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Worksite safety climate, smoking, and the use of protective equipment by blue collar building workers enrolled in the MassBUILT smoking cessation trial

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Abstract

Objective—In order to assess potential contributors to high injury rates and smoking prevalence among construction workers, we investigated the association of safety climate with personal protective equipment (PPE) use, and smoking behaviors.

Methods—Logistic regression models estimated risk ratios for PPE use and smoking using data from participants in MassBUILT smoking cessation intervention (n=1,725).

Results—Contractor safety climate was negatively associated with use of dust masks (RR=0.88,95%CI:0.83–0.94); respirators (RR=0.82,95%CI:0.75–0.89); general equipment (RR=0.98,95%CI:0.95–1.00); and fall protection (RR=0.94,95%CI:0.91–0.98) and positively associated with current smoking (RR=1.12,95%CI:1.01–1.25) but not smoking cessation. Coworker safety climate was negatively associated with use of dust masks (RR=0.87,95%CI: 0.82–0.92); respirators (RR=0.80,95%CI:0.74–0.87); general equipment (RR=0.96,95%CI:0.94–0.98); fall (RR=0.92,95%CI:0.89–0.96) and hearing (RR=0.88,95%CI:0.83–0.93) protection but not smoking.

Conclusions—Worksite safety climate may be important for PPE use and smoking, but further research is needed.

Keywords

safety climate; construction; blue collar; smoking; safety equipment

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Introduction

Worksite safety climate – the extent to which employees believe that safety is valued in an organization (1–6) – is emerging as an important determinant of occupational safety behaviors and worksite injuries (2–3, 7). At the organizational level, safety climate predicts employers' provision of personal protective equipment (8) and safety performance (9–10). Studies have also begun to link worksite safety climate to workers' individual safety behaviors, such as their use of personal protective equipment (9, 11). Among construction workers, safety climate predicts workers' use of hearing protection devices (11). In addition, Arcury and colleagues (9) found that worksite safety climate was positively associated with consistent individual-level use of personal protective equipment among poultry workers.

The relationship between safety climate and behavior is important to the health of construction workers for several reasons. First, the construction industry has the highest rate of fatal occupational injury of any profession in the country (12), and workers in construction disproportionately suffer from non-fatal occupational injuries (13). Second, several studies have pointed to potential work-related risk factors for construction workers' high ranking in unsafe health behaviors such as smoking (2, 5–6, 14). In 2010, the prevalence of smoking among construction workers was 30%, roughly equivalent to the smoking prevalence in the US general population 25 years ago (15–16).

The aim of this analysis was to use data from the 2005–2006 MassBUILT smoking cessation intervention for construction workers to investigate the association between safety climate and health and safety behaviors. This analysis examined the cross–sectional relationship between safety climate and the use of personal protective equipment and smoking status at baseline and the longitudinal relationship between safety climate and smoking cessation outcomes. Given that co-workers have been shown to have an independent, though informal, role in determining safety practices at worksites, we investigated co-worker safety climate in addition to contractor (i.e., supervisor) safety climate (14, 17–18). This analysis draws attention to worksite safety climate as an important factor that, if improved, may reduce both injury and illness among blue collar workers.

We expected contractor safety climate to be positively correlated with co-worker safety climate. First, we hypothesized that both low contractor- and coworker-safety climate would be associated with a lower prevalence of use of all types of safety equipment at baseline. Second, we hypothesized that both types of low safety climate would be associated with a higher risk of smoking at baseline and a lower likelihood of subsequent smoking cessation. Third, we hypothesized that low safety climate would be associated with a higher frequency and intensity of smoking at baseline, as well as a lower likelihood of decreasing smoking intensity or frequency over time.

Methods

Study Population

Data are from self-report questionnaires administered to construction apprentices in the MassBUILT smoking cessation trial. The protocol and results of the original study are described in further detail elsewhere (19–21). Briefly, ten out of sixteen eligible apprentice training sites for boilermakers, bricklayers, electricians, hoisting and portable engineers, ironworkers, painters, plumbers, pipefitters, sprinkler fitters, or refrigeration workers agreed to be size matched and randomly assigned to the treatment or control group. The approximately four-month long intervention added information on toxics and tobacco to existing apprenticeship training curriculum, and also included group-based smoking cessation counseling, nicotine replacement therapy, do-it-yourself quit kits, and environmental cues for smoking cessation (e.g., posters and written materials) (20). All workers were invited to participate in the study regardless of smoking status.

At baseline, 1,817 apprentices (96.3% response rate) completed baseline surveys. Of these, 1,725 had non-missing data for contractor and coworker safety climate and were included in cross-sectional analyses of safety climate with baseline smoking status and PPE use.

Of the 731 apprentices who were smokers at baseline, 478 had complete information on smoking cessation at both follow-up time points, and 456 also had complete information for safety climate, thus were included in the longitudinal analysis of the impact of safety climate on smoking cessation. Smoking cessation data was collected twice: one month after the MassBUILT intervention ended (follow-up one), and least six months after follow-up one (follow-up two).(19–21)

Measures

Outcome variables

The personal protective equipment use questionnaire assessed regular use of dust masks, respirators, hearing protection, general protective equipment, such as gloves or goggles, and fall protection at work. For each type of equipment, workers were asked "Do you typically wear/use ___equipment when required or needed"? Response options were yes or no. *Smoking status at baseline:* using CDC guidelines (22), workers were classified as smokers if they had smoked at least 100 cigarettes in their lifetime and had smoked in the past 30 days. All others were classified as nonsmokers. *Smoking cessation at follow-up one and two:* The study survey assessed 7-day smoking abstinence one month post-intervention (follow-up one) and sustained cessation for at least six months after follow-up one (follow-up two). *Smoking frequency* was measured as the number of days smoked out of the past 30, and *smoking intensity* was measured as the number of cigarettes smoked per day in the past 30 days. Smoking frequency and intensity were only assessed for workers who were smokers at baseline and who had complete data on smoking status for both follow-up time points. Changes in frequency and intensity over time were calculated by subtracting baseline smoking intensity and frequency from smoking intensity and frequency at each of the follow-up visits.

Independent Variables

Safety climate was measured using an adapted version of the NIOSH management safety commitment scale (23). Apprentices answered four questions about the safety practices and attitudes of their co-workers and contractors (i.e., supervisors). These questions asked 1) how well these individuals followed required or recommended safe work practices, 2) whether they corrected unsafe work practices, 3) whether they were committed to safety on the job, and 4) how often respondents felt pressured to take shortcuts in safety practices. Response options were on four-point Likert scales that ranged from “completely agree” to “completely disagree” for the first three questions and “always” to “never” for the fourth question. We summed responses to questions about contractors and coworkers in order to obtain total scores for contractor and coworker safety climate and then re-coded these figures so that higher scores reflected worse safety climate.

Using confirmatory factor analysis techniques in SAS 9.3, all contractor safety climate items loaded on a single factor (≥ 0.40). The fourth item of the coworker safety climate scale did not have a sufficient factor loading (<.40) and was dropped. The standardized Cronbach’s alpha was 0.81 for the four-item contractor safety scale and 0.77 for the 3-item coworker safety scale, suggesting high internal reliability. Mean contractor and coworker safety climate scores had skewed, non-normal distributions and non-linear associations with outcome variables. Therefore, both types of safety climate were dichotomized at their respective medians and analyzed as binary variables in logistic regression models (24).

Covariates included gender, race, income, and education, which were categorical, and age, which was continuous. Due to small cell sizes, we collapsed the “less than high school” and “high school or GED” education categories, as well as the Latino and “other” racial categories.

Data Analysis

We conducted cross-sectional analyses of baseline data from the MassBUILT intervention study and a longitudinal analysis of MassBUILT data on smoking cessation outcomes using SAS 9.3. We used Chi-square and Fisher’s Exact tests for bivariate analyses of categorical variables, and McNemar’s tests for continuous variables (age). As expected, contractor and coworker safety climate were highly correlated (Spearman’s r = 0.57, p<.0001); thus, they were modeled separately.

Due to high missingness for income (n=278, 15.3%), and some other covariates, including race (n=108, 6.3%) and education (n=80, 4.6%), we used Amelia II to perform multiple imputation for covariates only. Amelia uses an algorithm that combines Expectation-Maximization with bootstrapping to produce point estimates, and then combines this information with the original data to produce ten datasets with estimated values for each missing observation (25–26). We obtained final estimates with corrected standard errors using SAS PROC MIANALYZE, which combined results from ten multivariable regressions for each analysis we conducted.

We used PROC GLIMMIX in SAS 9.3 to create simple and multivariable logistic regression models of smoking status and PPE use that adjusted for clustering by worksite (27). To create consistency across the current smoking literature, all demographic covariates were included in final models (28–31). Effect estimates were expressed as risk ratios instead of odds ratios because of the high prevalence of smoking in the sample, which likely violated the rare disease assumption required by odds ratios (32). Models of smoking cessation outcomes were also adjusted for intervention group assignment (20). We also used

GLIMMIX to construct Poisson regression models to model changes in smoking intensity and frequency over time.

Results

As expected, the majority of the sample was male (95.0%, n=1600), White (82.1%, n=1328), and had an education of high school/ GED or less (51.8%, n=852). Mean age was 28.5 (SD=6.6). Income was rather equally distributed among the income brackets: $25,000–$49,999 (37.1%), $40,000–74,999 (25.6%), and $75,000 or greater (30.7%).

At baseline, 44.8% (n=772) of respondents reported low contractor safety climate, and 55.3% (n=953) reported low coworker safety climate (Table 1). Regular use of PPE was 74.8% (n=1128) for dust masks, 76.4% (n=1177) for hearing protection, 69.8% (n=736) for respirators, 88.1% (n=1331) for fall protection, and 95.1% (n=1497) for general equipment use, such as goggles or gloves.

Forty-three percent of respondents (n=731) were current smokers, and 57.0% (n=968) were nonsmokers. Of the 456 baseline smokers with complete information for safety climate and smoking cessation at both follow-up time points, 20.4% (n=93) had been abstinent from cigarettes in the past 7 days at follow-up one; 9.2% (n=42) had been abstinent from cigarettes for the past 6 months at follow-up two. Seven percent (7.2%, n=33) of workers who were smokers at baseline were abstinent from cigarettes at both follow-up time points.

Safety climate and PPE

In bivariate analyses, low contractor safety climate was associated with significantly lower use of dust masks (RR=0.87, 95%CI: 0.82–0.92), respirators (RR=0.82, 95%CI: 0.75–0.89), general equipment (RR=0.63, 95%CI: 0.40–0.99), and fall protection (RR=0.60, 95%CI: 0.44–0.82), but not hearing protection (RR=0.83, 95%CI: 0.65–1.05; Table 2). Likewise, there was an inverse association between coworker safety climate and all types of protective equipment use, including dust masks (RR=0.87, 95%CI: 0.82–0.91), respirators (RR=0.80, 95%CI: 0.74–0.87), hearing protection (RR=0.57, 95%CI: 0.45–0.72), general equipment (RR=0.44, 95%CI: 0.26–0.73), and fall protection (RR=0.48, 95%CI: 0.35–0.68; Table 2).

In multivariable models, low contractor safety climate remained significantly associated with lower use of dust masks (RR=0.88, 95%CI: 0.83–0.94); respirators (RR=0.82, 95%CI: 0.75–0.89); general equipment, such as goggles or gloves (RR=0.98, 95%CI: 0.95–1.00); and fall protection (RR=0.94, 95%CI: 0.91–0.98), but not hearing protection (RR=0.96, 95%CI: 0.91–1.01; Table 3). Coworker safety climate also remained significantly associated with lower levels of use of all types of equipment, including dust masks (RR=0.87, 95%CI: 0.82–0.92), respirators (RR=0.80, 95%CI: 0.74–0.87), hearing protection (RR=0.88, 95%CI: 0.83–0.93), general equipment, such as goggles and gloves (RR=0.96, 95%CI: 0.94–0.98), and fall protection (RR=0.92, 95%CI: 0.89–0.96; Table 3).

Safety climate and smoking

In unadjusted logistic regression models, poor contractor safety climate (RR=1.12, 95%CI: 1.00–1.24), but not poor coworker safety climate (RR=1.00, 95%CI: 0.90–1.12), was associated with baseline smoking status (Table 2). Adjusting for covariates, effect estimates remained virtually unchanged; workers who reported low contractor safety climate had a 12% higher risk of smoking than those who reported high contractor safety climate (RR=1.12, 95%CI: 1.01–1.25; Table 4), and results remained nonsignificant for coworker safety climate. Neither contractor nor coworker safety climate was significantly associated with seven-day abstinence or 6-month sustained abstinence in either unadjusted or adjusted models (Table 4). Safety climate was not a significant predictor of smoking frequency or intensity at baseline or follow-up, or changes in these variables over time.

Discussion

Based on emerging evidence of the importance of safety climate to workers' behaviors, this analysis sought to understand the cross-sectional association between safety climate and personal protective equipment use and smoking, as well as associations with longitudinal smoking behaviors. In keeping with findings regarding the influence of both supervisors and coworkers on safety climate, the analyses considered the safety climate shaped by these agents separately. The results show that both types of safety climate have important implications for personal protective equipment use among blue collar workers, and safety climate may play a role in the high prevalence of smoking among construction workers. This analysis calls attention to worksite safety climate as a potential contributor to construction workers' health and safety behaviors.

Existing research on individual-level safety climate and safety behavior supports our findings on PPE use. Hofmann et al (4) found a positive relationship between safety climate and safety behaviors, such as failure to wear PPE, among chemical plant workers. Eliseo et al (33) found a significant positive association between safety feedback and training (a component of safety climate), and safe work practices, such as wearing eye protection, among emergency medical service (EMS) workers.

Studies of aggregate measures of safety climate and safety behavior are less consistent. Arcury et al (9) found a positive association between mean worksite safety climate and individual-level use of special footwear and shoe insoles among Latino poultry workers. A study of Australian hospital employees found that aggregate measures of worksite safety climate were not associated with self-protective safety behaviors, but were associated with coworker-protective safety behaviors (34). These studies inform but are difficult to compare to our analysis because they measured safety climate at the group level while our study used individual level safety climate scores.

Though the direct link between safety climate and smoking remains understudied, the literature supports an association between occupational hazards and smoking (35–37). Albertsen et al (35) found a significant relationship between noise exposure, workload, psychological demands, and smoking cessation. Sorensen and colleagues found that addressing safety and other hazards at the organizational level improved smoking cessation outcomes for working class populations (36).

Several theories provide explanations for the link between safety climate and both PPE use and smoking. According to the theory of complementarity, workers in unsafe work environments may perceive hazardous work exposures as more dangerous than smoking and may be less likely to quit smoking as a result (38–39). Similarly, if workers believe that PPE will not reduce the health risks of work exposures, they may be less likely to use PPE. Our analyses did find a significant relationship between safety climate and PPE use but not between safety climate and smoking cessation outcomes. Another theory, common cause theory, suggests that individuals who are risk takers will choose both unsafe work environments and engage in risky behaviors such as lack of PPE use and cigarette smoking, creating an association between these two factors when no causal relationship exists (40). This is one possible explanation for our findings. However, apprentices are generally unable to choose who they work with, suggesting that this theory's application may be limited. Another possibility is that poor worksite safety climate is distressing. The link between distress and smoking behavior has been established, but it is unclear whether distress and PPE use are linked. Future studies should test these theories in order to further clarify our findings that safety climate was related to PPE use and smoking status but not to cessation, frequency and intensity.

This analysis has several limitations, the first of which is the cross-sectional nature of the data on safety climate, use of personal protective equipment, and baseline smoking status. Given that the existing literature suggests a relationship between safety climate and safety behavior, and safety behavior and smoking, we would have liked to test safety behavior as a mediator of the relationship between safety climate and smoking. However, mediation testing does not distinguish between mediators and confounders for cross-sectional data, and our small sample size for smoking cessation outcomes prevented us from performing a mediation analysis on our longitudinal data. An additional limitation is that, because our data on safety climate and PPE use was cross-sectional, this relationship is vulnerable to reverse causality. Workers who do not use PPE may be more likely to perceive their worksite safety climate as poor.

Another limitation of this analysis is the use of self-report measures. Even though participants were assured of confidentiality, social desirability may have led to over-reporting of safety equipment use. Also, biological measures would have been used to validate self-reported smoking. However, because of the high frequency of drug testing at worksites, the study staff was advised against collecting biological specimen (20). Also, the existing literature suggests that self-reported smoking is a valid assessment of cigarette use (41–42).

Smoking cessation analyses were limited in statistical power because of loss to follow-up and incomplete data. Another limitation is that we were only able to control for worksite-level variance, as opposed to quantifying it, because of the small number of worksites (n=10). Lastly, we adjusted for all available indicators of potential confounding, but unmeasured confounding is always possible.

This analysis also has several strengths. The careful consideration of clustering by worksite reduced the risk of Type I error, and validated questionnaires were used whenever possible.

By measuring both contractor and coworker safety climate, we tapped into potential differences in the influence of each type of safety climate on both PPE use and smoking. Another strength was our use of longitudinal data to test for a causal relationship between safety climate and smoking cessation outcomes.

Further research is needed to fully understand the relationship between safety climate and smoking and to increase the generalizability of these findings. In the future, researchers should use longitudinal data to test for causal relationships between safety climate and health and safety behaviors. Research should also attempt to establish the mechanisms underlying the relationship between safety climate and risk-taking behaviors. The co-occurrence of poor safety conditions and health behaviors is an issue that has plagued the construction industry in the United States for many years (2, 5, 11–12, 14, 43–44). Addressing safety and other hazards at the organizational level may impact the smoking prevalence and safety behaviors of working class populations.

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Table 1

Baseline Sample Characteristics for Cross-Sectional Analysis of American Building Apprentices Enrolled in the MassBUILT Smoking Cessation Trial (n=1725)[a,b]

		% (n)
Gender	Male	95.0 (1600)
	Female	5.0 (84)
Race	Hispanic	4.0 (64)
	Black	7.4 (119)
	Other	6.6 (106)
	White	82.1 (1328)
Age (continuous)	Mean (SD)	28.5 (6.6)
Education	≤High school/GED	51.8 (852)
	Some college/2yr degree	39.3 (647)
	≥4 years college	8.9 (146)
Income	<$25,000	6.7 (98)
	$25,000–$49,999	37.1 (545)
	$50,000–74,999	25.6 (376)
	≥$75,000	30.7 (451)
Contractor safety	Low	44.8 (772)
	High	55.3 (953)
Coworker safety	Low	58.1 (1002)
	High	41.9 (723)
Mask use	Yes	74.8 (1128)
	No	25.3 (381)
Respirator use	Yes	69.8 (736)
	No	30.2 (319)
Hearing protection use	Yes	76.4 (1177)
	No	23.6 (364)
General equipment use[c]	Yes	95.1 (1497)
	No	4.9 (77)
Fall protection use	Yes	88.1 (1331)
	No	11.9 (180)
Smoking status	Current smoker	43.0 (731)
	Nonsmoker	57.0 (968)

[a]Excludes respondents with missing values for coworker safety climate or contractor safety climate.

[b]Pre-imputation figures

[c]Such as goggles or gloves

Table 2

Personal protective equipment (PPE) use and baseline smoking status by safety climate among American building apprentices enrolled in the MassBUILT smoking cessation trial (n=1,725)[a]

	Contractor safety			Coworker safety		
	Low % (n)	**High % (n)**	**Unadjusted RR[b] (95%CI)**	**Low % (n)**	**High % (n)**	**Unadjusted RR[b] (95%CI)**
Mask use						
Yes	40.2 (453)	59.8 (675)	0.87 (0.82–0.92)*	52.4 (591)	47.6 (537)	0.87 (0.82–0.91)*
No	52.2 (199)	47.8 (182)		65.4 (249)	34.7 (13)	
Respirator use						
Yes	36.4 (268)	63.6 (468)	0.82 (0.75–0.89)*	47.6 (350)	52.5 (386)	0.80 (0.74–0.87)*
No	51.7 (165)	48.3 (154)		65.5 (209)	34.5 (110)	
Hearing protection use						
Yes	42.7 (502)	57.4 (675)	0.83 (0.65–1.05)	53.0 (624)	47.0 (553)	0.57 (0.45–0.72)*
No	46.7 (170)	53.3 (194)		65.7 (239)	34.3 (125)	
General equipment use[c]						
Yes	42.7 (639)	57.3 (858)	0.63 (0.40–0.99)*	55.4 (830)	44.6 (667)	0.44 (0.26–0.73)*
No	54.6 (42)	45.5 (35)		72.7 (56)	27.3 (21)	
Fall protection use						
Yes	42.5 (566)	57.5 (765)	0.60 (0.44–0.82)*	54.1 (720)	45.9 (611)	0.48 (0.35–0.68)*
No	55.0 (99)	45.0 (81)		71.7 (129)	28.3 (51)	
Smoking status						
Current smoker	47.5 (347)	52.5 (384)	1.12 (1.00–1.24)*	58.3 (426)	41.7 (305)	1.00 (0.90–1.12)
Nonsmoker	42.7 (413)	57.3 (555)		57.9 (560)	42.2 (408)	

* $p<.05$

[a] Excludes respondents with missing values for coworker safety climate or contractor safety climate.

[b] Risk ratios and 95% confidence intervals adjusted for clustering by worksite but unadjusted for covariates.

[c] Such as goggles or gloves

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Table 3

Multivariable logistic regression models of low safety climate and the use of personal protective equipment by American building apprentices enrolled in the MassBUILT smoking cessation trial (n=1,725)[a]

	Dust mask use[b]	Respirator use[b]	Hearing protection use[b]	Other equipment[b,c] use	Fall protection use[b]
	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)b	RR (95% CI)
Low contractor safety climate	0.88 (0.83–0.94)*	0.82 (0.75–0.89)*	0.96 (0.91–1.01)	0.98 (0.95–1.00)*	0.94 (0.91–0.98)*
Low coworker safety climate	0.87 (0.82–0.92)*	0.80 (0.74–0.87)*	0.88 (0.83–0.93)*	0.96 (0.94–0.98)*	0.92 (0.89–0.96)*

*p<.05

[a] Excludes respondents with missing values for coworker safety climate or contractor safety climate.

[b] Risk ratios and confidence intervals adjusted for clustering by worksite and covariates (gender, race, income, education, age)

[c] Such as goggles or gloves

Table 4

Multivariable logistic regression models of low safety climate and smoking status at baseline (n=1,725)[a] and smoking cessation outcomes during follow-up (n=456)[b] among American building apprentices enrolled in the MassBUILT smoking cessation trial[c]

	Contractor safety climate			Coworker safety climate		
	Baseline smoking status RR (95% CI)	7-day quit status,[d,e] RR (95% CI)	6-month quit status[e,f] RR (95% CI)	Baseline smoking status RR (95% CI)	7-day quit status[d,e] RR (95% CI)	6-month quit status[e,f] RR (95% CI)
Low safety climate	1.12 (1.01–1.25)*	1.39 (0.98–1.98)	1.50 (0.85–2.67)	0.99 (0.89–1.11)	0.95 (0.67–1.36)	1.17 (0.65–2.12)

*p<.05

[a]Excludes respondents with missing values for coworker safety climate or contractor safety climate.

[b]Smokers at baseline who had complete smoking cessation data one month after the intervention ended (follow-up one), and least six months after follow-up one (follow-up two)

[c]Risk ratios and confidence intervals adjusted for clustering by worksite and covariates (gender, race, income, education, age)

[d]Seven-day smoking abstinence immediately after the four-month intervention ended (i.e., follow-up one)

[e]Adjusted for worksite smoking cessation intervention group (treatment or control)

[f]Six-month smoking abstinence 6 months after follow-up one (i.e., follow-up two)