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Contractor-, steward-, and coworker-safety practice: associations with musculoskeletal pain and injury-related absence among construction apprentices

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Abstract

Objectives This paper sought to assess organizational safety practices at three different levels of hierarchical workplace structure and to examine their association with injury outcomes among construction apprentices.

Methods Using a cross-sectional sample of 1,775 construction apprentices, three measures of organizational safety practice were assessed: contractor-, steward-, and coworker-safety practice. Each safety practice measure was assessed using three similar questions (i.e., on-the-job safety commitment, following required or recommended safe work practices, and correcting unsafe work practices); the summed average of the responses ranged from 1 to 4, with a higher score indicating poorer safety practice. Outcome variables included the prevalence of four types of musculoskeletal pain (i.e., neck, shoulder, hand, and back pain) and injury-related absence.

Results In adjusted analyses, contractor-safety practice was associated with both hand pain (OR: 1.27, 95 % CI: 1.04, 1.54) and back pain (OR: 1.40, 95 % CI: 1.17, 1.68); coworker-safety practice was related to back pain (OR: 1.42, 95 % CI: 1.18, 1.71) and injury-related absence (OR: 1.36, 95 % CI: 1.11, 1.67). In an analysis that included all three safety practice measures simultaneously, the association between coworker-safety practice and injury-related absence remained significant (OR: 1.68, 95 % CI: 1.20, 2.37), whereas all other associations became non-significant.

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Conflict of interest The authors declare that they have no conflict of interest.

Conclusions This study suggests that organizational safety practice, particularly coworker-safety practice, is associated with injury outcomes among construction apprentices.

Keywords

Safety practice; Occupational injury; Musculoskeletal pain; Construction worker; Neck pain; Shoulder pain; Hand pain; Back pain

Introduction

With more than 5.5 million workers, construction is one of the largest private industries in the US, and it has one of the highest incidences of occupational injury among all private industries (Bureau of Labor Statistics 2012). In 2011, the construction industry had a fatal occupational injury rate of 8.9 per 100,000 full-time equivalent (FTE) workers, which is more than twice the national average (3.5 per 100,000 FTE) (Bureau of Labor Statistics 2012). Construction workers also have a high prevalence of non-fatal injuries, such as musculoskeletal disorders (Dong et al. 2012; Palmer et al. 2001). One US national survey of 49 major occupations reported that the prevalence of back pain is highest among male construction laborers (Guo et al. 1995).

A growing body of evidence links the organizational safety practices at construction worksites to workers' injury outcomes (Gillen et al. 2002, 1997; Probst et al. 2008) as well as to workers' safety behaviors, such as the use of hearing protection (Edelson et al. 2009). As articulated by Melia and colleagues, construction workers' safety behaviors and injury risk are simultaneously influenced by the safety practices of multiple agents at different levels of the worksite hierarchy (e.g., top management, contractors, supervisor, coworker, and workers); as a result, organizational safety practice should be estimated at as many of these levels as possible (Melia et al. 2008).

However, few studies have assessed organizational safety practice while considering the unique hierarchical workplace structure of the construction industry (Melia et al. 2008) and have examined the association between organizational safety practice and injury outcomes. A growing body of research suggests that while contractors and supervisors have formal power to influence workplace safety policy and practice, coworkers also play an important informal role in determining workers' safety performance (Lingard et al. 2011; Glazner et al. 1999; Conchie et al. 2013; Johnson 2007). One meta-analysis that reviewed 161 independent studies of a total of 77,954 workers found compelling evidence that coworkers significantly influence individual worker outcomes, including work attitude and effectiveness (Chiaburu and Harrison 2008).

To fill these knowledge gaps, we assessed safety practice from the three different workplace levels in the construction industry (i.e., contractor-, unions' steward-, and coworker-safety practice). Then, we examined the association of these three safety practice measures with musculoskeletal pain (MSPs) and injury-related absence among construction apprentices. Specifically, this paper sought to answer two primary research questions:

1. What are the associations between contractor-, steward-, and coworker-safety practice and MSPs (i.e., neck pain, shoulder pain, hand pain, and back pain) among construction apprentices?
2. What are the associations between contractor-, steward-, and coworker-safety practice and injury-related absence among construction apprentices?

Materials and methods

Study population

The data for the study are from the MassBUILT study, which was a group randomized controlled trial of a smoking cessation intervention. Detailed information about the study design, sample, and intervention results have been published elsewhere (Kim et al. 2012; Okechukwu et al. 2009). The study involved 10 different apprenticeship programs for building trades. Building trade apprenticeship programs train individuals to become bricklayers, painters, hoisting and portable engineers, ironworkers, boilermakers, pipefitters, sprinkler fitters, electricians, plumbers, or refrigeration workers. Apprentice training programs are typically located in union buildings, entail 3–4 years of classroom-based and on-the-job training, and are jointly funded by unions and construction businesses (Bilginsoy 2003). The apprentices in our study were unionized but construction workers work in different worksites with some worksites having only union workers while others might have both union and non-union workers. Unionized construction worksites have union stewards, who are elected through their trade union to represent all workers at the site and advocate with supervisors and management when safety issues arise at workplaces. The opinions of union stewards are critical when workplaces negotiate with unions around what types of safety measures are important to provide for all workers.

The data were collected in 2005 and 2006 via self-reported questionnaires. Questionnaire items were culled from existing literature but were also cognitively tested on construction apprentices as part of pilot study of protocol and processes for MassBUILT (Barbeau et al. 2006). Staff members from the Dana-Farber Cancer Institute were trained to administer the survey at regularly scheduled apprentice class and meeting times for each of the apprenticeship programs. In an effort to ensure a high response rate, staff members provided apprenticeship program coordinators with extra questionnaires and stamped return envelopes for distribution to apprentices who were not present at scheduled survey times. After obtaining informed consent from participants, 1,817 apprentices (93.6 %) completed the survey. All methods and materials used in the study were approved by the Dana-Farber Cancer Institute's Institutional Review Board, and all participant responses were kept confidential from apprentice management and study staff members.

Participants with missing values for the independent variables (contractor- or stewards- or coworker-safety practice) or the dependent variables (MSP or injury-related absence) were excluded from analyses. The associations of safety practice with MSP and injury-related absence were examined among the remaining participants, with sample sizes for the different dependent variables ranging from 683 to 1,734.

Exposure variables: contractor-, steward-, and coworker-safety practice

We modified a pre-existing measure of safety practice for use in the study (Goldenhar et al. 1998). The modified scale considers the effects of hierarchical workplace structure in the construction industry by assessing safety practice at three different levels (i.e., contractor, union steward, and coworker). Apprentices were asked to answer three questions about contractor-safety practice. The questions had four-point ordinal scales (1: completely agree, 2: generally agree, 3: generally disagree, 4: completely disagree) and included (1) Contractors are committed to safety on the job. (2) Contractors follow required or recommended safe work practices. (3) Contractors correct unsafe work practices when they occur. The summed scores from the three questions were divided by 3 and the resulting score ranged from 1 to 4, with a higher score indicating poorer safety practice. These same questions were repeated for coworker-safety practice, except that the wording was changed from “contractor” to “coworkers” for each of the three questions. The contractor and coworker questions had an internal consistency reliability of 0.86 and 0.79, respectively.

Many of the workers did not have an on-site union steward. Therefore, respondents were first asked the question, “In your current or most recent job, is there a steward from your union on-site?” If the apprentices answered “Yes” (N = 1,016), they were then asked to answer three questions to assess steward-safety practice. The same three questions were used for steward-safety practice as for contractor-safety practice with changes in wording from “contractor” to “your union's stewards. ” The internal consistency for steward-safety practice was 0.91.

Outcome variables: musculoskeletal pains and injury-related absence

The prevalence of MSPs was measured for each of four parts of the upper body (i.e., neck, shoulder, hand, and back) (Barbeau et al. 2005). We asked the following question: “Since starting work in your trade, have you had pain, aching, burning, stiffness, cramping, or soreness in your neck more than 3 times or that lasted more than 1 week?” Workers could answer Yes (coded as 1) or No (coded as 0).

To measure injury-related absence, we assessed whether apprentices had spent one or more days away from work due to work-related injury using the question “Since starting work in your trade, have you ever had an injury on the job that caused you to miss 1 or more days from work?” Apprentices could answer Yes (coded as 1) or No (coded as 0).

Covariates

Worksite variables were assessed as covariates. Apprenticeship training programs usually last between 3 and 5 years, depending on trade. We measured the year of training as a range of 1–5 years and modeled it as a categorical variable. In order to control any effect of workplace on the outcome and exposure variables, we included indicator variables in each model that represented the 10 workplaces. We also considered age, gender, race/ethnicity, education, and income as potential confounders. Age was coded as a four category variable (18–24, 25–34, 35–44, ≥45 years). Race/ethnicity was collapsed into Hispanic, non-Hispanic Black, non-Hispanic White, and non-Hispanic other. Educational attainment was seven categories and was re-coded as a four category variable (less than high school, high school or GED, some college or 2-year degree, or 4 years or more of college). Household income, which was originally coded as seven categories ranging from under $10,000 to $75,000 or more, was collapsed into four categories (<$25,000, $25,000–49,999, $50,000–74,999, and ≥$75,000).

Physical exposure to ergonomic strain was also included as a potential confounder of the association between safety practice and the outcome variables (Punnett et al. 2000; Punnett and van der Beek 2000). Ergonomic strain was assessed via self-report for each of the four MSPs using the following questions: "On average, over the past 12 months, when you work a full shift, how many hours" (1) do you work with your head bent forward, sideways, or backwards? (neck pain), (2) do you work with your hands above your head or your elbows above your shoulder? (shoulder pain) (3) do you repeat quick hand motions every few seconds? (hand pain) Examples include: hammering, driving a screw, or stapling? (4) do you work with your back bent forward or twisted to either side? (back pain). To facilitate comprehension, illustrations were provided for each of the four questions that depicted a figure in the positions of strain. The response range was a four-point ordinal scale (0: almost never, 1: sometimes but for less than 1 h, 2: 1–4 h, 3: more than 4 h). Ergonomic strain was coded as a categorical variable with "almost never" as the reference group.

Data analyses

STATA/SE version 11.0 (StataCorp., College Station, TX) was used to apply logistic regression to assess the associations between each of the three safety practice measures and MSPs and injury-related absence. In addition, we conducted a logistic regression including all the three safety practice measures simultaneously to examine the association between each safety practice measure and injury outcomes while adjusting for the other two safety practice measures.

A considerable number of apprentices ($N = 747$) did not answer the questions about steward-safety practice because they did not have on-site stewards in their current or most recent job. Those apprentices were excluded from all analyses of steward-safety practice. In order to account for missing values of demographic variables, multiple imputation was used for income ($n = 266$), race ($n = 120$), education ($n = 91$), gender ($n = 47$), self-reported ergonomic strain for neck pain ($n = 18$), shoulder pain ($n = 20$), hand pain ($n = 23$), and back pain ($n = 18$). Multiple imputations were conducted using the *mi impute mvn* command in STATA, which is based upon Markov Chain Monte Carlo techniques. After completing ten imputations, the *mi estimate* commands were used to combine the results from the ten imputed multivariate logistic regression models to analyze the relationship between each of the three safety practice measures with the injury outcomes (i.e., MSPs and injury-related absence).

Results

As indicated in Table 1, most of the construction apprentices were non-Hispanic white (82.3 %) males (95.2 %) under 35 years of age (81.0 %). Table 2 displays the results for the distributions of the four MSPs by self-reported ergonomic strain. Overall, back pain had the highest prevalence (50.5 %) and hand pain had the lowest prevalence (28.5 %) among the four MSPs. For each of four MSPs, greater self-reported ergonomic strain was significantly associated with higher prevalence of MSP. And 28.9 % of apprentices (=505 out of 1,747) reported that they had ever experienced injury-related absence (Data were not shown).

The steward-safety practice score (Mean: 1.52, SD: 0.58) was lower than both the contractor- (Mean: 1.88, SD: 0.57) and the coworker-safety practice scores (Mean: 1.82, SD: 0.56), indicating that steward-safety practice was better than the other two's (Table 3). All three measures of safety practice were significantly correlated with one another. Steward-safety practice was closely correlated with contractor-safety practice (r = .35) and with coworker-safety practice (r = .43).

Table 4 shows the association between each of the three different safety practice measures and the injury outcome variables (i.e., neck pain, shoulder pain, hand pain, back pain, and injury-related absence). In the fully adjusted model, we found that contractor-safety practice was associated with hand pain (OR: 1.27, 95 % CI: 1.04, 1.54) and back pain (OR: 1.40, 95 % CI: 1.17, 1.68). We also found significant associations between coworker-safety practice and back pain (OR: 1.42, 95 % CI: 1.18, 1.71) and injury-related absence (OR: 1.36, 95 % CI: 1.11, 1.67). No significant association was observed between steward-safety practice and any injury outcome.

In the combined analyses that included all three safety practice measures simultaneously, the association between coworker-safety practice and injury-related absence (OR: 1.68, 95 % CI: 1.20, 2.37) remained significant, whereas all of the other associations were attenuated and became nonsignificant (Table 5).

Discussion

This paper suggests that poor coworker-safety practice could be a particularly important risk factor of injury-related absence and should be investigated further. Previous studies support the finding that coworkers can play a critical role in workers' safety. Tucker et al. pointed out that coworkers are often perceived as experts on job tasks, and they interact more closely with workers than supervisors (Tucker et al. 2008). A longitudinal study with 2,542 youth workers analyzed the factors associated with individual worker's risk-taking orientation, which is a person's willingness to engage in activities that might entail physical danger. This study found that coworker's tolerance for risk-taking was a strong predictor of worker's risk-taking orientation, even more than supervisory influence (Westaby and Lowe 2005).

The observed association between contractor- and coworker-safety practice and injury outcome is consistent with previous research that reported that occupational injury outcome is related to poor safety climate, which is commonly defined as workgroup members' perceptions of the safety policy, management, and practice at their workplaces (Kines et al. 2011; Zohar 1980). In a study of injury severity among construction workers who experienced non-fatal occupation-related falls, Gillen et al. found that poor safety climate was related to injuries that resulted in higher functional limitations (Gillen et al. 1997). An ecological study of construction workplaces also found an association between safety climate and injury outcomes in which those workplaces with poor safety climates significantly underreported injury rates in comparison with those with positive safety climates (Probst et al. 2008).

Even though safety is an important part of union activities in workplaces (Kim et al. 2012; Sinclair et al. 2010), safety practices at the union-steward level were associated with neither MSP nor injury-related absence. It is important to note that all of the apprentices in the study were unionized, but not all of them had union stewards onsite. As a result, the association being examined is not the impact of unions but the impact of safety practice at the union steward level in comparison with safety practice at supervisor and coworker levels. Little is known about the role of union's steward on workers' health; more research is required to understand how union steward's safety practice can influence health outcomes for unionized workers.

This paper has several limitations. The major limitation is that because of the cross-sectional study design and self-reported organizational safety practice, we cannot provide information about the temporal relationship between organizational safety practice and injury outcomes. For example, it is possible that apprentices who experienced back pain are less satisfied with workplace safety practices and, as a result, are more likely to report poor organizational safety practice for their workplaces. Future study with a prospective design assessing organizational safety practice from administrative data (Zhan and Miller 2003) or from surveys directly asking supervisor about their safety practice (Huang et al. 2012) could be useful to investigate the temporal association.

Second, this paper could not adjust for some relevant potential psychosocial factors, such as job control and demand or relationship with supervisor, although they could be associated with perceived organizational safety practice and health outcome (Linton 2001). Future research is required to examine the role of these psychosocial factors in analyses of organizational safety practice and injury outcomes among construction workers.

Finally, a large number of apprentices did not answer the question about neck and shoulder pain. This is probably because of confusing skip instructions that preceded these two questions. We do not expect that these missing values can explain the significant associations observed in this study; however, because we found strong associations between safety practice and hand pain, back pain, and injury-related absence which were not related to these missing.

This study has several strengths. First, we assessed safety practice from multiple levels of workplace structure (i.e., contractor-, steward-, and coworker-safety practice) and examined their association with injury outcomes, reflecting the hierarchical workplace structure of the construction industry. In addition, we were able to achieve a high response rate to our survey even though it is usually difficult to gain access to construction workers.

Conclusions

Previous research about global burden of occupational risks has reported construction industry, along with agriculture and mining, is far more dangerous than other industries (Nelson et al. 2005). This paper found that poor organizational safety practice, particularly coworker-safety practice, may play an important role in developing occupational injury among construction workers. In order to confirm the causal associations between safety practice at different levels of workplace structure and injury outcomes among construction apprentices, future studies should examine the association between safety practice and injury outcomes with other psychosocial constructs, such as job control and demand, using a prospective study design. In addition, because this study assessed musculoskeletal pain through self-reporting, future studies are required to check whether similar associations are observed between organizational safety practice and more severe musculoskeletal injuries that can be measured using administrative data (e.g., back pain that causes days away from work). Future research should also attempt to develop effective interventions for organizational safety practice in order to reduce injury and injury-related absence among construction workers. Such an intervention would not only improve worker health and possibly help decrease the disparities in injury and illness across occupational classes, but would also help decrease the high costs of work-related injury and absence in the construction industry.

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Table 1

Demographic characteristics of construction apprentices in the MassBUILT study (*n* = 1,775)[a]

	N	%
Gender		
Male	1,645	95.2
Female	83	4.8
Age(*years*)		
18–24	578	32.6
25–34	859	48.4
35–44	302	17.0
45–	36	2.0
Race		
Hispanic	63	3.8
Black	119	7.2
Other	112	6.8
White	1,361	82.3
Education		
Less than high school	21	1.3
High school or GED	857	50.9
Some college or 2-year degree	654	28.8
4-year college or more	152	9.0
Annual income ($)		
<25,000	98	6.5
25,000–49,999	562	37.2
50,000–74,999	384	25.5
>75,000	465	30.8
Years of apprenticeship program		
1	330	18.5
2	438	24.5
3	393	22.0
4	303	17.0
5	321	18.0
Apprentice sites		
Plumbers	154	8.7
Electricians	59	3.3
Bricklayers	148	8.3
Ironworkers	109	6.1
Painters and allied trades	114	6.4
Sprinkler fitters	78	4.4
Pipefitters	279	15.7
Electricians 2nd group	681	38.4

	N	%
Operating engineers	30	1.7
Plumbers and pipefitters	123	6.9

GED general education development

[a]Totals do not add up to the same number because values were calculated prior to imputing missing covariates

Table 2

Distribution of self-reported ergonomic strain and musculoskeletal pains among construction apprentices in the MassBUILT study

Self-reported ergonomic strain[a] for each musculoskeletal pain	Neck pain		Shoulder pain		Hand pain		Back pain	
	Total *N*	Prevalence* *N* (%)	Total *N*	Prevalence* *N* (%)	Total *N*	Prevalence* *N* (%)	Total *N*	Prevalence* *N* (%)
Almost never	43	16 (37.2)	37	13 (35.1)	57	9 (14.0)	94	30 (32.0)
Sometimes but less than 1 h	240	74 (30.8)	234	83 (35.5)	367	85 (23.2)	465	204 (43.9)
1–4 h	624	239 (38.3)	690	268 (38.7)	771	220 (28.5)	815	415 (51.0)
More than 4 h	309	152 (49.2)	251	130 (51.8)	543	182 (33.5)	363	226 (62.3)
Missing	11	4 (36.4)	12	5 (29.4)	22	6 (27.3)	16	10 (62.5)
Total	1,227[b]	485 (39.5)	1,224[b]	498 (40.7)	1,760	501 (28.5)	1,753	885 (50.5)

* *p* value of the chi-square test about difference of prevalence of each musculoskeletal pain by self-reported ergonomic pain was <0.001 for each of four musculoskeletal pains

[a] Self-reported ergonomic strain was assessed by the amount of time on the job for stressful body postures for each musculoskeletal pain

[b] Sample size for the analysis about neck pain and shoulder pain is smaller than others, probably because of confusing skip instructions that preceded the questions about neck pain or shoulder pain

Table 3

Distribution of contractor-, steward-, and coworker-safety practice and Pearson's correlation coefficients between different measures of safety practice among construction apprentices

Safety practice (score range[a])	*N*	Mean (SD)	Correlation between safety practice from		
			Contractor	Steward	Coworker
Contractor (1–4)	1,749	1.88 (0.57)[c]	1		
Steward (1–4)	996[b]	1.52 (0.58)[c]	0.35*	1	
Coworker (1–4)	1,725	1.82 (0.56)[c]	0.55*	0.43*	1

* $p < 0.001$: *p* value of Pearson's correlation coefficients between safety practice measures from different levels

[a] Higher score in safety practice indicating poorer practice

[b] Sample size for steward-safety practice is smaller than others because apprentices who did not have on-site stewards ($N = 747$) were not eligible to answer the questions about steward-safety practice

[c] Steward-safety practice was significantly lower (*p* value <0.001) than both contractor- and coworker-safety practice when paired t test was conducted among the apprentices who reported all the three safety practice measures

Table 4

Association of contractor-, steward-, and coworker-safety practice with upper body musculoskeletal pain and injury-related absence among construction apprentices in the MassBUILT study in the adjusted model

Injury outcomes	Contractor-safety practice[a]			Steward-safety practice			Coworker-safety practice		
	N	OR	95 % CI	*N*[b]	OR	95 % CI	*N*	OR	95 % CI
Upper body musculoskeletal pain									
Neck pain[c]	1,205	0.95	(0.77, 1.18)	705	1.03	(0.79, 1.35)	1,194	1.10	(0.89, 1.38)
Shoulder pain[c]	1,202	1.04	(0.84, 1.29)	703	1.02	(0.77, 1.33)	1,191	1.20	(0.96, 1.49)
Hand pain	1,734	1.27*	(1.04, 1.54)	979	1.11	(0.86, 1.43)	1,712	1.19	(0.98, 1.45)
Back pain	1,727	1.40***	(1.17, 1.68)	974	1.19	(0.94, 1.51)	1,705	1.42***	(1.18, 1.71)
Injury-related absence	1,721	1.19	(0.97, 1.44)	968	1.04	(0.81, 1.34)	1,700	1.36**	(1.11, 1.67)

Adjusted for age, gender, race, education level, income, the years of apprenticeship program, apprentice site, and self-reported ergonomic strain

[a] Each of safety practice measures ranged from 1 to 4, with a higher score indicating poorer safety practice

[b] Sample size for steward-safety practice is smaller than others because apprentices who did not have on-site stewards ($N = 747$) were not eligible to answer the questions about steward-safety practice

[c] Sample size for the analysis about neck pain and shoulder pain is smaller than others, probably because of confusing skip instructions that preceded the questions about neck pain or shoulder pain

* $p < 0.05$;

** $p < 0.01$;

*** $p < 0.001$

Table 5

Association of contractor-, steward-, and coworker-safety practice with upper body musculoskeletal pain and injury-related absence among construction apprentices in the MassBUILT study in the adjusted model

Injury outcomes	Safety practice[a]	N	OR	95 % CI
Neck pain	Contractor	685	0.91	(0.65, 1.28)
	Steward		1.04	(0.76, 1.42)
	Coworker		1.07	(0.75, 1.52)
Shoulder pain	Contractor	683	1.06	(0.75, 1.49)
	Steward		0.87	(0.63, 1.19)
	Coworker		1.29	(0.90, 1.85)
Hand pain	Contractor	952	1.09	(0.80, 1.49)
	Steward		1.04	(0.78, 1.40)
	Coworker		1.12	(0.80, 1.55)
Back pain	Contractor	947	1.33	(0.99, 1.8)
	Steward		1.00	(0.76, 1.32)
	Coworker		1.16	(0.85, 1.58)
Injury-related absence	Contractor	942	0.92	(0.67, 1.27)
	Steward		0.86	(0.64, 1.16)
	Coworker		1.68 **	(1.20, 2.37)

* $p < 0.05$;

** $p < 0.01$;

*** $p < 0.001$

Adjusted for age, gender, race, education level, income, the years of apprenticeship program, apprentice site, and self-reported ergonomic strain

[a]Each of safety practices measures ranged from 1 to 4, with a higher score indicating poorer safety practice