangerous industry. For such reduction to be realized, more concrete and efficient injury prevention approaches that eliminate or reduce hazardous exposures must be made available to workers (Herrick and Dement 1994, Castillo et al. 2011, Lipscomb HJ and Schoenfisch AL 2014). Union construction workers often receive OSHA Outreach Training as part of a formal apprenticeship program for which training may be an essential component of broader efforts to prevent work-related injury. Thus, as expected, these data do not demonstrate the likelihood that OSHA Outreach Training alone meaningfully decreases injury rates among union construction industry workers, although noteworthy benefits may be observed within specific worker sub-groups (e.g., by trade or experience) for whom efforts to improve retention – including through improved training participation – are needed for as the demand for a skilled construction workforce increases (Bilginsoy 2003, Glover and Bilginsoy 2005).

PRESENTATIONS, PUBLICATIONS, & DISSEMINATION PLANS

- Sinyai, C., Schoenfisch, A., & Lipscomb, H. "Can a Union-led Occupational Health and Safety Training Program Reduce Workplace Injuries and Illnesses? (And Can We Prove It?)" United Association for Labor Education's 2015 Conference. Orlando, FL. March 2015.

- Sinyai, C., Schoenfisch, A., & Lipscomb, H. "Can a Joint Labor-Management Safety Training Program reduce Workplace Injuries?" Labor and Employment Relations Association (LERA) 67th Annual Meeting. Pittsburgh, PA. May 2015.

- Sinyai, C., Schoenfisch, A., & Lipscomb, H. "Union-led Occupational Safety Training and Health and Safety Outcomes: Results from a Large Cohort Study in Washington State." United Association for Labor Education's 2016 Conference. Washington, DC. April 2016.

- Sinyai, C., Schoenfisch, A., Lipscomb, H. "Occupational Safety and Health: Training and Outcomes Does Hazard Awareness Training Reduce Workers' Compensation Claims?" Labor and Employment Relations Association (LERA) 68th Annual Meeting. Minneapolis, MN. May 2016.

- Schoenfisch, A., Lipscomb, H., Sinyai, C, Adams, D. Effectiveness of OSHA Outreach Training on Union Carpenters' Rates of Workers' Compensation Claims, Washington State. American Journal of Industrial Medicine. *In Review*.

- Schoenfisch, A., Sinyai, C., Lipscomb, H. Does Construction Hazard Awareness Training Reduce Rates of Workers' Compensation Claims? Labor and Employment Relations Association (LERA) 68th Annual Meeting Proceedings. *In Review*.

- Future dissemination plans:

    - (In progress) Brief report for a trade journal, discussing training effectiveness from and economic perspective.

    - Select published materials and a brief 1-page summary will be provided to the PNWRCC, PNWRCC Training Centers, and CTWW.

REFERENCES

Amick III, B. C., S. Hogg-Johnson, D. Latour-Villamil and R. Saunders (2015). "Protecting construction worker health and safety in Ontario, Canada: identifying a union safety effect." Journal of Occupational and Environmental Medicine **57**(12): 1337-1342.

Azaroff, L. S., C. Levenstein and D. Wegman (2002). "Occupational injury and illness surveillance: conceptual filters explain underreporting." American Journal of Public Health **92**(9): 1421-1429.

Bena, A., P. Berchialla, M. Coffano, M. Debernardi and L. Icardi (2009). "Effectiveness of the training program for workers at construction sites of the high-speed railway line between Torino and Novara: Impact on injury rates." American Journal of Industrial Medicine **52**(12): 965-972.

Bilginsoy, C. (2003). "The hazards of training: Attrition and retention in construction industry apprenticeship programs." Industrial & Labor Relations Review **57**(1): 54-67.

Byrd, B. and M. Weinstein (2005). Construction apprenticeship in Oregon: An analysis of data on union and open-shop apprenticeship programs. Report prepared for the Oregon State Building and Construction Trades Council, Portland, OR.

Castillo, D., T. Pizatella and N. Stout (2011). Injuries and Occupational Safety. Occupational and Environmental Health: Recognizing and Preventing Disease and Injury. Barry S. Levy, David H. Wegman, Sherry L. Baron, and Rosemary K. Sokas. Philadelphia, Pa., Lippincott, Williams, and Wilkins.

Cohen, A., M. J. Colligan, R. Sinclair, J. Newman and R. Schuler (1998). Assessing occupational safety and health training. Cincinnati, Ohio: National Institute for Occupational Safety and Health**:** 98-145.

Darragh, A. R., L. Stallones, P. L. Bigelow and T. J. Keefe (2004). "Effectiveness of the HomeSafe pilot program in reducing injury rates among residential construction workers, 1994–1998." American Journal of Industrial Medicine **45**(2): 210-217.

Dong, X., P. Entzel, Y. Men, R. Chowdhury and S. Schneider (2004). "Effects of safety and health training on work-related injury among construction laborers." Journal of Occupational and Environmental Medicine **46**(12): 1222-1228.

Fan, Z. J., D. K. Bonauto, M. P. Foley and B. A. Silverstein (2006). "Underreporting of work-related injury or illness to workers' compensation: individual and industry factors." Journal of Occupational and Environmental Medicine **48**(9): 914-922.

Forst, L., E. Ahonen, J. Zanoni, A. Holloway-Beth, M. Oschner, L. Kimmel, C. Martino, E. Rodriguez, A. Kader and E. Ringholm (2013). "More than training: Community-based participatory research to reduce injuries among hispanic construction workers." American Journal of Industrial Medicine **56**(8): 827-837.

Friedman, L. S. and L. Forst (2007). "The impact of OSHA recordkeeping regulation changes on occupational injury and illness trends in the US: a time-series analysis." Occupational and Environmental Medicine **64**(7): 454-460.

Glover, R. W. and C. Bilginsoy (2005). "Registered apprenticeship training in the US construction industry." Education+ Training **47**(4/5): 337-349.

Government Accountability Office (2009). "Workplace Safety and Health: Enhancing OSHA's Records Audit Process Could Improve the Accuracy of Worker Injury and Illness Data." GAO Report 10-10. Washington, DC. Available at: http://www.gao.gov/new.items/d1010.pdf (Accessed July 2012).

Herrick, R. and J. Dement (1994). Chapter 10. Industrial Hygiene (pp 169-193) Philadelphis, PA, WB Saunders Company.

Hilbe, J. M. (2011). Negative binomial regression. New York, Cambridge University Press.

Johnson, K. A. and J. Ruppe (2002). "A job safety program for construction workers designed to reduce the potential for occupational injury using tool box training sessions and computer-assisted biofeedback stress management techniques." International Journal of Occupational Safety and Ergonomics **8**(3): 321-329.

Kaskutas, V., A. M. Dale, H. Lipscomb and B. Evanoff (2013). "Fall prevention and safety communication training for foremen: Report of a pilot project designed to improve residential construction safety." Journal of safety research **44**(February): 111-118.

Kinn, S., S. A. Khuder, M. S. Bisesi and S. Woolley (2000). "Evaluation of safety orientation and training programs for reducing injuries in the plumbing and pipefitting industry." Journal of Occupational and Environmental Medicine **42**(12): 1142-1147.

Leigh, J. P., J. P. Marcin and T. R. Miller (2004). "An estimate of the US government's undercount of nonfatal occupational injuries." Journal of Occupational and Environmental Medicine **46**(1): 10-18.

Lipscomb, H., J. Dement, J. Gaal and W. Cameron (2000). "Work-related injuries in drywall installation." Applied Occupational and Environmental Hygiene **15**(10): 794-802. PMID: 11036730.

Lipscomb, H., J. Dement, L. Li, J. Nolan and D. Patterson (2003). "Work-related injuries in residential and drywall carpentry." AOEH **18**(6): 479-488. PMID: 12746070.

Lipscomb, H., J. Nolan, D. Patterson, V. Sticca and D. Myers (2013). "Safety, incentives, and the reporting of work-related injuries among union carpenters:"You're pretty much screwed if you get hurt at work"." American Journal of Industrial Medicine **56**(4): 389-399.

Lipscomb, H., A. Schoenfisch and W. Cameron (2015). "Non-reporting of work injuries and aspects of jobsite safety climate and behavioral-based safety elements among carpenters in Washington state." American Journal of Industrial Medicine **58**(4): 411-421.

Lipscomb, H., A. Schoenfisch, W. Cameron, K. Kucera, D. Adams and B. Silverstein (2014). "Twenty years of workers' compensation costs due to falls from height among union carpenters, Washington State." American Journal of Industrial Medicine **57**(9): 984-991. PMID: 24771631.

Lipscomb, H., A. Schoenfisch, W. Cameron, K. Kucera, D. Adams and B. Silverstein (2015). "Contrasting patterns of care for musculoskeletal disorders and injuries of the upper extremity and knee through workers' compensation and private health care insurance among union carpenters in Washington State, 1989 to 2008." American Journal of Industrial Medicine **58**(9): 955-963. PMID: 25939759.

Lipscomb, H., A. Schoenfisch, W. Cameron, K. Kucera, D. Adams and B. Silverstein (2015). "Workers' compensation claims for musculoskeletal disorders and injuries of the upper extremity and knee among union carpenters in Washington State, 1989–2008." American Journal of Industrial Medicine **58**(4): 428-436. PMID: 25712704.

Lipscomb HJ and Schoenfisch AL (2014). "Reflections on Occupational Injury Control." Safety Science Monitor **18**(1): 1-8.

McCoy, A., K. Kucera, A. Schoenfisch, B. Silverstein and H. Lipscomb (2013). "20 years of work-related injury and illness among union carpenters in Washington State." American Journal of Industrial Medicine **56**(4): 381-388.

Mullan, B., L. Smith, K. Sainsbury, V. Allom, H. Paterson and A.-L. Lopez (2015). "Active behaviour change safety interventions in the construction industry: A systematic review." Safety science **79**(November): 139-148.

Nizam, A. (2014). Poisson Regression Analysis. Applied Regression Analysis and Other Multivariable Methods. David G. Kleinbaum, Lawrence L. Kupper, Azhar Nizam, and Eli S. Rosenberg. Boston, MA, Cengage Learning**:** 743-780.

NORA Construction Sector Council (2008). "National Occupational Research Agenda (NORA), National construction agenda for occupational safety and health research and practice in the US construction sector.".

OSHA. (2014). "OSHA Outreach Training Program." Retrieved October 15, 2014, from https://www.osha.gov/dte/outreach/.

Robson, L. S., C. M. Stephenson, P. Schulte, B. Amick, S. Chan, A. Bielecky, A. Wang, T. Heidotting, E. Irvin and D. Eggerth (2010) ""A Systematic Review of the Effectiveness of Training & Education for the Protection of Workers." Toronto: Institute for Work & Health, 2010; Cincinnati, OH: National Institute for Occupational Safety and Health. This publication can also be tracked as DHHS (NIOSH) Publication No. 2010-127."

Robson, L. S., C. M. Stephenson, P. A. Schulte, B. C. Amick III, E. L. Irvin, D. E. Eggerth, S. Chan, A. R. Bielecky, A. M. Wang and T. L. Heidotting (2012). "A systematic review of the effectiveness of occupational health and safety training." Scandinavian journal of work, environment & health **38**(3): 193-208.

Roelofs, C. (2012). "Evaluation of the implementation and impact of a Massachusetts construction OHS training rule." Center for Construction Research and Training (CPWR), Silver Spring MD **20910**.

Rosenman, K. D., A. Kalush, M. J. Reilly, J. C. Gardiner, M. Reeves and Z. Luo (2006). "How much work-related illness and injury is missed by the current national surveillance system?" Journal of Occupational and Environmental Medicine **48**(4): 357-365.

Ruttenberg, R. (2013) ""The Economic and Social Benefits of OSHA-10 Training in the Building and Construction Trades." CPWR. Accessed October 15, 2014 from: http://www.cpwr.com/sites/default/files/publications/RuttenbergEcoSocialBenefits.pdf."

Sanyang, A. (2007). "OSHA 10: Key in Construction Safety Awareness." Blueprints: A Technical Publication of American Society of Safety Engineers' Construction Practice Specialty **7**(1): 12-17.

Schoenfisch, A., H. Lipscomb, W. Cameron, D. Adams and B. Silverstein (2014). "Rates of and circumstances surrounding work-related falls from height among union drywall carpenters in Washington State, 1989–2008." Journal of safety research **51**: 117-124. PMID: 25453185.

Schoenfisch, A., H. Lipscomb, S. Marshall, W. Cameron, D. Richardson and C. Casteel (2013). "Work-related injuries among union drywall carpenters in Washington State, 1989–2008." American Journal of Industrial Medicine **56**(10): 1137-1148. PMID: 23861237.

Schoenfisch, A., H. Lipscomb, S. Marshall, C. Casteel, D. Richardson, M. Brookhart and W. Cameron (2014). "Declining rates of work-related overexertion back injuries among union drywall installers in Washington State, 1989–2008: Improved work safety or shifting of care?" American Journal of Industrial Medicine **57**(2): 184-194. PMID: 24038384.

Shannon, H. S. and G. S. Lowe (2002). "How many injured workers do not file claims for workers' compensation benefits?" American Journal of Industrial Medicine **42**(6): 467-473.

Sinyai, C., P. Stafford and C. Trahan (2013). "Doing it Old School: Peer-led occupational safety training in the US construction Industry." McGill Journal of Education/Revue des sciences de l'éducation de McGill **48**(3): 605-611.

Sokas, R. K., E. Jorgensen, L. Nickels, W. Gao and J. L. Gittleman (2009). "An intervention effectiveness study of hazard awareness training in the construction building trades." Public Health Reports **124**(4): 161-168.

Taylor, E. L. (2014) ""Safety Benefits of Mandatory OSHA 10 Hour Training." CPWR. Accessed January 2015 from http://www.cpwr.com/sites/default/files/publications/TaylorBenefitsOfMandatoryOSHA10_0.pdf."

Trabeau, M., R. Neitzel, H. Meischke, W. E. Daniell and N. S. Seixas (2008). "A comparison of "Train-the-Trainer" and expert training modalities for hearing protection use in construction." American Journal of Industrial Medicine **51**(2): 130-137.

Welch, L., X. Dong, F. Carre and K. Ringen (2007). "Is the apparent decrease in injury and illness rates in construction the result of changes in reporting?" International Journal of Occupational and Environmental Health **13**(1): 39-45.

Wilkins, J. R. (2011). "Construction workers' perceptions of health and safety training programmes." Construction Management and Economics **29**(10): 1017-1026.

Williams, Q., M. Ochsner, E. Marshall, L. Kimmel and C. Martino (2010). "The impact of a peer-led participatory health and safety training program for Latino day laborers in construction." Journal of Safety Research **41**(3): 253-261.

Wuellner, S. E. and D. K. Bonauto (2014). "Exploring the relationship between employer recordkeeping and underreporting in the BLS Survey of Occupational Injuries and Illnesses." American Journal of Industrial Medicine **57**(10): 1133-1143.

Zeger, S., K. Liang and P. Albert (1988). "Models for longitudinal data: a generalized estimating equation approach." Biometrics **44**(December): 1049-1060.

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