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The relationship between safety climate and injury rates across industries: The need to adjust for injury hazards

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Abstract

Previous studies have suggested that strong safety climates (shared perceptions of safe conducts at work) are associated with lower workplace-injury rates, but they rarely control for differences in industry hazards. Based on 33 companies, we assessed its association with injury rates using three rate based injury measures (claims per 100 employees, claims per 100,000 h worked, and claims per US$ 1 million payroll), which were derived from workers' compensation injury claims. Linear regression models were used to test the predictability of safety climate on injury rates, followed by controlling for differences in hazard across industries gauged by national industry-specific injury rates. In the unadjusted model, company level safety climate were negatively and significantly associated with injury rates. However, all of the above associations were no longer apparent when controlling for the hazardousness of the specific industry. These findings may be due to over adjustment of hazard risk, or the overwhelming effects of industry specific hazards relative to safety climate effects that could not be differentiated with the statistical power in our study. Industry differences in hazard, conceptualized as one type of injury risk, however need to be considered when testing the association between safety climate and injury across different industries.

Keywords: Safety climate; Employee safety control; Workplace injury; Workers' compensation; Organizational factors; Safety management

1. Introduction

Research has long identified a wide range of physical, biological, and chemical hazards in the workplace, and more recently has recognized biomechanical and ergonomic hazards (Saari, 1990; Salminen et al., 1993). Workplace organizational risk factors are another important determinant of occupational health and safety that are receiving increasing attention, and include psychosocial factors such as safety climate (Saari, 1990, 2001; Salminen et al., 1993; Zohar, 1980, 2000, 2002a,b; Shannon et al., 2001; Gillen et al., 2002; Glendon and Litherland, 2001; Hofmann and Stetzer, 1998).

Safety climate is one multidimensional organizational construct believed to influence the safety behavior of workers at the individual, group, or organizational level. The term safety climate is conceptualized as employees' share perceptions regarding how safety practices, policies, and procedures are implemented and prioritized, compared to other priorities such as productivity. Furthermore, it can be viewed as a snapshot of the prevailing state of safety in the organization at a discrete point in time and may change over time (Cooper and Phillips, 2004; Griffin and Neal, 2000; Guldenmund, 2000; Zohar, 1980, 2000, 2002a,b, 2003; Cheyne et al., 1998).

Theoretically, safety climate would act as a frame of reference that guides normative safety behavior, such that employees develop coherent sets of perceptions and expectations regarding safety behavior-outcome contingencies, and thus behave accordingly (Zohar, 1980). Furthermore, workers usually develop these perceptions and expectations by looking to the actions of their supervisors to determine the prioritization and importance of safety (Zohar, 2000). Safety climate predicts employees' motivation to work safely, which affects employees' safety behaviors and subsequent experiences of workplace injuries or incidents (Griffin and Neal, 2000; Mueller et al., 1999; Zohar, 2003). It has also been directly associated with increases

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in safety behaviors (Hofmann and Stetzer, 1996; Hofmann et al., 2003), and decreases in workplace injuries, but the measures of injuries were inconsistently used in literatures (Zohar, 2002a; Hofmann and Stetzer, 1996; Huang et al., 2003).

To effectively assess potential effects of safety climate on injury or accidents at work, it is essential to choose appropriate injury-related measures. Over the past decades, conventional dichotomization (i.e., high versus low injury rates or counts), objective indexes such as number of OSHA recordable, or lost-day injuries have been used (Hofmann and Stetzer, 1996; Zohar, 2000; Simard and Marchand, 1997). Most of these measures are, however studied at the employee level rather than at the company level.

Among the infrequent studies of work organization factors that use organizational level injury rates as the primary safety outcome, few have considered the inherent hazardousness across industries (Thoms and Venkataraman, 2002). Moreover, many studies draw their association between safety climate and occupational safety based on analyses of single companies or industries, or multiple worksites within the same company (Cooper and Phillips, 2004; Guldenmund, 2000; Gadd and Collins, 2002; Yule, 2003). Single-industry studies can control to some extent for risk exposure differences across different industries, and are useful to identify companies with many similarities but with different approaches to safety. However most single-industries studies also assume that workers are exposed to similar workplace hazards and consequently, results from these studies may not be generalizable across different work hazards (Salminen et al., 1993; Zohar, 2000). For those studies targeting multiple industries, little recognition has been given to the fact that different industries have different inherent injury risks and different levels of exposure to hazard. While we found several studies of injury risks that controlled for industry hazards (Thoms and Venkataraman, 2002; Veazie and Smith, 2000; Zohar, 1980), only one (Zohar, 1980) examined safety climate. This study used expert ratings of safety performance to separate companies into hazard categories. Our study improves on this subjective nature of assessing hazard by using objective, industry-specific data to assess the relative hazard across industries and assess the effect of adjusting for this hazard.

Several other studies of individual companies have also recognized the importance of adjusting for differences in job hazards when studying organizational factors such as safety climate. Zohar's study of micro-accidents controlled for risk level of individual work groups in a single metal processing plant using three safety experts to rate the environmental dangers associated with the jobs in each subunit, and at an individual level using supervisors rating of each job in their subunit (Zohar, 2000). A study of the relationship of managers' personality profiles to injury rates in their departments also adjusted for work hazard across different worksites in the same company using expert opinions (Thoms and Venkataraman, 2002). However neither study compared their results with the unadjusted findings. We however found one study of psychosocial work characteristics that examined the effect of using a three-level adjustment for job hazard or work environment when comparing injury rates across 45 different workplaces (1, office/administration work; 2, manual work involving machinery or tools; 3, other jobs not involving classes 1 or 2) (Swaen et al., 2004). A number of factors such as job demands, decision latitude, and social support were initially significantly associated with increased risk of an occupational injury. However when investigators adjusted for work environment (hazard) and other confounders such as gender, education, and shift work, the association between decision latitude and injury risk was no longer significant and the association of most other factors was also reduced. The authors concluded, "This crude association is the result of differences in jobs."

The aim of our study, therefore, is to extend our previous work that relied on self-reported data (Huang et al., 2006) and to assess the association between company-level safety climate and three separate of measures injury risk. We also included an objective measure of inherent work hazards to adjust for differences in industry hazardousness.

2. Methods

2.1. Survey and study population

Data for this study were obtained from the loss prevention unit of a major workers' compensation insurance company. Since 1997 the insurer conducted risk management assessments (RMAs) in many client companies across the United States. These surveys were used to assess current safety practices in a company and were conducted on an as needed basis as part of regular loss prevention activities and were not designed to be representative of all industries. As part of these assessments certain loss prevention consultants with an interest in safety climate included a module to access the safety climate of specific worksites (Huang et al., 2003, 2004a,b, 2006). We reviewed the over 200 reports available to us which included the safety climate module, and identified reports on 33 companies which for which we were able to obtain reliable data on both the employed population and WC injury claims data, and where detailed results of the standardized safety climate surveys conducted at the company were available. For most other companies' detailed information, especially the population employed was not available to us.

The safety climate surveys were conducted only once at the 33 company work sites between 1999 and early 2002. The companies ranged in size from 70 to over 18,000 employees and covered a wide range of industries (see Table 1). Identical safety climate questionnaires were mailed to an anonymous sample of employees at each facility (sampling proportion varied depending on company size). The number of completed questionnaires returned by employees in each company ranged from 25 to 490 questionnaires (median 140). The response rate varied from 15 to 75% with a median of 56% and a mean of 51.6% (S.D. = 15.9). Only five companies had a response rate of less than 40% (three were from 30 to 39%). Data was not available for each individual respondent but only as a company average for each question in the survey.

Table 1
Industrial sectors covered by the 33 study companies, specific SIC[a] groups represented, and number of employees in each sector

Industry description (SIC[a])	Number of workers
Mineral industries (13)	238
Construction industries (16, 17)	1223
Manufacturing	
Paper and allied products (26)	1611
Printing and publishing (27)	4724
Primary metal industries (33)	572
Fabricated metal products (34)	832
Electrical and electronic equipment (36)	24698
Miscellaneous manufacturing industries (20, 35, 39)	1995
Wholesale trade (50)	815
Retail trade (58)	1759
Finance insurance, real estate (65)	341
Service (70, 73)	2800
Total	41678

Note: Each industry group is represented by multiple companies at both the two- and three-digit SIC code level.
[a] SIC, standard industrial classification.

2.2. Study variables

2.2.1. Safety climate

The safety climate survey questions were developed as a part of a broader assessment of safety practices, and represents dimensions of practical value to those involved in implementing prevention programs. The same survey was used in our earlier studies of different companies that examined issues ranging from safety polices and injury outcomes, relationships between job satisfaction and employment status, and the associations among post injury job satisfaction, organizational support, and return-to-work policies (Huang et al., 2003, 2004a,b). The reliability and validity of the survey questions and subsequent scales developed from them were demonstrated in these earlier studies. Our most recent study used the same safety survey to assess overall safety climate and its relationship to self-reported injury risk (Huang et al., 2006). This current study used the same survey instrument to examine actual injury rates in all 33 companies under study. Based on the safety climate literature (especially the work of Zohar, 2000; Griffin and Neal, 2000) and analyses of the psychometric properties of the questions (Huang et al., 2004a, 2006), we identified 14 questions in the survey that represent four different dimensions of safety climate (i.e., management commitment on safety, quality of return-to-work policies, quality of post-injury administration, and safety training) (Ho, 2004; Huang et al., 2006). Full details of these analyses are referred to in our earlier paper (Huang et al., 2006), and are briefly described below. It should be noted that the current study is the first to assess company-level safety climate and its relationship to objective company-level injury rates.A 6-point scale was used for responses to each question, ranging from “Strongly Disagree” (1) to “Strongly Agree” (6). Based on these questions we created an overall safety climate score for each specific company by pooling results from individuals within that company and then dividing the total by 14 (the number of items used). Higher scores imply a stronger safety climate and range from 1 to 6. The coefficient alpha of the overall scale was 0.85. Examples of the items used to create the score are:

- “Employees believe the company emphasizes safe behavior above all other activities”;
- “My immediate supervisor acknowledges when I work safely and tells me when I’m not working safely.” More details of the question contents can be found in Huang et al. (2004a) and the survey questions are available from the authors on request.

2.2.2. Workers’ compensation injury rates

For each company we linked the safety climate scores with their WC claims for the preceding 2 years. It is unlikely that the injury rates or perceptions of safety climate have altered much in the 2 years preceding the RMA survey as RMAs were conducted as part of initial assessments and not in response to changes within a company. Data was compiled on the number of employees, total payroll, and the number of registered WC claims for the two years preceding the survey. We then created three injury indexes:

1. Claims per US$ 1 million payroll, using the annual average number of claims paid as the numerator, and the companies’ annual payroll as the denominator.
2. Claims per 100 employees. The claims rate per 100 employees was generated by using the number of employees as the denominator.
3. Claims per 100,000 h worked. Claims per 100,000 h worked are a better exposure-based measure of risk but was not directly available to us. However we were able to estimate the total number of hours worked for companies in the study, which are a function of the average wage and the total annual payroll. To estimate the average wage we used the bureau of labor statistics (BLS) published mean hourly wage nationally for that particular industry’s three-digit standard industrial classification (SIC) code in 1999 (the median data year for injury data from companies) (BLS, 2004). We then divided the company’s total payroll by the average wage to estimate hours worked. For example for SIC code 173 our total payroll was US$ 39,094,288. The BLS mean hourly wage for this industry group was US$ 18.49/h. therefore the estimated number of hours worked = payroll/mean hourly wage = US$ 39,094,288/US$ 18.49 = 2,114,348 h worked.

2.2.3. Industry-specific hazard adjustment

The underlying nature of the work performed and associated hazards are an important determinant of injury risk in a specific industry (Harrell, 1990; Veazie et al., 1994). One method used in other studies of adjusting for differences in inherent hazards across industry has been to use average industry specific rates as a control variable (Veazie and Smith, 2000). Following this approach, we used the companies’ SIC code to derive comparable, nationwide injury rates for the same three-digit SIC codes from the bureau of labor statistics (BLS) on-line database using 1999 lost-workday cases only (BLS, 2004). Calculations similar to those used to generate the WC injury rates were performed with industry-wide figures to generate BLS rates of injury per 100 workers, rates per US$ 1 million payroll, and rates per 100,000 h worked. We also calculated the ratios between the companies' injury rates and the BLS injury rates to show how they differed from the industry average.

2.3. Data analysis

Separate linear regression models were used to test the relationship between the company-level safety climate and three company-level injury rates: claims/100 workers, claims/100,000 h worked, and claims per US$ 1 million payroll. Additional analyses were then conducted for each injury rate, adjusting for the inherent hazard of the jobs using the three BLS-based control variables described above (Veazie and Smith, 2000).

3. Results

The 33 companies comprised a wide range of industries from construction to service industries (Table 1); the largest numbers ($n = 19$ companies) were in manufacturing. The 12 major industry groups represented a total of 41,608 workers.

As seen in Table 2, safety climate scores varied widely by industry group ranging from 3.6 to 5.7 (mean 4.6, standard deviation 0.5) at the two-digit SIC industry group level. The highest safety climate score was in a property management company and the lowest was a manufacturing plant. Data for individual companies identifiable at the three-digit level were combined to create industry averages at the two-digit SIC industry group in order to simplify the table, illustrate the variation, and to protect the confidentiality of individual companies as some three-digit SIC codes contained only one company. Injury rates varied widely between the two-digit SIC industry groups, with some groups having higher injury rates than the industry average (as reflected in the higher rate ratios) and others had lower than average rates. In most industry groups the rate ratios were similar across all three-rate measures, although the rate ratios for claims/US$ 1 million payroll showed much less variation with BLS figures.

For each of the three relationships of interest we generated an unadjusted and an adjusted model based on the three-digit SIC code information for each individual company. In the unadjusted models, company-level safety climate was significantly related directly to each of the three injury outcomes: the estimated claims per 100 employees in each company, the estimated claims per US$ 1 million payroll, and the estimated claims per 100,000 h worked, as described in Table 3. In the adjusted models that controlled for injury hazard (i.e., industry-specific BLS rates), however, the relationships between safety climate and the three injury outcomes are no longer significant. An analysis of the association of the BLS-based injury rates (our control variables) with company injury rates using multiple linear regression found them to be very strong predictors of an individual company's injury rate for each of our three rate measures examined ($p < 0.01$). In the adjusted models the safety climate explained from 22 to 32% of the variance in injury rates (the R^2s were 0.22,

Table 2
Mean safety climate score and injury rates by SIC code for the 16 two-digit SIC groups representing 33 companies by claims per 100 workers, per 100,000 h worked, and per US$ 1 million payroll, and comparison with national BLS industry group rates

SIC code	Mean safety climate score[a]	Claims per 100 workers			Claims per 100,000 h worked			Claims per US$ 1 million payroll		
		Study population rate	BLS-SIC injury rate	Study/BLS ratio	Study population rate	BLS-SIC injury rate	Study/BLS ratio	Study population rate	BLS-SIC injury rate	Study/BLS ratio
13	5.4	23.5	8.5	2.8	5.7	3.2	1.8	4.8	5.0	1.0
16	4.5	38.9	7.6	5.1	9.4	2.0	4.7	10.2	4.2	2.4
17	4.2	19.0	8.1	2.3	4.6	1.8	2.6	4.9	3.0	1.6
20	5.3	4.4	8.2	0.5	1.1	2.1	0.5	1.3	3.2	0.4
26	5.4	21.5	5.8	3.7	5.2	1.4	3.7	5.1	4.6	1.1
27	4.0	5.6	5.4	1.0	1.4	1.5	0.9	1.7	1.6	1.1
33	4.5	23.7	9.9	2.4	5.7	2.6	2.2	6.3	4.3	1.5
34	4.6	18.8	11.3	1.7	4.5	3.0	1.5	5.5	3.4	1.6
35	3.6	16.8	10.0	1.7	4.0	2.1	1.9	4.4	3.4	1.3
36	4.7	0.8	5.6	0.1	0.2	1.3	0.2	0.2	0.6	0.3
39	4.1	3.4	7.6	0.4	0.8	1.4	0.6	1.1	1.6	0.7
50	4.1	22.0	9.1	2.4	5.3	2.2	2.4	6.1	5.5	1.1
58	4.5	17.4	6.2	2.8	4.2	1.0	4.2	10.0	12.3	0.8
65	5.7	22.3	4.9	4.6	5.3	1.1	4.8	7.9	4.6	1.7
70	5.1	34.7	7.2	4.8	8.3	1.8	4.6	8.6	2.6	3.3
73	4.4	13.6	6.4	2.1	3.3	1.5	2.2	6.7	3.1	2.2
Average[b]	4.6	17.1	7.6	2.3	4.1	1.7	2.4	5.2	3.4	1.5

[a] The values presented represent the mean of the companies in that two-digit SIC group. Subsequent regression analyses used data for individual companies at the three-digit SIC level.

[b] Average represents the average value based on summing numerators and denominators for each variable by company.

Table 3
Relationship between safety climate and three measures of work injury risk; injuries per US$ 1 million payroll, injuries per 100,000 h worked and injuries per 100 employees, among 33 companies studied

Dependent variable	Unadjusted model safety climate				Adjusted model safety climate			
	Parameter estimate	S.E.	*t*	*p*	Parameter estimate	S.E.	*t*	*p*
Claims frequency per US$ 1 million payroll	−0.37	0.12	−3.02	0.005*	−0.06	0.17	−0.36	0.72
Claims per 100,000 h worked	−0.43	0.13	−3.23	0.006*	−0.05	0.17	−0.29	0.77
Claims per 100 employees	−0.47	0.15	−3.16	0.002*	−0.05	0.15	−0.34	0.74

S.E., standard error; *t*, *t*-value; *p*, signifiance level.
* Significance at alpha equals 0.05, two-tailed, $n = 33$.

0.24, and 0.32, respectively, for the relationship of safety climate to injury claims frequency per US$ million payroll, claims per 100,000 h worked and claims per 100 employees).

4. Discussion

The purpose of this study was to assess the association between company-level safety climate and injury risk by taking industry hazardousness into consideration. Our initial analyses using objective injury rates found that better safety climate was significantly associated with lower injury rates, and confirmed findings from our earlier study at the individual level that relied on self-reported injuries (Huang et al., 2006), and those of other studies suggesting that organizations with strong safety climates report fewer workplace injuries than do organizations with weak safety climates (Cooper and Phillips, 2004; Zohar, 2000; Brown and Holmes, 1986; Felknor et al., 2000; Grosch et al., 1999; Gershon et al., 2000; Siu et al., 2004; Varonen and Mattila, 2000). In contrast with most previous studies, however, we found that the relationship between safety climate and injury was reduced and no longer significant when we used a proxy measure of job risk to control for the degree of hazard in the overall industry. This may be because the effects of safety climate, while potentially large in an individual organization, may be small relative to the large differences in inherent risk by industry. The theoretical upper limit score of safety climate is determined by the end point of the measure; while there are no upper limits for injury risk as well as industry hazard. Hence, the statistical power to observe a significant correlation by partially out industry hazardousness would be further weaker. This statistical power problem is further a concern for conducting this type of study in the future when range restrictions on safety climate measure within each participating company are apparent. Of course, large groups of participating companies and measures prone not to have range of restriction are needed in order to adequately replicate the current findings. It is also possible that industry hazard was such a strong predictor of injury rates we may have obscured any effect of safety climate and a significant association may very well exist. This may also indicate that workers' perception of the hazard and risk in their workplace are likely an important factor that formulates perception of safety climate, and their perceptions of safety climate are likely to be related to both their perception of the company's safety record both within the industry and also to those outside their industry.

Much of the current safety climate literature has examined the association between safety climate and non-injury outcomes such as workers' compliance with safety regulations and other behavior-oriented safety performance measures (McCoy et al., 2001; Lindell and Brandt, 2000). Many of these associations were statistically significant, e.g., associated with positive job satisfaction (Zohar, 2003; Payne et al., 1976; Day and Bedeian, 1991). Some studies also have suggested the use of safety climate scores as a common denominator for comparing different industries and claimed that using an overarching measure such as safety climate scores will better enable comparisons across different technologies and risk levels when studying industrial safety programs (Niskanen, 1994; Lindell and Brandt, 2000; Dedobbeleer and Beland, 1991). However, the wide variation in hazards across industries is well known (NIOSH, 2002; Harrell, 1990). The BLS-based injury rates we used as control variables were very strong predictors of an individual company's injury rate and confirms that the inherent hazards of a particular industry are an important determinant of its injury rate and need to be considered when comparing data across industries.

One of the strengths of our study is the large number of workers in the study which allowed actual objective injury rates to be compared across companies rather than relying on self-reported injury rates as in earlier studies (Huang et al., 2006). We also had multiple outcome measures: claims per 100 workers, claims per 100,000 h worked and also claims per US$ 1 million payroll. The claims per US$ 1 million payroll showed much less variation across companies, are a poorer indicator of risk, and rely more on the wage rates of individual workers than the population at risk. Another possible explanation could be that industries with higher inherent hazards need to pay higher wages but we found no significant correlation between mean hourly wage and claims per US$ million payroll ($r = 0.06$). The rate by hours worked is a better denominator for calculating rates and controls for an important exposure measure, hours worked. It is a separate measure from that just based on payroll as it accounts for wide differences in average hourly wage across industries and is a function of both the average hourly wage in the industry and the total payroll. We estimated work hours by dividing the total worksite payroll by the national average hourly wage for that specific three-digit SIC code (BLS). The findings for this rate are however consistent with the other rates we used.

There are also some limitations to our current study. Similar to earlier studies (Veazie and Smith, 2000) we used national industry-specific injury rates by SIC code to adjust for variations in the inherent hazard and tasks performed across different industries. However in attempting to control for the inherent hazardousness of the industry we may have over adjusted for the hazards as the average industry rate is at best a crude proxy for overall hazards in the industry. In addition, our results were based on a small sample of 33 companies and the statistical power to detect the association after controlling for inherent risk may thus be limited. Furthermore, our study utilized workers' compensation claims data and shares some of the same limitations as other workers' compensation claims studies, that are vulnerable to a variety of filtering effects, and there may be variations in reporting and recording practices by employer, location, and state of occurrence (Webb et al., 1989, Smith et al., 2005). While we were unable to examine reporting practices it is unlikely that there is a systematic bias that would significantly alter our findings.

In this current study, we only examined an overall safety climate score and not the different dimensions such as used in our earlier study (Huang et al., 2006). Even though we had a large number of workers in the study there were only 33 companies available for analysis and the small sample size restricted our ability to examine different dimensions of safety climate, or to examine industry subgroups. We also only had access to group level safety climate scores for each company and were not able to evaluate the characteristics of individual respondents or evaluate variability within companies. Another limitation of our study is that it relies on data collected as part on an ongoing safety program and so we were not able to fully control all aspects of data collection. For example, the companies were not selected to be representative of all industries, although they do cover a wide range of industry groups. We also do not have data on those participants who did not complete the survey and only had access to group level safety climate scores and thus were not able to evaluate the representativeness of individual respondents. In addition it was not possible to adjust for many other potential confounders such as sex, age, employment experience, educational level, smoking, alcohol, drugs, size of company, shift work, night work, over-time work, etc. Ideally future studies should attempt to include these variables. In addition as we only had WC claims for the 2 years preceding the survey we were not able to determine if the safety performance on WC claims led to any changes in safety climate. However the RMA surveys were generally done in preparation for making changes in safety practice rather than as an evaluation tool after changes were made.

The response rates for the surveys varied by company and the low participation in some companies may also be a limitation. However persons who responded to questionnaires are always a self-selected group and we have no way of knowing if they were more likely to consider their safety climate to be good or poor. For example disgruntled employees who think the workplace is unsafe may be very motivated to respond and score their company poorly or on the other hand may be uninvolved in the workplace and refuse to participate in the survey. As mentioned earlier, we do not have information on the characteristics of each respondent or those not responding. While we found no correlation between response rates and a company's safety climate score, we did not adjust for industry-specific hazardousness. To exclude companies with low response rates would have jeopardized the study power, and is unlikely to greatly affect our findings. The 33 companies in our study were not chosen at random but rather were those for which data was available, and we cannot determine how representative these companies were. The reasons for conducting the surveys vary; some companies had high injury rates and sought to lower their rates and others had good safety histories and conducted the surveys as part of their ongoing safety efforts. However our large sample size of employed persons in the companies under study, and ability to include objective injury data over a cross section of industries may overcome many of the above limitations.

5. Conclusion

In this study, we have improved upon existing safety climate research by using multiple types of objective injury data, rather than relying on self-reported injury or other more subjective outcome data. Our results initially found an association of safety climate and injury risk but this was reduced and no longer significant when we used a proxy measure to adjust for injury hazard. Hazard differences among industries need to be accounted for when examining safety climate's association with injury. In addition safety climate, as a concept for capturing the prevailing state of safety of an organization, may be less suited for the purposes of across-industry safety comparisons, since the underlying safety risks are different by industry and these may affect employees' perceptions of the safety climate in their workplace.

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References

Brown, R.L., Holmes, H., 1986. The use of factor-analytic procedures for assessing the validity of an employee safety climate model. Accid. Anal. Prev. 18, 455–470.

Bureau of Labor Statistics (BLS), 2004. United States Department of Labor. Online database: nonfatal cases involving days away from work: selected characteristics (1992–2001). 1999 data available at: http://www.bls.gov/iif/home.htm. Accessed January 14, 2004.

Cheyne, A., Cox, S., Oliver, A., Tomas, J.M., 1998. Modeling safety climate in the prediction of levels of safety activity. Work Stress 12, 255–271.

Cooper, M.D., Phillips, R.A., 2004. Exploratory analysis of the safety climate and safety behavior relationship. J. Saf. Res. 35 (5), 497–512.

Day, D.V., Bedeian, A.G., 1991. Work climate and type A status as predictors of job satisfaction: a test of the interactional perspective. J. Vocational Behav. 38, 39–52.

Dedobbeleer, N., Beland, F., 1991. A safety climate measure for construction sites. J. Saf. Res. 22, 97–103.

Felknor, S.A., Aday, L.A., Burau, K.D., Delclos, G.L., Kapadia, A.S., 2000. Safety climate and its association with injuries and safety practices in public hospitals in Costa Rica. Int. J. Occup. Environ. Health 6, 18–25.

Gadd, S., Collins, A.M., 2002. Safety culture: a review of the literature. Health and Safety Laboratory Human Factors Group, Sheffield, UK. Health and Safety Laboratory Report HSL/2002/25. Available at: http://www.ic.polyu.edu.hk/esh/KB/safety.climate/hsl02-25.pdf. Accessed August 1, 2005.

Gershon, R.R.M., Karkashian, C.D., Grosch, J.W., Murphy, L.R., Escamilla-Cejudo, A., Flanagan, P.A., Bernacki, E., Kasting, C., Martin, L., 2000. Hospital safety climate and its relationship with safe work practices and workplace exposure incidents. Am. J. Infect. Control 28, 211–221.

Gillen, M., Baltz, D., Gassel, M., Kirsch, L., Vaccaro, D., 2002. Perceived safety climate, job demands, and coworker support among union and nonunion injured construction workers. J. Saf. Res. 33, 33–51.

Glendon, A.I., Litherland, D.K., 2001. Safety climate factors, group differences, and safety behavior in road construction. Saf. Sci. 39, 157–188.

Griffin, M.A., Neal, A., 2000. Perceptions of safety at work: a framework for linking safety climate to safety performance, knowledge, and motivation. J. Occup. Health Psychol. 5, 347–358.

Grosch, J.W., Gershon, R.R., Murphy, L.R., DeJoy, D.M., 1999. Safety climate dimensions associated with occupational exposure to blood-borne pathogens in nurses. Am. J. Ind. Med. 1, 122–124.

Guldenmund, F.W., 2000. The nature of safety culture: a review of theory and research. Saf. Sci. 34, 215–257.

Harrell, W.A., 1990. Perceived risk of occupational injury: control over pace of work and blue-collar versus white-collar work. Perceptual Motor Skills 70, 1351–1359.

Ho, M.C., 2004. Safety Climate and Self-reported Injury: Assessing the Mediating Role of Employee Safety Control. Unpublished Doctoral Thesis. Johns Hopkins University.

Hofmann, D.A., Morgeson, F.P., Gerras, S.J., 2003. Climate as a moderator of the relationship between leader-member exchange and content specific citizenship: safety climate as an exemplar. J. Appl. Psychol. 88, 170–178.

Hofmann, D.A., Stetzer, A., 1996. A cross-level investigation of factors influencing unsafe behaviors and accidents. Personnel Psychol. 49 (2), 307–339.

Hofmann, D.A., Stetzer, A., 1998. The role of safety climate and communication in accident interpretation: implications for learning from negative events. Acad. Manage. J. 41 (6), 644–646.

Huang, Y.H., Ho, M., Smith, G.S., Chen, P.Y., 2006. Safety climate and self-reported injury: assessing the mediating role of employee safety control. Accid. Anal. Prev. 38, 425–433.

Huang, Y.H., Chen, P.Y., Krauss, A.D., Rogers, D.A., 2004a. Quality of the execution of corporate safety policies and employee safety outcomes: assessing the moderating role of supervisor safety support and the mediating role of employee safety control. J. Business Psychol. 18 (4), 483–506.

Huang, Y.H., Chen, P.Y., Rogers, D.A., Krauss, A.D., 2003. Role of workplace safety: a revisit of the relationship between job satisfaction and employment status. Work: J. Prev. Assess. Rehabil. 21 (3), 251–256.

Huang, Y.H., Shaw, W.S., Chen, P.Y., 2004b. Worker perceptions of organizational support and return-to-work policy: associations with post-injury job satisfaction. Work: J. Prev. Assess. Rehabil. 23, 225–232.

Lindell, M.K., Brandt, C.J., 2000. Climate quality and climate consensus as mediators of the relationship between organizational antecedents and outcomes. J. Appl. Psychol. 85, 331–348.

McCoy, K.D., Beekmann, S.E., Ferguson, K.J., Vaughn, T.E., Torner, J.C., Woolson, R.F., Doebbeling, B.N., 2001. Monitoring adherence to standard precautions. Am. J. Infect. Control 29, 24–31.

Mueller, L.M., DaSilva, N., Townsend, J.C., Tetrick, L.E., 1999. An empirical investigation of competing safety climate measurement models. Paper presented to the 14th Annual Meeting of the Society for Industrial and Organizational Psychology, Dallas, TX.

National Institute for Occupational Safety and Health (NIOSH). Worker Health Chartbook, 2000 Nonfatal Injury. Cincinnati, OH. May 2002. DHHS (NIOSH) Pub. No. 2002-119. Available at: www.cdc.gov/NIOSH. Accessed January 3, 2003.

Niskanen, T., 1994. Assessing the safety environment in the work organization of road maintenance jobs. Accid. Anal. Prev. 26, 27–39.

Payne, R.L., Fineman, S., Wall, T.D., 1976. Organizational climate and job satisfaction: a conceptual synthesis. Organizational Behav. Human Perform. 16, 45–62.

Saari, J., 2001. Successes and failures in occupational injury prevention. Inj. Prev. 7, 1–2.

Saari, J., 1990. On strategies and methods in company safety work: from informational to motivational strategies. J. Occup. Accid. 12, 107–118.

Salminen, S., Saari, J., Saarela, K.L., Rasanen, T., 1993. Organizational factors influencing serious occupational accidents. Scand. J. Work Environ. Health 19, 257–352.

Shannon, H.S., Robson, L.S., Sale, J.E., 2001. Creating safer and healthier workplaces: role of organizational factors and job characteristics. Am. J. Ind. Med. 40, 319–334.

Simard, M., Marchand, A., 1997. Workgroups' propensity to comply with safety rules: the influence of macro–micro organisational factors. Ergonomics 40, 172–188.

Siu, O., Phillips, D.R., Leung, T., 2004. Safety climate and safety performance among construction workers in Hong Kong: the role of psychological strains as mediators. Accid. Anal. Prev. 36 (3), 359–366.

Smith, G.S., Wellman, H.M., Warner, M., Sorock, G.S., Courtney, T.K., Pransky, G.S., 2005. Injuries at work in the U.S. adult population: contributions to the total injury burden. Am. J. Public Health 95, 1213–1219.

Swaen, G.M., van Amelsvoort, L.P., Bultmann, U., Slangen, J.J., Kant, I.J., 2004. Psychosocial work characteristics as risk factors for being injured in an occupational accident. J. Occup. Environ. Med. 46 (6), 521–527.

Thoms, P., Venkataraman, R.R., 2002. Relation of managers' personality to accident and injury rates. Psychol. Rep. 91, 1107–1115.

Varonen, U., Mattila, M., 2000. The safety climate and its relationship to safety practices, safety of the work environment and occupational accidents in eight wood-processing companies. Accid. Anal. Prev. 32, 761–769.

Veazie, M.A., Landen, D.D., Bender, T.R., Amandus, H.E., 1994. Epidemiologic research on the etiology of injuries at work. Annu. Rev. Public Health 15, 203–221.

Veazie, M.A., Smith, G.S., 2000. Heavy drinking, alcohol dependence, and injuries at work among young workers in the United States labor force. Alcohol Clin. Exp. Res. 24, 1811–1819.

Webb, G.R., Redman, S., Wilkinson, C., Sanson-Fisher, R.W., 1989. Filtering effects in reporting work injuries. Accid. Anal. Prev. 21, 115–123.

Yule, S., 2003. Senior Management Influence on safety performance in the UK and US energy sectors. Doctoral thesis, University of Aberdeen, Scotland. Available at: http://www.abdn.ac.uk/~psy296/dept/Yule_safety climate and culture review.htm. Accessed August 1, 2005.

Zohar, D., 1980. Safety climate in industrial organizations: theoretical and applied implications. J. Appl. Psychol. 65, 96–102.

Zohar, D., 2000. A group-level model of safety climate: testing the effects of group climate on micro-accidents in manufacturing jobs. J. Appl. Psychol. 85, 587–596.

Zohar, D., 2002a. Modifying supervisory practices to improve subunit safety: a leadership-based intervention model. J. Appl. Psychol. 87, 156–163.

Zohar, D., 2002b. The effects of leadership dimensions, safety climate, and assigned priorities on minor injuries in work groups. J. Organizational Behav. 23, 75–92.

Zohar, D., 2003. Safety climate: conceptual and measurement issues. In: Quick, J.C., Tetrick, L.E. (Eds.), Handbook of Occupational Health Psychology. American Psychological Association, Washington, DC, pp. 123–142.