A short scale for measuring safety climate

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Abstract

A 6-item measure that assesses global work safety climate was validated using multiple samples each from a hospital and a nuclear energy population. Across all 14 samples the 6-item measure had acceptable internal consistency. The measure was associated with better adherence to safe work practices, reduced exposure to environmental stressors, the presence of more safety policies and procedures, a positive general organizational climate, and decreased accidents. As evidence for discriminant validity, safety climate was unrelated to most demographic measures and had relatively small relationships with sleeping problems and negative mood. Evidence suggests that this measure is a reliable and valid way to assess global safety climate.
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1. Introduction

1.1. Safety climate

The past decade has seen renewed interest in the role of safety climate in accident/injury prevention. Guldenmund (2000) found 10 studies on safety climate that appeared in the literature during the 1990s, in contrast to only two empirical articles that appeared in the decade when Zohar (1980) published his now classic article. This trend has continued and seems to be growing in the present decade, with at least 25 empirical articles already published since 2000.

Safety climate refers to shared perceptions of employees about the safety of their work environment, and provides a background against which day-to-day tasks are performed. These shared perceptions derive from

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several factors, including management decision making, organizational safety norms and expectations, and safety practices, policies, and procedures which together serve to communicate organizational commitment to safety. Employee perceptions about safety are important because safety climate has been linked to better adherence to safe work behaviors (DeJoy et al., 1995; Hofmann and Stetzer, 1996; Varon and Mattila, 2000) and fewer injuries (Barling et al., 2002; Cohen, 1977; Dedobbeleer and Beland, 1991; Gillen et al., 2002; Hofmann and Stetzer, 1996; Mearns et al., 2003; Zohar, 1980, 2000). Organizations with strong safety climates tend to have fewer employee injuries, not only because the workplace has well developed and effective safety programs, but also because the very existence of these programs sends 'cues' to employees regarding management's commitment to safety. If there is evidence that the organization is serious about adherence to safe work practices, then employees are more likely to adhere.

Interest in measuring safety climate at the National Institute for Occupational Safety and Health (NIOSH) was stimulated by newly funded studies of occupational HIV/AIDS in 1992 which examined the role of job and organizational factors in worker adherence to recommended, safe work practices (i.e., Universal Precautions). Despite published guidelines for worker protection from occupational HIV/AIDS (Centers for Disease Control and Prevention, 1987), it was apparent that adherence to Universal Precautions was not optimal. For example, Kelen et al. (1990) found only 44% adherence to UP in the emergency room of Johns Hopkins University Medical Center, and Hammond et al. (1990) reported that among house officers, only 16% strictly adhered to UP. Most studies that investigated this problem focused on the importance of individual-level factors, such as age, occupation, tenure, personality traits, and education (e.g., Kelen et al., 1990; Linn et al., 1990; Willy et al., 1990) with virtually no attention to organizational factors that had been routinely used in traditional occupational safety studies (e.g., Cohen, 1977; Sheehy and Chapman, 1987).

In 1992, NIOSH initiated a series of studies to examine job and organizational factors as predictors of worker adherence to safe work practices (DeJoy et al., 2000; Gershon et al., 1995). In these studies, job and organizational factors were measured using 37 items that tapped various dimensions of safety climate (management commitment, performance feedback, knowledge, etc.), in addition to job characteristics such as workload, role relationships, social support, and job stress. The items measuring safety climate were constructed based on a review of the scientific and lay literature on safety management and accidents/injuries (e.g., Cohen, 1977; DeJoy, 1986; Sheehy and Chapman, 1987; Zohar, 1980). The NIOSH studies demonstrated that safety climate was an important predictor of adherence to safe work practices, explaining far more variance than demographic or other individual factors (DeJoy et al., 1998, 1995, 2000; Gershon et al., 1995; Grosch et al., 1999; Murphy et al., 1996, 1997).

1.2. Present study

The present article takes those studies one step further by examining the reliability and validity of a short form of the safety climate scale described in DeJoy et al. (2000). Neal and Griffin (2004) and Seo et al. (2004) recently reviewed current safety climate measures and found there were few climate measures with less than 10 items. Safety climate measures tended to have multiple dimensions and examine several aspects of safety climate (Cox and Cheyne, 2000; Diaz and Cabrera, 1997; Hayes et al., 1998; Lee and Harrison, 2000; Mearns et al., 1998; Zohar, 1980). These longer measures are useful when organizations are interested in targeting specific aspects of safety climate. However, a brief, global measure of safety climate can be useful when organizations are interested in efficiently assessing general perceptions of safety climate. If a global measure suggests potential safety climate concerns, then a more in-depth quantitative or qualitative assessment may be appropriate. A brief measure could also easily be incorporated into existing employee opinion surveys to allow monitoring of safety climate with little additional time investment.

In their review of the current measures of safety climate, Seo et al. (2004) concluded that, with a few notable exceptions, one of the major problems with measuring safety climate is that few of the instruments have provided evidence of construct validity. In the present study, we examined the convergent and discriminant validity of the 6-item safety climate scale in multiple organizations with different missions (healthcare and nuclear energy). Convergent validity of the measure was examined relative to four general factors: environmental conditions, safety policies, safety performance, and general organizational climate. Discriminant validity was examined relative to two general factors, demographics and general mood.

1.2.1. Convergent validity hypotheses

Hypothesis 1. Safety climate will be negatively related to environmental conditions, such as exposure to loud noise and heat, and positively related to workspace cleanliness. Reducing these negative environmental conditions has been a primary target for enhancing safety and reducing workplace accidents (DeJoy et al., 2004). Therefore, it is expected that perceptions of these conditions will be related to scores on the short measure of safety climate.

Hypothesis 2. Safety climate will be positively related to safety policies, such as safety training and availability of safety equipment, and safety climate will be negatively related to perceived barriers to safe behavior. Some measures of safety climate have included the existence of safety training and the availability of safety equipment as dimensions of safety climate (see review by Flin et al., 2000). However, several authors have suggested that it is important to differentiate between safety climate and the structural elements of a safety system, such as the existence of policies and procedures (Hale, 2000; Huang et al., 2006). Huang and his colleagues pointed out that organizations may have structural policies, such as safety training or available safety equipment, for reasons other than a strong belief about the value of safety (e.g., industry regulations, strong training/development programs). Thus, it is possible that organizations may have safety policies ''on the books,'' but that these policies may not stem from an organizational belief in the importance of safety. On the other hand, in an organization with a strong safety climate, where management places a high value on employee safety, we would expect more safety policies and practices. The items on the present safety climate measure were developed to assess attitudes about the value of safety, rather than structural elements of safety. However, we expect that our measure of safety climate will be related to organizational safety policies and procedures, such as safety training and safety equipment availability.

Hypothesis 3. Safety climate will be related to safety performance, such as engaging in safe work practices, fewer exposures to hazardous conditions, and fewer accidents. One of the main foci of the safety climate literature has been examining the link between safety climate, safe behavior, and accidents (Cooper and Phillips, 2004). Most of these studies suggest that safety climate is a determinant of safe behavior and is negatively related to accidents and near accidents (Cheyne et al., 1998; Mearns et al., 2003; Zacharatos et al., 2005). Thus, we expect that our measure of safety climate will predict safe behavior and accidents.

Hypothesis 4. Safety climate will be positively related to aspects of general organizational climate, such as organizational communication, employee involvement, decision making, and general quality of feedback. Recently, there have been several studies focusing on the relationship between general organizational climate, safety climate, and safe behavior (DeJoy et al., 2004; Neal et al., 2000). These studies have found that aspects of general organizational climate predict safety climate. The basic premise underlying why these relationships exist is that factors that influence a positive organizational climate, such as open communication, good feedback, and employee involvement are also factors that are important for a positive safety climate. Thus, we expect that our measure of safety climate will be positively related to facets of general organizational climate.

1.2.2. Discriminant validity hypotheses

Hypothesis 5. Safety climate should be unrelated to demographic variables such as age, gender, length of tenure, and number of hours worked per week. It is expected that perceptions of safety climate are rooted in the work environment and thus should be unrelated to demographic measures.

Hypothesis 6. Safety climate should be unrelated or related at a weaker magnitude to mood and sleeping habits. While poor safety climate may have some negative effects on mood and sleep, it is expected that the magnitude of these correlations will be much weaker than the relationships between safety climate and the other sets of variables such as safe behavior, safety policies, environmental conditions, and organizational climate.

The convergent and discriminant validity hypotheses were tested in two different studies using samples from two different industries. Study 1 used samples of healthcare workers and Study 2 used samples from the

nuclear energy industry. Because the two studies shared most, but not all of the same measures, different convergent and discriminant validity hypotheses were tested in both studies. In Study 1, Hypotheses 1, 2, 3, 5, 6 were examined. In Study 2, Hypotheses 1, 3–6 were examined.

2. Study 1

2.1. Sample

Details of the study design and sample can be found in Gershon et al. (1995). Briefly, questionnaires were sent to 3000 healthcare workers from three large hospitals in different regions of the United States. A total of 1716 usable questionnaires was returned (57% response rate). Occupations of participants responding to the survey included nurses, physicians, dentists, dental technicians, technologists, phlebotomists, administrators, and management. Based on three criteria we created six different subsamples from this larger sample for use in the present study. First, each hospital was identified as a separate sample because we were interested in an organizationally influenced variable, safety climate, and it was expected that safety climate would vary by hospital. We further divided each of these three samples by occupation. The present study only included occupations that had direct patient care roles because we were interested in safety practices and procedures involved with direct patient care. To ensure adequate power to detect relationships we included only occupations with more than 100 workers within a hospital site. Based on these three criteria six subsamples were created: three samples of nurses (one from each hospital), one sample of physicians, and two samples of technologists. Sample sizes and descriptive demographics for the total sample as well as each of the subsamples are presented in Table 1.

We compared safety climate scores between Hospitals 1, 2, and 3 and between occupational groups within each hospital. A one-way between groups ANOVA revealed differences between the hospitals in mean safety climate, $F(2, 1445) = 22.62$, $p < .001$. Tukey post-hoc testing revealed differences in mean safety climate between all of the hospitals. Mean safety climate scores for Hospitals 1, 2, and 3 were 18.75, 17.60, and 18.16, respectively. We also found occupational differences in mean safety climate within each of the three hospitals. Within Hospital 1, an independent samples t-test indicated that technologists ($M = 19.48$) had a higher mean safety climate than nurses ($M = 18.64$), $t(535) = 2.80$, $p < .001$. In Hospital 2, technologists ($M = 18.19$) also had a higher mean safety climate than nurses ($M = 17.32$), $t(404) = 2.51$, $p = .01$. In Hospital 3, nurses ($M = 18.95$) reported a higher mean safety climate than physicians ($M = 17.43$), $t(258) = 4.53$, $p < .001$. (Data from technologists were not examined in Hospital 3, because there were fewer than 100 responses.)

2.2. Measures

The development and description of all measures mentioned in this article can be found in DeJoy et al. (1995) and Gershon et al. (1995).

Table 1
Demographics for hospital samples

Sample	n	M Age	M Position tenure (years)	% Female	% College graduate	% Full-time
Hospital 1						
Nurse	428	33.89	5.29	95.30	89.50	83.40
Technologist	109	35.82	7.79	82.60	88.10	80.70
Hospital 2						
Nurse	271	36.27	7.17	91.10	85.70	78.80
Technologist	113	37.74	9.07	93.80	85.00	75.20
Hospital 3						
Nurse	103	36.47	4.06	89.10	84.50	95.50
Physician	150	36.69	4.31	32.00	100.00	98.70
Combined samples						
Total	1450	35.88	6.05	79.00	86.10	85.70

Safety climate. In their factor analyses, DeJoy et al. (2000) identified 16 items that represented four factors of safety climate: management commitment to safety, supervisory performance feedback, worker involvement in safety, and coworker behavior norms. We used these four factors as the structure of the short measure of safety climate and chose six items from these four factors: one item measuring each of the dimensions of supervisory performance feedback, worker involvement in safety, and coworker behavior norms and three items assessing management commitment to safety. Single items from each of the feedback, involvement, and behavior norms scales were chosen since these dimensions are fairly straightforward and concrete. Management commitment, on the other hand, is a broader construct and more items were judged necessary for adequate measurement. For each of the four factors, we selected the highest loading item(s) from the exploratory factor analysis to be included in the 6-item measure (DeJoy et al., 2000). Each item was responded to using a 4-point scale ranging from "Strongly agree" to "Strongly disagree." The six items are presented in Table 2.

Clean workplace. Participants responded to two items asking the extent to which they agreed that their work area was kept clean and uncluttered. Responses were made on a 4-point scale ranging from "Strongly disagree" to "Strongly agree."

Environmental stressor. Exposure to environmental stressors was measured with seven items. Participants indicated on a 5-point scale ranging from "Always" to "Never" how frequently they were bothered by various environmental stressors (e.g., loud noise, temperature variation, poor light).

Safety training. Safety training was measured by a single item ("In the past month how many hours of training did you receive on Universal Precautions (UP)?") using a 4-point categorical response scale (e.g. 0 h, 1–2 h, 3–5 h, 6 or more hours).

Safety equipment availability. Four items measured the extent to which safety equipment was available (e.g., "At my facility medical waste containers and bags are readily available"). Responses were made on a 4-point scale ranging from "Strongly disagree" to "Strongly agree."

Safe behavior barriers. Two items measured the perceptions of whether job duties interfere with the ability to comply with safety practices. (e.g., "My job duties often interfere with my being able to comply with Universal Precautions"). Responses were made on a 4-point scale.

Body fluid exposure. Participants reported the number of needle stick injuries, splashes to eyes or mouth, contacts with open wounds on skin, and cuts with sharp objects that occurred during the previous 6 months. Body fluid exposure was calculated as the sum of exposures across the four categories.

Safe work practices. A simple composite scale was formed from responses to 14 items measuring the frequency of various safe work practices, such as wearing protective masks, recapping needles, wiping up spills with disinfectant, wearing gloves, and proper disposal of sharp objects. Responses were made on a 5-point scale ranging from "Always" to "Never."

Accidents. A single item was used to measure accidents: Participants indicated the number of work-related accidents experienced during the past 6 months. Because very few respondents indicated more than one accident during the past 6 months, we dichotomized accidents into groups experiencing and not experiencing an

Table 2
Items on safety climate measure for hospital samples and department of energy samples

Hospital measure	DOE measure
1. New employees quickly learn that they are expected to follow UP (Universal Precautions). (BN)	1. New employees learn quickly that they are expected to follow good health and safety practices. (BN)
2. Employees are told when they do not follow UP. (FB)	2. Employees are told when they do not follow good safety practices. (FB)
3. Where I work, employees, supervisors, and managers work together to ensure the safest possible working conditions. (MC)	3. Workers and management work together to ensure the safest possible conditions. (MC)
4. In my organization, there are no significant compromises or shortcuts taken when worker protection from infectious diseases is at stake. (MC)	4. There are no major shortcuts taken when worker health and safety are at stake. (MC)
5. The protection of workers from occupational exposure to HIV is a high priority with management where I work. (MC)	5. The health and safety of workers is a high priority with management where I work. (MC)
6. I feel free to report safety violations where I work. (WI)	6. I feel free to report safety problems where I work. (WI)

Note: BN = coworker behavior norms dimension, FB = safety feedback dimension, MC = management commitment dimension, WI = worker involvement in safety dimension.

accident. Across the total sample, 15% of respondents reported an accident. Within the six subsamples, accident reports ranged from 10% to 18%.

Employment status. Participants indicated whether they were employed full-time or part-time.

Hours worked per week. Using a 4-point categorical response scale ranging from "less than 40 h per week" to "more than 60 h" participants indicated the number of hours they worked in a typical week.

Education. Using a 4-point categorical response scale ranging from "Vocational/Technical school" to "Postgraduate work" participants indicated their educational background.

Negative mood. Five items from the General Mental Health Scale of the Medical Outcomes Study were used to measure negative mood (Ware and Sherbourne, 1992). Respondents indicated how much of the time each statement reflected their feelings during the past 30 days. Responses were made on a 6-point scale ranging from "All of the time" to "None of the time."

Trouble falling asleep. Trouble falling asleep was measured using a single item asking participants the extent to which the statement, "I have trouble falling asleep" applies to them. Responses were made on a 4-point scale ranging from "Does not apply to me" to "Does apply to me."

2.3. Data analysis strategy

Using exploratory and confirmatory factor analyses, we examined the factor structure of the 6-item measure of safety climate. We then compared the internal consistency estimates of the 6-item measure with the 16-item measure of safety climate. We also examined convergent and discriminant validity and compared the magnitude of the correlations for the 6-item and the 16-item safety climate measures. Finally, we examined whether the safety climate measure could predict accidents.

2.4. Results

2.4.1. Factor analyses

To examine the factor structure of the 6-item measure, we conducted both exploratory and confirmatory analyses on the hospital samples. For the exploratory factor analysis we used data from Hospital 1 and then conducted the confirmatory factor analysis using data from Hospital 2. We conducted our analyses on data from Hospital 1 ($n = 734$) and Hospital 2 ($n = 552$) because they had the largest sample sizes. To maximize sample size, responses from all employees who had direct patient care occupations were included in the factor analyses; thus, data that were excluded from some of the other analyses because of small occupation subsample sizes were included in the factor analyses. We used the maximum likelihood extraction technique for the exploratory factor analysis and found that the first eigenvalue was 2.90 and accounted for 48.39% of the variance in responses. The remaining eigenvalues were less than 1 (eigenvalue for the second factor was .82) suggesting that these six items were assessing a single factor.

Using a confirmatory factor analysis approach we compared a single factor model with a two-factor model where the three management commitment items loaded on one factor and the three items representing the other three factors (feedback, involvement, and behavior norms) loaded on the second factor. Confirmatory factor analyses requires that each identified factor have a minimum of two variables representing it, therefore it was impossible to test a four-factor model where the factors were the original four dimensions (i.e., supervisory performance feedback, coworker behavior norms, worker involvement in safety, and management commitment to safety) that comprised the items on the scale. The two-factor model where the management commitment items loaded on one factor and the remaining items loaded on a second factor seemed to be a reasonable model against which to test the single factor model. All confirmatory factor analyses were based on the covariance matrix and were conducted using maximum likelihood estimation. Several fit indices, including the goodness-of fit index (GFI), the comparative fit index (CFI), the non-normed fit index (NNFI), and the root mean square error of approximation (RMSEA) were examined to determine the best fitting model (Hu and Bentler, 1999). For the NNFI and the CFI, values greater than .95 are consistent with a good fit between the data and the hypothesized model (Hu and Bentler, 1999). RMSEA values of less than .08 indicate acceptable levels of fit and values of .06 or less indicate a good fit (Browne and Cudeck, 1993; Hu and Bentler, 1999). Additionally, we used the chi-square difference test to statistically compare the models.

Table 3
Safety climate confirmatory factor analysis fit indices for hospital sample

Model	χ^2	df	p	GFI	NNFI	CFI	RMSEA
One-factor	21.74	9	.01	.99	.98	.99	.05
Two-factor	16.31	8	.04	.99	.98	.99	.04

As can be seen in Table 3, the GFI, NNFI, CFI and RMSEA fit indices for the one-factor and two-factor models were all consistent with a good fit, and there was little difference in the magnitude of the fit indices for the one and two-factor models. The chi-square difference test ($\Delta X^2(1) = 5.43$, $p < .02$) indicated that the two-factor model provided a statistically significant better fit to the data than the one-factor model.

Overall, the results from the exploratory and confirmatory factor analyses support a one-factor model of safety climate. While the chi-square difference test indicated a better statistical fit for the two-factor model, other indices indicated a good fit for the one-factor model, and the exploratory factor analysis yielded a one-factor solution which is more parsimonious. The slightly better fit for the two-factor model may be a reflection of differences in the specificity of content of the items between the two factors. Two of the three items in the management commitment factor dealt with more general safety concerns, while two of the three items in the second factor dealt with more specific HIV/UP concerns. As will be discussed later in Section 3.4.1, similar factor analyses of data collected in Study 2, in which all items in both factors dealt with more general safety concerns, revealed clear support for a one-factor model of safety climate.

2.4.2. Internal consistency

Coefficient alpha for the 16-item measure of safety climate ranged from .81 to .92 across the six different samples. The coefficient alphas for the nurse samples from Hospitals 1, 2, and 3 were .86, .88, and .89, respectively. The coefficient alphas for the technologist samples from Hospitals 1 and 2 were .92 and .91, respectively. The coefficient alpha for the physician sample was the lowest at .81. Internal consistency for the 6-item measure of safety climate ranged from .71 to .85 across the six different samples. For the 6-item measure, the coefficient alphas for the nurse samples from Hospitals 1, 2, and 3 were .76, .79, and .80, respectively. The coefficient alphas for the technologist samples from Hospitals 1 and 2 were .80 and .85, respectively. For the 6-item measure, the coefficient alpha for the physician sample was again the lowest at .71.

2.4.3. Convergent and discriminant validity

Table 4 contains the zero-order correlation matrix for all study variables for the combined data from all three hospitals and including all occupations. Pearson product–moment correlations were calculated to assess relationships between non-dichotomous variables. When one of the variables was dichotomous (i.e., sex, accident), we used a point-biserial correlation. We found support for convergent validity Hypothesis 1 as safety climate was correlated with environmental conditions such as clean workplace (.42) and environmental stressors (−.13). Consistent with Hypothesis 2, we found that safety climate was correlated with a variety of safety policies and procedures, such as the availability of safety equipment (.43), perceived barriers to safe behavior (−.32), and safety training (.31). Hypothesis 3 was also supported in the overall sample, as safety climate was related to engaging in safe work practices (.34), fewer exposures to body fluid resulting from needlesticks, cuts, and blood splashes (−.20), and fewer accidents (−.07). The discriminant validity hypotheses were also supported as the correlations between safety climate and measures of demographics, such as age (.04), sex (−.08), education (−.13), position tenure (.03), and number of hours worked (−.04) were generally much lower in magnitude than the convergent validity measures. Additionally, the relationships between safety climate and mood (−.13) and sleep habits (−.08) were weaker than relationships between safety climate and other safety-related outcomes.

Correlations of the 6 and 16-item safety climate measures with other constructs provide evidence of convergent and discriminant validity. These correlations are presented in Table 5 for each of the six samples. For almost all of the correlations, the magnitude of the correlations changed minimally when using the 6-item safety climate scale instead of the longer, 16-item measure. This is expected as the correlation between the 6

Table 4
Intercorrelations between demographics and measures for total hospital sample

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Age	–															
2. Sex (0 = female, 1 = male)	09**	–														
3. Education	−02	33**	–													
4. Position tenure	55**	−03	−08**	–												
5. Hours worked/week	05*	50**	43**	−09**	–											
6. Negative mood	−07**	−09**	−06*	−05*	−06*	(82)										
7. Trouble falling asleep	02	−06*	−06*	03	−10**	32**	–									
8. Environment stressor	−04*	−16**	−10**	04*	−10**	21**	12**	(79)								
9. Safety training	−11**	−09**	−20**	−06*	−15**	−02	−01	05*	–							
10. Safety equipment	05*	−01	−04*	06*	00	−06*	−11**	−13**	10**	(81)						
11. Safe behavior barriers	00	11**	05*	03	07**	13**	08**	09**	−09**	−19**	(70)					
12. Clean workplace	05*	07**	02	−04*	09**	−13**	−06*	−32**	15**	32**	−17**	(83)				
13. Body fluid exposure	−04*	08**	11**	−03	19**	08**	02	02	−09**	−13**	21**	−15**	(50)			
14. Accident	00	04*	02	−01	07**	05*	01	05*	−03	−01	08**	−03	31**	–		
15. Safe work practices	−02	−15**	−17**	00	−14**	−12**	−02	02	20**	21**	−30**	16**	−20**	−05*	(74)	
16. Safety climate (6)	04*	−08**	−13**	03	−04*	−13**	−08**	−13**	31**	43**	−32**	42**	−20**	−07**	34**	(79)

Note: Internal consistency estimates are shown on the diagonal for multi-item scales. Decimals have been omitted. Internal consistency measured using Cronbach's alpha. $n = 1450$.

* $p \leqslant .05$.
** $p \leqslant .01$.

and 16-item measure in the combined samples is $r(1448) = .93$. Thus, the predictive ability of the 6-item measure is similar to the 16-item measure, at least for the constructs examined in the present study.

Several of the correlations in Table 5 provide support for the convergent validity of the 6-item measure of safety climate. The results presented above examining the convergent validity correlations in the combined data sets, predominantly mimic the results in the individual samples. Consistent with Hypothesis 1, in a majority of samples, safety climate was related to a safer work environment as safety climate was positively related to clean workspace and negatively related to environmental stressors, such as loud noise and poor lighting. Consistent with Hypothesis 2, safety climate was related to safety policies and practices. For example, in a majority of the samples, people who reported higher levels of safety climate also indicated that safety equipment was more available to them at work, and they were less likely to report that their job tasks were a barrier to engaging in safe work practices. Additionally, for five of the six samples, higher safety climate scores were related to more training on safety procedures. Partial support was found for Hypothesis 3 as safety climate was related to some types of safe behavior. In all six samples, people who reported higher levels of safety climate also reported being more likely to engage in safe work practices (e.g. wearing facemasks, gloves, and appropriately disposing of used needles). Additionally, in most of the samples, safety climate was significantly, negatively correlated with body fluid exposures. Thus, higher safety climate was related to fewer expo-

Table 5
Correlations between safety climate and convergent and discriminant measures for six hospital samples

Variable	Hospital 1		Hospital 2		Hospital 3	
	Nurse	Tech	Nurse	Tech	Nurse	Physician
6-item safety climate convergent validity						
Available safety equipment	.39*	.39*	.39*	.49*	.57*	.52*
Safe work practices	.35*	.28*	.36*	.25*	.28*	.39*
Clean workspace	.39*	.44*	.44*	.44*	.51*	.48*
Safety training	.17*	.30*	.36*	.14	.18*	.27*
Accident	−.09*	−.19*	.05	−.26*	.05	−.10
Body fluid exposure	−.13*	−.21*	−.13*	−.29*	−.16	−.26*
Environmental stressors	−.16*	−.12	−.23*	−.26*	−.24*	−.17*
Barriers to safe behavior	−.29*	−.18	−.37*	−.51*	−.34*	−.18*
6-item safety climate discriminant validity						
Negative mood	−.15*	−.27*	−.14*	−.12*	−.13	−.08
Trouble falling asleep	−.16*	−.01	.00	−.17*	−.15	.00
Sex	.03	−.08	.03	−.01	−.12	.04
Education	−.05	−.18	.01	.06	.04	.06
Employment status	−.12*	−.07	−.04	.05	−.04	.00
Hours worked/week	.10*	.06	.05	.03	−.07	.04
16-item safety climate convergent validity						
Available safety equipment	.43*	.35*	.37*	.50*	.58*	.50*
Safe work practices	.38*	.37*	.35*	.27*	.29*	.37*
Clean workspace	.42*	.48*	.45*	.47*	.55*	.51*
Safety Training	.23*	.33*	.38*	.14	.21*	.32*
Accident	−.08	−.18	.05	−.28*	−.06	−.06
Body fluid exposure	−.12*	−.20*	−.13*	−.27*	−.21*	−.26*
Environmental stressors	−.13*	−.13	−.23*	−.29*	−.17	−.16*
Barriers to safe behavior	−.29*	−.13	−.37*	−.48*	−.39*	−.14
16-item safety climate discriminant validity						
Negative mood	−.19*	−.27*	−.12*	−.12	−.06	−.13
Trouble Falling Asleep	−.16*	.00	.04	−.12	−.10	−.01
Sex	.03	−.10	.05	−.04	−.13	.03
Education	−.08	−.22*	.02	.05	.02	−.01
Employment status	−.11*	−.06	−.02	.07	−.02	−.01
Hours worked/week	.10*	.03	.01	.01	−.03	.11

* $p \leqslant .05$.

sures to potentially harmful blood and body fluid as a result of cuts, needlesticks, and blood splashes. Additionally, a small to modest significant relationship between safety climate and the occurrence of a work-related accident was found in three of the six samples.

As evidence for discriminant validity Hypothesis 4, the 6-item safety climate measure was found to be unrelated to many demographic variables, such as sex, education and, in all but one sample, employment status and the number of hours worked per week. Additionally, consistent with discriminant validity Hypothesis 5, safety climate had weak or non-significant relationships with negative mood and trouble falling asleep.

A hierarchical logistic regression analysis was conducted to determine whether the 6-item safety climate scale was associated with self-report accidents, after controlling for other variables. Predictor variables were entered into the equation in three blocks: demographics (education, position tenure, hours worked per week), stressors/outcome variables (negative mood, sleep difficulties, environmental stressors, safety training, workplace cleanliness, safety equipment availability), and safety climate. The outcome variable, accidents, was coded as a dichotomous variable. For the nurse, technologist, and physician samples combined across the three hospitals, ($n = 1227$), a total of 184 people reported accidents. Only one variable, the number of hours worked per week, significantly predicted accidents ($B = .23$, $SE = .10$, $p = .02$). Two other variables were associated with accidents, physical stressors ($B = .03$, $SE = .02$, $p = .07$) and safety climate ($B = -.06$, $SE = .03$, $p = .07$). Even though safety climate was entered last into the equation to predict accidents, it was still marginally significant.

Based on the findings from the six samples of hospital workers, the psychometric properties of the 6-item measure of safety climate are adequate. Exploratory and confirmatory factor analyses results, while mixed, generally seem to support a one-factor safety climate measure. Across five of the six subsamples, the internal consistency estimates of the safety climate measure are above .75. Comparisons of the 6 and 16-item measures of safety climate indicate that the 6-item measure has comparable predictive ability across all six samples for the constructs examined in the present study. Convergent validity correlations indicate that the 6-item safety climate measure is related to a variety of safe work behaviors, such as engaging in safe work practices, decreased exposure to blood and body fluid, and reports of safer work environments.

3. Study 2

3.1. Sample

The study design and description of the sample can be found in Murphy and Pepper (2003). Questionnaires were sent to 3716 employees working at two Department of Energy (DOE) worksites. In both cases, a stratified, random sampling strategy was employed to select at least 40% of the total working population. Site A was located in the southwestern USA, and their principal mission was assembling and disassembling nuclear weapons. The site employed 2963 workers, of whom 1273 were selected to receive questionnaires and 788 returned completed surveys (response rate = 62%). Site B was located in the Midwestern USA, and had traditionally produced highly enriched uranium and other components for nuclear weapons, but its new mission included dismantling nuclear weapons, manufacturing weapons components, warehousing nuclear materials for defense capabilities, and transferring technology. Site B employed 5927 workers, of whom 2442 were selected to receive questionnaires and 1153 returned completed surveys (response rate = 48%). Across both sites, the occupations of survey respondents included craft, office worker, scientist, service, laborer, professional/administrative, engineer, operator, technician, and management. Only occupations with more than 100 people were retained for analysis to ensure adequate power to detect relationships. Based on these criteria, eight subsamples were examined: three subsamples from Site A (management, technician, and professional/administrative) and five subsamples from Site B (management, technician, engineer, professional/administrative, and craft). Sample sizes and descriptive statistics for the combined data from both sites and for all subsamples are presented in Table 6.

Comparisons in safety climate scores between Site A and Site B and between occupational groups within each site were conducted. An independent samples *t*-test revealed that workers at Site A reported a higher mean safety climate ($M = 23.88$) than workers at Site B ($M = 22.41$), $t(1283) = 7.63$, $p < .001$. Within Site A, the ANOVA revealed differences in mean safety climate between occupational groups $F(2, 408) = 5.35$,

Table 6
Demographics for department of energy samples

Sample	n	M Tenure position (years)	M Tenure DOE (years)	% Female	% College graduate	% White	% Older than 50
Site A							
Manager	109	4.10	13.11	18.90	68.90	86.70	29.20
Tech	147	9.41	13.87	22.30	14.90	83.60	33.80
Admin	155	5.33	11.10	45.10	65.00	82.20	25.30
Site B							
Manager	142	5.62	18.97	18.60	61.70	94.30	53.20
Tech	104	9.87	16.47	29.10	27.80	95.10	35.50
Admin	279	6.45	15.83	55.90	61.60	91.40	36.30
Craft	138	16.53	20.43	5.10	4.30	97.80	56.20
Engineer	210	7.59	17.51	11.90	85.20	92.90	44.30
Combined samples							
Total	1284	8.06	15.68	30.60	45.10	89.40	38.80

$p = .01$. Post-hoc Tukey tests indicated that managers ($M = 24.95$) reported a higher mean safety climate than technicians ($M = 23.55$) or administrative staff ($M = 23.45$). There was no significant difference in mean safety climate between the technicians and administrative staff. Within Site B, the ANOVA revealed differences in mean safety climate between occupational groups $F(4, 873) = 5.62$, $p < .001$. Post-hoc Tukey tests indicated that the craftspeople ($M = 21.44$) and the technicians ($M = 21.50$), the occupational groups with the lowest mean safety climate scores, differed significantly from the managers ($M = 23.09$) and the administrative staff ($M = 22.77$), the groups with the two highest safety climate means. There were no differences in mean safety climate scores between the engineers ($M = 22.57$) and any of the other occupational groups.

3.2. Measures

Many of the measures used in this study were identical to those described earlier in the healthcare study; more details on measures unique to this study can be found in Murphy and Pepper (2003).

Safety climate. To use the short safety climate measure in a non-healthcare setting, the wording of some of the items was altered to make them more generic. The items used in Study 2 are presented in Table 2 alongside the safety climate items used in Study 1. Wording changes focused on substituting hospital-specific safety concerns (i.e., exposure to HIV and infectious disease) and regulations (Universal Precautions) with generic wording (safety and health). Additionally, at the request of the organization under study, the response scale was changed so that the items would be more compatible with other scales in the study. The new response scale was changed to a 5-point "Strongly agree–Strongly disagree" format that included a neutral midpoint (Neither agree nor disagree). Although it would have been preferable to use the original 4-point scale, the 5-point scale still allows us to examine the stability of the reliability coefficients and the pattern of inter-relationships among items.

Environmental stressors. Exposure to environmental stressors was assessed using three items measuring perceived threat from chemicals, air pollution, and risk of catching diseases. Responses were made on a 3-point scale, "Not exposed", "Exposed, but a slight problem", and "Exposed, sizable or great problem."

Noise. Noise was measured by responses to the question, "While you are working, how loud would you have to talk to be heard by someone standing next to you?". Responses were made on a 4-point scale ranging from "Whisper" to "Shout."

Injury. Injury was measured by the item, "In the past 6 months how often did you get injured on the job." Responses were made on a 4-point categorical scale ranging from "Never" to "6 or more times." However, participants overwhelmingly used only the first two response options. Only one participant endorsed the response option "3–5 injuries" during the past 6 months, and no participants reported "6 or more injuries" during the past 6 months. Therefore, injury was treated as a dichotomous variable and responses were recoded to indicate either "injury" or "no injury" during the past 6 months.

Communication. Three items measured the strength of communication between levels of management and between management and employees. Responses were made on a 5-point "Strongly agree" to "Strongly disagree" scale.

Involvement. Job involvement was measured using three items from Cook and Wall's (1980) Organizational Commitment scale.

Feedback quality. Feedback quality was assessed using three items measuring how frequently the quality and timing of information received on the job influenced effective job performance. Responses were made on a 4-point scale ranging from "Never" to "Always."

Decision authority. Perceptions of the amount of authority one has in making decisions on the job were measured with three items from the Quality of Employment Survey (Quinn and Staines, 1978). Responses were made on a 4-point scale ranging from "Strongly agree" to "Strongly disagree."

Sleep problems. Three items were used to measure sleep difficulties. Participants responded "yes" or "no" to whether they had been bothered by various sleep problems during the past month.

Negative mood. Negative mood was measured using three items asking participants how often, during the past 4 weeks, they felt "calm and peaceful", "downhearted and blue", and "had a lot of energy." Responses were made on a 6-point scale ranging from "All of the time" to "None of the time."

3.3. Data analysis strategy

For Study 2, we followed the same data analysis approach as Study 1. To assess the validity of the short measure of safety climate, we examined the factor structure, internal consistency, and pattern of convergent and discriminant validity correlations. Consistent with Study 1, we also conducted a regression analysis to determine if the safety climate measure was useful in predicting accidents after demographics, stressors, and outcome measures were already considered. Additionally, to examine the effects of the wording changes on the safety climate measure, we compared inter-item correlations and standardized factor loadings for the hospital and nuclear energy surveys.

3.4. Results

3.4.1. Factor analyses

As in Study 1, the factor structure of the 6-item measure was examined by conducting exploratory factor analysis on one sample (Site A: $n = 411$) and confirming on the second sample (Site B: $n = 873$). Again the exploratory factor analysis with maximum likelihood estimation yielded a single factor. The first eigenvalue was 3.96 and accounted for 65.9% of the variance in responses. The remaining eigenvalues were less than 1 (eigenvalue for the second factor was .56) and accounted for very little variation in responses suggesting that these six items were assessing a single aspect of safety climate.

For the confirmatory factor analysis we again compared a single-factor model with a two-factor model where the management commitment items loaded on one factor and the items representing the other three dimensions loaded on a second factor. As can be seen in Table 7, the GFI, NNFI and CFI fit indices all suggested a good (greater than .95) model fit for both the one and two-factor models, and there were no differences in the magnitude of these fit indices for the two models. The values for the RMSEA indicated an acceptable fit for both the one and two-factor models. The comparison of the one- and two-factor models using the difference in chi-square test indicated that there was no difference between the one- and two-factor models, $\Delta X^2(1) = .04$, $p > .05$.

Table 7
Safety climate confirmatory factor analysis fit indices for department of energy sample

Model	χ^2	df	p	GFI	NNFI	CFI	RMSEA
One-factor	57.89	9	.001	.98	.96	.98	.08
Two-factor	57.85	8	.001	.98	.96	.98	.08

Results from the exploratory and confirmatory factor analyses from the DOE samples provide a consistent picture of the factor structure of the safety climate measure. Both sets of analyses indicate that a single factor provides the best explanation for the items on the measure.

3.4.2. Internal consistency

Compared with the hospital samples, the internal consistency estimates in the DOE samples were higher, ranging from .84 to .92. The administrative assistants had the highest coefficient alphas at both Site 1 ($\alpha = .92$) and Site 2 ($\alpha = .88$). The coefficient alphas for the manager samples from Sites 1 and 2 were .86 and .84, respectively. The coefficient alphas for the craftspeople and engineers samples (Site 2 only) were .84 and .87, respectively.

3.4.3. Measure comparability

As previously mentioned, we modified the wording of some items on the DOE safety climate measure to create a more generic measure that can be used in a variety of industries. To assess the impact the wording modification had on the scale properties, we compared the confirmatory factor analysis standardized factor loadings for the DOE and hospital samples. Additionally, we examined the pattern of inter-item correlations for the two samples.

Table 8 includes the confirmatory factor analysis standardized parameter estimates of the safety climate items for the hospital and DOE samples. The standardized factor loadings ranged from .46 to .79 in the hospital sample and were higher in the DOE sample, ranging from .58 to .84. A comparison of the factor loadings between the two samples suggests similarities. Across both samples, the three highest loading items were the management commitment to safety items. Additionally, across both samples, the items representing supervisory feedback, worker involvement in safety, and coworker behavior norms all had lower loadings that were more similar in magnitude. In the DOE samples, however, we found smaller differences in the magnitude of the factor loadings between the management commitment items and the items representing the other three dimensions of safety climate.

Further evidence for the similarity between the hospital and DOE versions of the safety climate scale comes from an examination of inter-item correlations for each sample. The DOE safety climate measure had higher inter-item correlations (ranging from .43 to .73) than the hospital measure (ranging from .24 to .60). In both samples, the highest inter-item correlations were found among the three items intended to assess management commitment to safety. The inter-item correlations between the management commitment items ranged from .64 to .73 in the DOE sample and from .55 to .60 in the hospital sample. Additionally, for both samples generally the lowest inter-item correlations were found between the items measuring safety feedback, worker involvement in safety, and coworker behavior norms with inter-item correlations for the DOE sample ranging from .43 to .48 and from .24 to .34 in the hospital sample. Inter-item correlations between the management commitment items and the items representing the other three aspects of safety climate were generally in the middle ranging from .48 to .63 for the DOE sample and .33 to .39 for the hospital sample. Overall, the pattern of inter-item correlations is consistent with the results of the confirmatory factor analysis standardized parameter estimates. Across both samples, the three management commitment items had the strongest inter-item

Table 8

Confirmatory factor analysis standardized factor loadings for one-factor solution for hospital and DOE samples

Item	Hospital sample	DOE sample
1. New employees learn quickly that they are expected to follow good health and safety practices. (BN)	.46	.65
2. Employees are told when they do not follow good health and safety practices. (FB)	.55	.58
3. Workers and management work together to ensure the safest possible conditions. (MC)	.78	.81
4. There are no major shortcuts taken when worker health and safety are at stake. (MC)	.76	.73
5. The health and safety of workers is a high priority with management where I work. (MC)	.79	.84
6. I feel free to report safety problems where I work. (WI)	.53	.69

BN = coworker behavior norms dimension, FB = safety feedback dimension, MC = management commitment dimension, WI = worker involvement in safety dimension.

correlations and the highest standardized factor loadings. The three items assessing the other aspects of safety climate had the weakest inter-item correlations and lower standardized factor loadings.

Finally, evidence of the similarity between the items on the two safety climate measures comes from the exploratory and confirmatory factor analyses. As previously indicated, in both the hospital and DOE samples, exploratory factor analyses suggested that a single factor best represented the safety climate items. The results of the confirmatory factor analyses for the hospital and DOE samples were mixed with the DOE analyses strongly indicating a single factor safety climate measure and with most, but not all, of the indicators from the hospital analyses suggesting a single factor.

As noted earlier, the DOE items all dealt with general safety concerns, while in the hospital sample, half of the items dealt with more specific safety concerns (i.e., HIV/Universal Precautions) and half with more general safety concerns. This difference the specificity of the items between the DOE and hospital versions of the safety climate measure could contribute to the higher internal consistency of the DOE measure. Despite this difference, the general pattern of inter-item correlations and standardized factor loadings indicated comparability across samples.

3.4.4. Convergent and discriminant validity

Table 9 contains the zero-order correlation matrix for all study variables for the combined data from both DOE sites including all occupations. Pearson product–moment correlations, and where appropriate point-biserial correlations, were calculated to assess relationships between variables. Consistent with convergent validity Hypothesis 1, safety climate was again correlated with environmental stressors (−.30). Consistent with Hypothesis 3, there was also a small correlation between injuries and safety climate (−.10). Additionally, evidence supported Hypothesis 4, as safety climate was related to aspects of general organizational climate, such as communication (.49), involvement (.36), feedback quality (.30), and decision authority (.32). Also, as found in Study 1 and consistent with discriminant validity Hypothesis 4, safety climate was not highly correlated with demographic measures, such as minority status (.01), age (−.04), and education (.07). Relationships between safety climate and mood (−.15) and sleep habits (−.11) were moderate, but most were much lower in magnitude than relationships between safety climate and other convergent validity measures.

Correlations of the 6-item safety climate measure with other constructs for each of the eight DOE samples provides evidence of convergent and discriminant validity. These correlations are presented in Table 10. Consistent with Hypothesis 1, in six of the eight samples, higher safety climate scores were related to reports of fewer environmental stressors, and in three of the samples higher safety climate was related to less exposure to loud noise. Limited support was found for Hypothesis 3, as safety climate was related to self-report injuries in only one of the eight samples (in both of the manager samples, no injuries were reported). Additionally, consistent with the combined data set analyses of Hypothesis 4, we found that in all or most of the samples, safety climate was related to aspects of general organizational climate, such as communication, feedback quality, decision authority, and involvement. Workers who reported higher levels of safety climate felt they had more decision making control in their jobs, and they reported higher levels job involvement. Additionally, higher levels of safety climate were related to better general organizational communication and more frequent, high quality feedback that allowed employees to do their job better. In fact, among all of the variables tested, organizational communication had the strongest correlations with safety climate, ranging from .37 to .53 across the eight samples. It is reasonable to expect that organizations with positive safety climates would also be effective at communicating as safety climate is transmitted largely through communications.

As evidence for discriminant validity Hypothesis 5, safety climate was not significantly related to sex, age, or minority status. Scores on safety climate were also unrelated to education level and position tenure in all but one sample. These findings are consistent with the results from the hospital samples indicating that safety climate is not related to demographic factors. Discriminant validity Hypothesis 6 predicted that safety climate would be related at a much lower magnitude to problems sleeping and negative mood. In Study 2 sleep difficulties and negative mood were more strongly related to safety climate than in the hospital samples. In five of the eight DOE samples safety climate was significantly related to negative mood, and the magnitude of these significant relationships ranged from −.21 to −.31. In the hospital samples, sleeping problems was only significantly related to safety climate in two of the six samples, whereas safety climate was significantly related

Table 9
Intercorrelations between demographics and measures for total department of energy sample

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Age	–														
2. Sex	16**	–													
3. Minority (0 = non-white, 1 = white)	−03	−03	–												
4. Education	−07**	03	−02	–											
5. Position tenure	33**	19**	02	−30**	–										
6. Environmental stress	05*	19**	02	−26**	25**	(80)									
7. Problems sleeping	−05*	−09**	−04*	05*	−07**	05*	(83)								
8. Negative mood	−11**	−15**	−07**	13**	−12**	−02	49**	(80)							
9. Noise	09**	16**	05*	−27**	21**	38**	02	−05*	–						
10. Decision authority	02	−01	−09**	25**	−12**	−27**	−05*	−09**	−21**	(77)					
11. Involvement	04*	−09**	−03	08**	−13**	−18**	−02	−07**	−07**	28**	(73)				
12. Feedback quality	04*	−07**	05*	−19**	07**	−10**	−16**	−28**	01	20**	15**	(87)			
13. Communication	02	−03	00	03	−09**	−24**	−17**	−22**	−11**	33**	27**	37**	(88)		
14. Injury	02	−03	05*	−11**	08**	13**	06*	09**	10**	−05*	−04	00	−03	–	
15. Safety climate (6)	−04*	−03	01	07**	−11**	−30**	−11**	−15**	−15**	32**	36**	30**	49**	−10**	(87)

Note: Internal consistency estimates are shown on the diagonal for multi-item scales. Decimals have been omitted. Internal consistency measured using Cronbach's alpha. $n = 1284$.

* $p \leqslant .05$.
** $p \leqslant .01$.

Table 10
Correlations between safety climate and convergent and discriminant measures for eight department of energy samples

Variable	Site A			Site B				
	Manager	Tech	Admin	Manager	Tech	Engineer	Admin	Craft
Convergent validity								
Environ. Stress	−.34[*]	−.04	−.42[*]	−.27[*]	−.18	−.22[*]	−.13[*]	−.33[*]
Noise	−.31[*]	−.03	−.20[*]	−.04	−.22[*]	.06	−.10	−.06
Injury	−[a]	−.07	−.01	−[a]	−.03	.06	−.20[*]	.01
Communication	.53[*]	.37[*]	.50[*]	.50[*]	.37[*]	.47[*]	.37[*]	.39[*]
Feedback	.22[*]	.27[*]	.18[*]	.36[*]	.36[*]	.37[*]	.27[*]	.23[*]
Decision authority	.35[*]	.02	.40[*]	.39[*]	.18	.27[*]	.21[*]	.26[*]
Involvement	.53[*]	.36[*]	.56[*]	.30[*]	.20[*]	.32[*]	.32[*]	.34[*]
Discriminant validity								
Negative mood	−.30[*]	−.07	−.04	−.21[*]	−.25[*]	−.07	−.31[*]	−.30[*]
Sleep problems	−.10	.03	−.07	−.18	−.19[*]	−.17[*]	−.16[*]	−.24[*]
Sex	.08	−.01	−.14	.09	.06	.03	−.04	−.15
Education	.06	−.01	.24[*]	.02	−.15	.08	−.04	.00
Age	.16	.03	−.12	.10	.00	−.03	−.01	−.08
Minority	−.10	−.00	.06	.09	.14	−.08	.04	.11
Tenure	.02	−.07	−.32[*]	−.08	−.06	.03	.01	−.16

[a] Value not computed because no injuries were reported in the sample.
[*] $p \leqslant .05$.

to problems sleeping in four of the eight DOE samples, with the magnitude of the significant correlations ranging from −.16 to −.24.

We also examined the ability of safety climate to predict accidents, after controlling for other demographic, stressor and outcome variables. Because of the large number of variables entered into the equation, we conducted the analyses on the combined DOE samples, rather than on individual subsamples. Consistent with the hospital data analyses, variables were entered into the regression equation in three blocks: demographics (education, job tenure, age, and sex), stressors/outcomes (environmental stressors, noise, decision authority, feedback, communication, involvement, negative mood, problems sleeping) and safety climate. Of the 13 variables entered into the model to predict accidents only three were statistically significant, education ($B = −.33$, SE = .12, $p < .001$), environmental stressors ($B = .26$, SE = .11, $p = .02$), and negative mood ($B = .21$, SE = .06, $p < .001$). Even though it was entered into the equation after 12 other variables, safety climate was still marginally significant in predicting accidents ($B = −.09$, SE = .06, $p = .06$).

4. Discussion

4.1. Measure validation results

The results support the validity and reliability of a 6-item safety climate scale. The scale taps four fundamental dimensions of safety climate: management commitment, safety performance feedback, worker involvement, and safety behavior norms. Exploratory and confirmatory analyses generally suggest that the scale is unidimensional. We recommend the wording of the items from the DOE scale because all of the items deal with generic safety issues, and there is more consistent statistical evidence for a unidimensional measure. The scale demonstrates good internal consistency across six samples of healthcare workers and across multiple occupations in two DOE work sites. The safety climate scale correlates with safe workplace behavior, measures of environmental stressors, and safety policies (convergent validity), but is unrelated or much less related to demographics, sleeping problems, and negative mood (discriminant validity). Additionally, across both studies, the safety climate scale was marginally significant in predicting self-reported accidents after controlling for other demographic, stress, and outcome variables.

Safety climate most strongly relates to measures of effective communication and feedback. These relationships seem quite reasonable as commitment to safety is transmitted through communication by management.

Barling et al. (2002) demonstrated that transformational leaders who focused on safety were able to successfully communicate high safety standards and encourage employees to accept safety goals and that their organizations had higher levels of safety climate and fewer occupational injuries.

In addition to effective communication and feedback, safety climate also relates to a variety of positive experiences, such as job involvement and higher levels of decision making. Other research that has focused on the relationship between safety climate and general organizational climate variables such as, communication, feedback, job involvement, and decision making have found similar strong relationships between general organizational climate and safety climate (DeJoy et al., 2004; Neal et al., 2000). Neal et al. (2000) suggest that general organizational climate provides a backdrop for which other workplace perceptions, such as safety, are made. James and James' (1989) also found support for this idea. They examined a variety of psychological climate variables, such as perceptions of leader support, role stress, job challenge and autonomy, and work group cooperation, and found that a single higher-order factor seemed to underlie the diverse perceptions. James and James (1989) identified this factor as a general evaluation of "the degree to which the overall work environment is personally beneficial versus personally detrimental to the organizational well-being of the individual" (p. 739). These studies suggest that organizations that place a high priority on general employee well-being, may also value employee safety, and these organizations effectively communicate this to their employees.

Much has been written about the number of dimensions of safety climate and various authors have proposed as few as two factors and as many as nine (Brown and Holmes, 1986; Cox and Cheyne, 2000; Dedobbeleer and Beland, 1991; DeJoy et al., 2000; Diaz and Cabrera, 1997; Mearns et al., 2003; Williamson et al., 1997; Zohar, 1980). Some have suggested that identical safety climate dimensions across organizations do not in fact exist (Coyle et al., 1995). This is likely to be the case if one includes more individual factors in the safety climate questionnaire, such as optimism and fatalism. However, if safety climate is restricted to assessments of perceptions about safety "policies in use", as suggested by Zohar (2003), and is restricted to assessments of organizational factors, not personal beliefs (as distinct from perceptions), then a more unified picture seems to emerge. Factors such as management commitment to safety, supervisory performance feedback, worker involvement, and behavior norms are commonly reported in prior studies and would seem to form essential elements of a generic safety climate scale (Flin et al., 2000). This suggestion aligns with the conceptualization of safety climate as a social, rather than psychological, construct (Zohar, 2003).

In our measure, we opted to focus on global perceptions of safety climate, in contrast to perceptions of specific, individual policies or procedures. This approach results in a smaller number of key factors or constructs, as Griffin and Neal (2000) demonstrated, and best suited our goal of producing a brief yet reliable and valid scale that organizations can use to assess overall level of safety climate present at the workplace. A short scale such as this can easily be incorporated into existing employee opinion or organizational climate surveys to provide a rapid assessment of the overall safety climate.

4.2. Study limitations

There are several limitations of the present study. First, because of the cross-sectional nature of the study we can not provide predictive validity evidence for the safety climate measure. Second, the study uses data from only two industries (healthcare and nuclear energy) for validation of the measure. However, within each industrial sector, our samples included multiple occupations which permitted an examination of the external validity of the scale that was developed within the healthcare sector. A third limitation is the reliance on self-report data, which may result in artificially inflated correlations among variables (Podsakoff et al., 2003). Podsakoff et al. (2003) identified several techniques for reducing common method bias, and some of these techniques are present in the current study. First, Podsakoff et al., suggests that when measures on a survey do not seem, by the respondents, to be related to one another that method bias may be minimized because respondents may not feel the need to maintain consistency in their responses. Because the nuclear energy survey was not designed to examine safety issues, rather the focus of the survey was on the effects of downsizing, potential self-report biases may be lessened. A second suggestion that Podsakoff et al. (2003) have for minimizing self-report biases is to use different types of response scales for the various self-report measures. In both of the studies, a Likert response scale was used for the safety climate measure; how-

ever, participants responded to many of the criterion measures using a variety of different response scales. The other criterion measures that also used a Likert response scale include workplace cleanliness, safety equipment availability, safe behavior barriers, decision authority, and communication. Thus, the relationships between these variables and safety climate are potentially at risk for self-report biases.

4.3. Conclusions and future research

With respect to future research, we believe that it is important to test whether the measure can successfully be aggregated from individual perceptions to higher levels such as the workgroup or organization. In the present study, the safety climate measure was validated at the individual level. Based on these analyses, we can conclude that *individuals' perceptions* about the importance of safety to the organization are related to *individual* safe behavior, perceptions of safe environments, and safety policies and procedures. However, safety climate research has begun to focus on *shared group perceptions* regarding the importance of safety to the organization. Thus, it is important to see if responses to this brief measure can be aggregated to higher levels and still predict safety-related outcomes. This is a level of analysis issue and requires that data be collected at multiple levels or at least that each level of the organization be coded in the dataset. Such data would allow one to test the reliability and inter-rater agreement at multiple levels and decide the appropriate level of aggregation (Zohar, 2000).

The renewed interest in safety climate research is welcome at a time when organizational downsizings are increasing and workers who are retained report increasingly high workload and hours of work (Sauter and Murphy, 2003). Both trends may have important consequences for worker safety and health, and any efforts to improve the safety and health at the workplace could reap important benefits. This brief, reliable, non-industry-specific measure may allow organizations to easily track general perceptions of safety climate in their workforces. This information can provide organizations with a relatively inexpensive and proactive method of enhancing safe behavior at work.

References

Barling, J., Loughlin, C., Kelloway, E.K., 2002. Development and test of a model linking safety-specific transformational leadership and occupational safety. Journal of Applied Psychology 87, 488–496.

Brown, R.L., Holmes, H., 1986. The use of a factor-analytic procedure for assessing the validity of an employee safety climate model. Accident Analysis and Prevention 18, 455–470.

Browne, M.W., Cudeck, R., 1993. Alternative ways of assessing model fit. In: Bollen, K.A., Long, J.S. (Eds.), Testing Structural Equation Models. Sage, Thousand Oaks, CA.

Centers for Disease Control and Prevention, 1987. Update: Human immunodeficiency virus infection in health-care workers exposed to blood of infected patients. Morbidity and Mortality Weekly Reports 36, 285–289.

Cheyne, A., Cox, A., Oliver, A., Tomas, J.M., 1998. Modeling safety climate in the prediction of levels of safety activity. Work and Stress 12 (3), 255–271.

Cohen, A., 1977. Factors in successful occupational safety programs. Journal of Safety Research 9, 168–178.

Cook, J., Wall, T., 1980. New work attitude measures of trust, organizational commitment, and person need non-fulfillment. Journal of Occupational Psychology 53, 39–52.

Cooper, M.D., Phillips, R.A., 2004. Exploratory analysis of the safety climate and safety behavior relationship. Journal of Safety Research 35, 497–512.

Cox, S.J., Cheyne, A.J.T., 2000. Assessing safety culture in offshore environments. Safety Science 34, 111–129.

Coyle, I.R., Sleeman, S.D., Adams, N., 1995. Safety climate. Journal of Safety Research 26, 247–254.

Dedobbeleer, N., Beland, F., 1991. A safety climate measure for construction sites. Journal of Safety Research 22, 97–103.

DeJoy, D.M., 1986. Behavioral-diagnostic model for self-protective behavior in the workplace. Professional Safety 31, 26–30.

DeJoy, D.M., Gershon, R.M., Murphy, L.R., 1998. Minimizing the risk of occupationally-acquired HIV/AIDS: universal precautions and health care workers. In: Feyer, A.M., Williamson, A. (Eds.), In: Occupational Injury: Risk, Prevention, and Intervention. Taylor-Francis, London.

DeJoy, D., Murphy, L.R., Gershon, R., 1995. Safety climate in health care settings. In: Bittner, A.C., Champey, P.C. (Eds.), Advances in Industrial Ergonomics and Safety VII. Taylor and Francis Ltd., London.

DeJoy, D.M., Searcy, C.A., Murphy, L.R., Gershon, R.M.M., 2000. Behavioral-diagnostic analysis of compliance with universal precautions among nurses. Journal of Occupational Health Psychology 5, 127–141.

DeJoy, D.M., Schaffer, B.S., Wilson, M.G., Vandenberg, R.J., Butts, M.M., 2004. Creating safer workplaces: Assessing the determinants and role of safety climate. Journal of Safety Research 35, 81–90.

Diaz, R.I., Cabrera, D.D., 1997. Safety climate and attitude as evaluation measures of organizational safety. Accident Analysis and Prevention 29, 643–650.

Flin, R., Mearns, K., O'Connor, P., Bryden, R., 2000. Measuring safety climate: Identifying the common features. Safety Science 34, 177–192.

Gershon, R.M., Vlahav, D., Felknor, S., Vesley, D., Johnson, P.C., Delclos, G.L., Murphy, L.R., 1995. Compliance with universal precautions among health care workers. American Journal of Infection Control 23, 225–236.

Gillen, M., Baltz, D., Gassel, M., Kirsh, L., Vaccaro, D., 2002. Perceived safety climate, job demands, and coworker support among union and nonunion injured construction workers. Journal of Safety Research 33, 33–51.

Griffin, M.A., Neal, A., 2000. Perceptions of safety at work: A framework for linking safety climate to safety performance, knowledge, and motivation. Journal of Occupational Health Psychology 5, 347–358.

Grosch, J.W., Gershon, R., Murphy, L.R., DeJoy, D., 1999. Safety climate dimensions associated with occupational exposure to blood borne pathogens in nurses. American Journal of Industrial Medicine (Supplement 1), 122–124.

Guldenmund, F.W., 2000. The nature of safety culture: A review of theory and research. Safety Science 34, 215–257.

Hale, A.R., 2000. Editorial: Culture's confusions. Safety Science 34, 1–14.

Hammond, J.S., Eckes, J.M., Gomez, G.A., Cunningham, D.N., 1990. HIV, trauma, and infection control: universal precautions are universally ignored. Journal of Trauma 30, 555–561.

Hayes, B.E., Peranda, J., Smecko, T., Task, J., 1998. Measuring perceptions of workplace safety: development and validation of the workplace safety scale. Journal of Safety Research 29, 145–161.

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

Hu, L., Bentler, P.M., 1999. Cutoff criteria for fit indices in covariance structure analysis: conventional versus new alternatives. Structural Equation Modeling 6, 1–55.

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. Accident Analysis and Prevention 38, 425–433.

James, L.A., James, L.R., 1989. Integrating work environment perceptions: explorations into the measurement of meaning. Journal of Applied Psychology 74, 739–751.

Kelen, G.D., DiGiovanna, T.A., Celentano, D.D., Kalainov, D., Bisson, L., Junkins, E., et al., 1990. Adherence to universal (barrier) precautions during interventions on critically ill and injured emergency department patients. Journal of Acquired Immune Deficiency Syndromes 3, 987–994.

Lee, T., Harrison, K., 2000. Assessing safety culture in nuclear power stations. Safety Science 34, 61–97.

Linn, L.S., Kahn, K.L., Leake, B., 1990. Physician's perceptions about increased glove-wearing in response to risk of HIV infection. Infection Control and Hospital Epidemiology 11, 248–254.

Mearns, K., Flin, R., Gordon, R., Fleming, M., 1998. Measuring safety climate on offshore Installation. Work and Stress 12, 238–254.

Mearns, K., Whitaker, S.M., Flin, R., 2003. Safety climate, safety management practice and safety performance in offshore environments. Safety Science 41, 641–680.

Murphy, L.R., Pepper, L., 2003. Effects of organizational downsizing on worker stress and health: a North American case study. In: Peterson, C. (Ed.), In: Work Stress: Studies of the Context, Content, and Outcomes of Stress. Baywood Publishing Company, New York.

Murphy, L.R., Gershon, R.M., DeJoy, D., 1996. Stress and occupational exposure to HIV/AIDS. In: Cooper, C.L. (Ed.), . In: Handbook of Stress, Medicine, and Health. CRC Press, Boca Raton, FL.

Murphy, L.R., Grosch, J., Gershon, R., DeJoy, D., 1997. Safety climate and injuries: the case of occupational exposure to HIV. In: Seppälä, P., Luopajärvi, T., Nygård, C.-H., Mattila, M. (Eds.), In: From Experience to Innovation, vol. 5. Finnish Institute of Occupational Health, Helsinki.

Neal, A., Griffin, M., 2004. Safety climate and safety at work. In: Barling, J., Frone, M.R. (Eds.), The Psychology of Workplace Safety. American Psychological Association, Washington, DC.

Neal, A., Griffin, M.A., Hart, P.M., 2000. The impact of organizational climate on safety climate and individual behavior. Safety Science 34, 99–109.

Podsakoff, P.M., MacKenzie, S.B., Lee, J.-Y., Podsakoff, N.P., 2003. Common method biases in behavioral research: a critical review of the literature and recommended remedies. Journal of Applied Psychology 88, 879–903.

Quinn, R.P., Staines, G.L., 1978. The 1977 Quality of Employment Survey. Survey Research Center, Ann Arbor, MI.

Sauter, S.L., Murphy, L.R., 2003. Monitoring the changing organization of work: International practices and new developments in the United States. Society for Preventive Medicine 48, 341–348.

Seo, D.-C., Torabi, M.R., Blair, E.H., Ellis, N.T., 2004. A cross-validation of safety climate scale using confirmatory factor analytic approach. Journal of Safety Research 35, 427–445.

Sheehy, N.P., Chapman, A.J., 1987. Industrial accidents. In: Cooper, C.L., Robertson, I.T. (Eds.), International Review of Industrial and Organizational Psychology. Wiley, Chichester, England.

Varon, 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 plants. Accident Analysis and Prevention 32, 761–769.

Ware, J.E., Sherbourne, C.D., 1992. The MOS 36-item short form health survey (SF-36): conceptual framework and item selection. Medical Care 30, 473–483.

Williamson, A.M., Feyer, A., Cairns, D., Biancotti, D., 1997. The development of a measure of safety climate: the role of safety perceptions and attitudes. Safety Science 25, 15–27.

Willy, M.E., Dhillon, G.L., Loewen, N.L., Wesley, R.A., Henderson, D.K., 1990. Adverse exposures and universal precautions practices among a group of highly exposed health professionals. Infection Control and Hospital Epidemiology 11, 351–356.

Zacharatos, A., Barling, J., Iverson, R.D., 2005. High-performance work systems and occupational safety. Journal of Applied Psychology 90, 77–93.

Zohar, D., 1980. Safety climate in industrial organizations: theoretical and applied implications. Journal of Applied Psychology 65, 96–102.

Zohar, D., 2000. A group-level model of safety climate: testing the effect of group climate on micro accidents in manufacturing jobs. Journal of Applied Psychology 85, 587–596.

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.