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Perceived colleagues' safety knowledge/behavior and safety performance: Safety climate as a moderator in a multilevel study

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ABSTRACT

This study presented a model specifying the relationship of unit-level safety climate and perceived colleagues' safety knowledge/behavior (PCSK/B) to safety behavior (safety compliance and safety participation), as well as safety performance (injuries and near misses). PCSK/B, a measure of descriptive norms, was taken as a new individual-level predictor. Hierarchical linear modeling analyses indicated the significant cross-level interaction effects of unit-level safety climate and PCSK/B on safety behavior, i.e., the more positive the safety climate, the stronger effects PCSK/B has on safety behavior. The effect of PCSK/B on injuries was mediated by safety behavior. Implications for management and safety climate research were discussed.

1. Introduction

Injuries and accidents in workplace have always been a major issue worldwide, including China. In 2006, for example, 112,822 workers lost their lives in 627,158 industrial accidents, which means 320 workers died each workday on average (State administration of work safety, 2007). In addition to the costs in human suffering and loss of lives, industrial accidents cost China's economy an estimated 2% GDP, about 250 billion RMB (State administration of work safety, 2005). The similar astonishing statistics data were also obtained in other countries (Zohar, 2000). However, despite the serious social and economic implications, organizational safety issues have remained outside the mainstream of management research (Fahlbruch and Wilpert, 1999; Hofmann et al., 1995; Shannon et al., 1997; Zohar, 2002), and the situation in China is even more serious.

Accident investigations have revealed that organizational and cultural factors, considered as new research interests after nuclear accident at Chernobyl in 1986 (Cox and Flin, 1998; Pidgeon, 1998), are underlying causal factors of accidents (Seo, 2005). Generally speaking, safety climate was used to explain the organizational factors (e.g., McDonald et al., 2000), or as part of the organizational factors (Hetherington et al., 2006), the manifestation and snap of safety culture (Mearns and Flin, 1999). Therefore, safety climate was regarded as an important indicator of workplace safety performance (Clarke, 2006; Cooper and Phillips, 2004). It relates to shared perceptions with regard to safety policies, procedures and practices, of which formal policy is explicit, relating to overt statements and formal procedures, while enforced policy or enacted practices are tacit, derived from observing management patterns of action concerning key policy issues (managerial practices) (Flin et al., 2000; Griffin and Neal, 2000; Zohar, 1980, 2008).

Not only safety climate which resulting from employee perceptions regarding the actions of management (Hofmann and Stetzer, 1996), but also their peers' behavioral pattern concerning safety is likely to affect individuals' safety performance (Kozlowski and Klein, 2000); and the two influence processes are shown separately (Clarke and Ward, 2006). Individuals make real changes to the feelings and behaviors as a result of interaction with others who are perceived to be similar, desirable, expert or the majority, which is the process of social influence (Rashotte, 2007). The general colleagues around might become the important referent social group of the employees. Based on this, we proposed an individual variable orienting direct contextual influence, perceived colleagues' safety knowledge and behavior (PCSK/B), to measure the group social influence. Additionally, research on safety climate has rarely been conducted in non-Western contexts. Compared to Westerners, people in China, think holistically instead of being analytically (Nisbett et al., 2001), which is a typical character of eastern culture—concerning contextual factors rather than rules (Peng et al., 2005). They feel more obliged to worry about the harmony of the in-group rather than their personal interests (Markus and Kitayama, 1991; Oyserman et al., 2002). The different cultural

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values might make the local employees have different perceptions of the safety climate and PCSK/B. Thus, the objectives of the current study were to examine the cross-level (the individual PCSK/B and unit-level safety climate) effect on safety performance in Chinese context.

1.1. Unit-level safety climate

Safety climate can be conceptualized as a higher order or global factor involving perceptions of workplace safety-related attributes and the relative priority of safety with other competing goals (such as productivity and speed) (Griffin and Neal, 2000; Zohar and Luria, 2005). Researchers who examined the effect of multilevel constructs argue that unit-level safety climate exists in a single organization because of different group processes (Neal and Griffin, 2006).

Unit-level safety climate refers to the shared safety perceptions of the unit as a whole (Neal and Griffin, 2006) with shared unit properties in the nature of the structure. According to Kozlowski and Klein's (2000) typology, shared unit properties are hypothesized to originate in various individual psychological processes or behaviors, and to converge among unit employees.

Zohar (2000) and Zohar and Luria (2005) empirically proved that unit-level safety climate converged because of different leadership processes, as leaders of each unit were taking their effect by holding distinctive criteria with regard to priority of safety versus other competing goals. The direct supervisors' managerial practices shape employees' perceptions of safety management commitment of their unit, which was showed significantly associated with unsafe behaviors (including different types of errors and violations), actual accidents, as well as the emotional outcomes (such as satisfaction) (Hofmann and Mark, 2006; Hofmann and Stetzer, 1996; Wallace et al., 2006). Study on the safety-specific leadership showed transformational leadership can improve employees' perceived safety climate (Barling et al., 2002). So it is logical to argue that in the same organization, significant between-unit variance of safety perception can be resulted from the influence of different leadership processes, which make it necessary to theoretically explore the effect of unit-level safety climate on safety performance.

1.2. Perceived colleagues' safety knowledge/behavior

In the workplace, employees' perceptions might be influenced not only by managerial practices and formal policies and procedures, but also by colleagues in the same work-unit (Clarke and Ward, 2006; DeJoy et al., 2004). Hofmann and Stetzer (1996), for example, suggested that approaching intentions, which is the likelihood that a team member would approach another team member engaged in unsafe behavior, play a mediating role in the relationship between group process and unsafe behavior. Clarke and Ward (2006) indicated that a possible reason for the absence of safety climate mediation on the leader influence tactics (coalition)–safety participation relationship is that this influence on behavior depends upon pressure from other team members rather than from the leader.

The effect of supervisors and team members on individuals' safety-related perceptions is shown separately (Clarke and Ward, 2006; Zohar, 2008) as the former is from the hierarchical position (Clarke, 1999) and authority, while the latter is a social influence process (Lapinski and Rimal, 2005). The social influences affecting individual psychological processes were initially categorized into normative influence and informational influence by Deutsch and Gerard (1955). Based on that, Cialdini and Raymond (1990) distinguished descriptive norms from injunctive norms, which are important measures of social norms under social setting or group norms under organizational setting (e.g., Klein and Boster, 2006; Ehrhart and Naumann, 2004). Descriptive norms, referring to what is done, are beliefs and perception about what is actually done by most others in one's social group. And injunctive norms describing what ought to be done, are perceptions of what others approve or disapprove (Kallgren et al., 2000). Descriptive norms can affect people's behavior particularly when the norms are in the focus of attention (Cialdini and Raymond, 1990). In social setting, the effect of descriptive norms on individual behavior or intention has been proved in judgment (Deutsch and Gerard, 1955), shopping (Burnkrant and Cousineau, 1975), technology acceptance (Venkatesh and Davis, 2000), stereotype beliefs (Wittenbrink and Henly, 1996), etc. In workplace setting, similar effect has also been proved, for example, people would adopt an innovation after they learn from social others' (such as peers) successful experiences with the innovation (Rogers, 1986). One of the most pervasive determinants of an individual's behavior is the influence of those around him (Burnkrant and Cousineau, 1975). From the interactionism perspective, unit members with similar backgrounds are likely to be a credible referent group for individuals (Ashforth, 1985). Thus, colleagues' safety beliefs, habits and behavior as a measure of descriptive norms, are likely to play important role in workplace safety.

Furthermore, studies in other field have already demonstrated the effect of culture on the relationship between normative factors and behavioral intentions. Bagozzi et al. (2000), for instance, found that their Chinese participants exhibiting the strongest relationship between norms and behavioral intention in fast food consumption; Park and Levine (1999) showed that the normative factors were significantly associated with interdependent but not independent self-construal. So in Chinese organizational context, employees would pay relatively more attention to the unit members around them, and the perceptions of colleagues' safety habits and behavior acting as descriptive norms would influence their own safety behavior, which is why PCSK/B is used to measure the descriptive norms in current study.

1.3. The relationship between unit-level safety climate, PCSK/B and safety performance

Safety compliance and safety participations are two kinds of safety behaviors. Safety compliance refers to activities employees need to do in order to maintain workplace safety (Griffin and Neal, 2000). When employees do not obey the procedures and rules, their behaviors are labeled "unsafe activities" or "violations". Thus, unsafe activities and safety compliance behaviors are two ends of one dimension. Safety participation refers to voluntary safety behaviors (Griffin and Neal, 2000). Safety compliance would be part of work role, whereas safety participation includes behaviors beyond formal role. Like the concept of organizational citizenship behaviors (OCBs) (Smith et al., 1983), which refers to extra-role voluntary behaviors beneficial to the organization, safety participation is also called "safety citizenship behavior" (Hofmann et al., 2003). Regarding safety-related outcomes, injuries and near misses are often used by safety researchers. Near misses are defined as incidents that could have caused an injury but did not (Goldenhar et al., 2003). In the current study, safety behaviors and safety-related outcomes were both taken as safety performance indicators.

Recent researches supported the validity of unit-level safety climate in predicting unsafe behaviors and accidents (Hofmann and Stetzer, 1996; Wallace et al., 2006), safety motivation and then safety behavior (Neal and Griffin, 2006), as well as medication errors (Hofmann and Mark, 2006). From social exchange perspective, if priority of safety is valued by unit leaders and top managers (i.e., with positive safety climate), they would demonstrate their commitment toward safety and concern for employees. And then employees would behave in a safe manner for an implied obligation (Hofmann and Morgeson, 1999; Hofmann et al., 2003). Therefore, we generated the following hypothesis:

Hypothesis 1a. Unit-level safety climate is positively related to safety compliance and safety participation.

According to the focus theory of normative conduct, perceptions of what others do (descriptive norms) provide the most efficient and adaptive actions, especially in ambiguous situations (Lapinski and Rimal, 2005). In the work setting, colleagues' safety knowledge/behavior would provide a guide for employees. If employees believe their colleagues are working safely, they would do so in the same manner. Thus, the following hypothesis was developed:

Hypothesis 1b. PCSK/B is positively related to safety compliance and safety participation.

Unit-level safety climate reflects management commitment and leaders' value on priority of safety, providing a guide when facing competing goals, complex and ambiguous information in the workplace (Gonzalez-Roma et al., 2002; Zohar and Tenne-Gazit, 2008). Although safety climate reflecting leaders' messages and actions may reduce complexity and ambiguity, unit members "are still exposed to a variety of discrepant organizational information such as job performance versus promotion decisions" (Zohar and Tenne-Gazit, 2008). Clarke and Ward (2006) found the effect of safety climate on safety participation was not significant and they suggested a possible reason is this effect on behavior depends on other team members. That is to say, PCSK/B might play an incremental role in providing another guide for safety behavior.

Within positive safety climate, safety behavior is valued, expected and rewarded in the unit, and if other members in the unit obey safety rules, and voluntarily participate in dealing safety issues, as a result, employees would be more likely to engage in such a behavior that is not only valued and beneficial, but also prevalent and adaptive (e.g., what others do) in the unit.

Therefore, within positive safety climate, employees would be more likely motivated by PCSK/B and displaying much more safety behavior, while in negative safety climate, safety performance was less emphasized; the effect of PCSK/B on employees' safety behavior would be weaker. The following hypothesis was made:

Hypothesis 2. Unit-level safety climate moderates the effect of PCSK/B on safety behavior; specifically, the more positive the safety climate, the stronger the effect of PCSK/B on safety behavior.

Finally, with improved safety compliance and participation, as defined, employees would comply to the procedures and rules and voluntarily participate safety meetings and give suggestions, so accident risk associated with unsafe practices and rule violations would be reduced, and potential risks might be resolved in advance. As Neal and Griffin (2006) found, improvements of safety behavior within groups were associated with a subsequent reduction in accidents and injuries. Therefore, we hypothesized below:

Hypothesis 3a. Employee's safety behavior (safety compliance and safety participation) is related to lower levels of workplace injuries and near misses.

Other researchers suggested that attitudes and perceptions can predict behavior (i.e., safety compliance and safety participation) (Probst and Brubaker, 2001). Accidents are outcomes of numerous factors, and the individual unsafe behavior is one of the most direct trigger factor (Reason, 1990). The empirical link between safety climate and micro-accidents at group level was also established (Zohar, 2000). It was hypothesized that:

Hypothesis 3b. Employees' safety behavior (safety compliance and safety participation) will mediate the relationship between PCSK/B and safety-related outcomes (injuries and near misses).

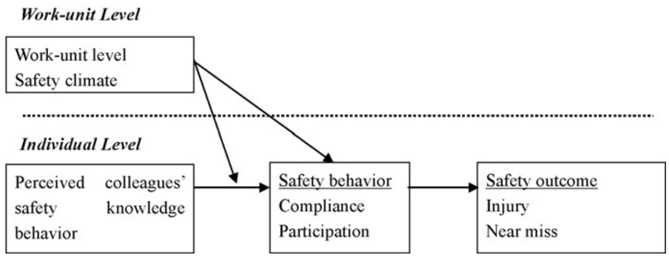

Fig. 1. A multilevel theoretical model of safety climate, safety performance and safety-related outcomes. The dash line separates work-unit level constructs and individual-level constructs.

The whole multilevel theoretical model illustrating the relationship among safety climate, safety performance and safety-related outcomes was depicted in Fig. 1.

2. Methods

2.1. Participants

Survey was administrated at 23 work-units (including polyester, decomposition, maintenance, etc.) of two petroleum and chemical corporations in China. Participants were all frontier employees. To control any differences between these two organizations, a dummy-coded variable was used in the analyses.

A total of 749 surveys were distributed with 631 valid responses returned, resulting a response rate of 84.2%. A total of 61.9% participants were male. A majority of the participants (75%) had a job tenure between 11 and 25 years. Gender was not significantly correlated with safety climate ($r = 0.06$), PCSK/B ($r = 0.05$), safety compliance ($r = -0.03$), safety participation ($r = -0.04$). Tenure was not significantly correlated with safety climate ($r = -0.06$), or PCSK/B ($r = 0.00$). There was low correlation between tenure and safety compliance ($r = 0.10$), safety participation ($r = 0.20$).

2.2. Measures

To ensure the equivalence of the measures in Chinese and English versions of the instrument, standard translation and back-translation procedure (Brislin, 1980) were followed.

2.2.1. Safety climate

The items were mainly adapted from two safety climate scales: one was developed for railway industry (Glendon and Evans, 2007), and the other was validated in aviation (Evans et al., 2007). A total of 14 items were selected according to the characteristics of the energy industry. Employees responded on a 7-point scale to all items ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). *Safety training* was evaluated by three items which were asked about the effectiveness of training for safety in the organization. An example of the items was "Training provides adequate skills and experience to carry out normal duties safely". *Management commitment and communication for safety* was evaluated by seven items that were asked about the degree to which managers were perceived to value priority of safety and the way in which safety issues were communicated. A sample item was "Management regard safety as an important part of operations." *Safety equipment and maintenance* was evaluated by four items that were asked about the way in which safety issues were maintained. A sample item was "Plant and equipment are maintained to a safe standard." To examine the structure of safety climate scale in our study, we randomly selected 50% of the data to conduct exploratory factor analysis (EFA), and the remaining data were submitted to confirmatory factor analysis (CFA). EFA results showed eigen values of one factor (accounting

Table 1
Item loadings for exploratory factor analyses of safety climate and perceived colleagues' safety knowledge/behavior.

Concept	Items	Factor
Safety climate	Management concerns staff's safety	0.86
	Management were genuinely interested in safety issues	0.83
	Management has a good understanding of operational issues that impact upon safety	0.83
	Staff are able to openly discuss problems with supervisors or managers	0.78
	Sufficient money are allocated for maintenance to be completed to an adequate standard	0.77
	Staff who report issues are provided with timely feedback	0.77
	Sufficient staff are allocated for maintenance to be completed to an adequate standard	0.74
	Maintenance on reported faults is carried out in a timely manner	0.72
	Management consult staff about safety issues	0.70
	Training provides adequate skills and experience to carry out normal duties safely	0.67
	Adequate training is received when new procedures or equipment are introduced	0.63
	Management regard safety as an important part of operations	0.61
	Regular training is provided for a range of emergency situations	0.55
	Plant and equipment are maintained to a safe standard	0.50
PCSK/B	My colleagues are familiar with the usage of safety equipments (e.g., fire extinguisher, fire hydrant)	0.76
	My colleagues concern safety issues in the workplace	0.75
	My colleagues are qualified with work knowledge and skills	0.73
	My colleagues comply with safety procedures at all times.	0.69
	My colleagues are with good safety habits (e.g., wear helmet and safety belts)	0.67
	My colleagues thoroughly communicate work-related information with each other	0.63

Note: PCSK/B: perceived colleagues' safety knowledge/behavior.

Table 2
Goodness-of-fit for confirmatory factor analyses of safety climate and behavior measures.

Concept	Model	χ^2	df	CFI	RFI	IFI	RMSEA
PCSK/B	Single factor model	22.93	9	0.96	0.90	0.96	0.06
Safety Climate	Single factor model	200.31	74	0.95	0.90	0.95	0.07
Safety behavior	Single factor model	92.96	9	0.94	0.85	0.94	0.12
	2-factor model	28.79	8	0.99	0.95	0.99	0.06
Measurement model		872.31	281	0.92	0.90	0.92	0.06

Note: PCSK/B: perceived colleagues' safety knowledge/behavior.

for 51% variance) was larger than 1 (Table 1), and indices of one-factor model CFA met the requirements (Table 2). Based on that, we treated safety climate as a global factor in the following analysis which is consistent with Griffin and Neal's (2000) and Zohar and Luria's (2005) research.

2.2.2. PCSK/B

A 6-item scale was used to assess PCSK/B. An example of the items read "My colleagues comply with safety procedures at all times." Table 1 shows the EFA results with item factor loadings, and one-factor model CFA results were illustrated in Table 2. This construct was treated by single factor solution with all parameters meeting the requirements.

2.2.3. Safety behavior

A 6-item scale from Neal and Griffin (2006) was adopted to assess two dimensions of safety performance. Safety compliance was assessed by three items. An example item was "I use all the necessary safety equipment to do my job." Safety participation was assessed by three items too. An example item was "I voluntarily carry out tasks or activities that help to improve workplace safety." With CFA, a two-factor model of safety behavior, including safety compliance and safety participation fit the data well with all parameters meeting the requirements (Table 2), which is in consistence with Griffin and Neal's (2000) model.

The reliability of every scale was equal to or above 0.75 (Cronbach's alphas are in Table 3), which is at an accepted level. Reliability of safety compliance was 0.75.

2.2.4. Self-report injuries

Employees reported whether each major body part had been injured during the past year, including head, neck, eyes, shoulder, arms, wrist, hand, upper back, lower back, legs, ankles, feet, and other (Goldenhar et al., 2003). And then injury variable in the following analyses was a summation of the responses to these questions.

2.2.5. Self-report near misses

Employees were also asked to recall the total number of near misses (i.e., an incident that could have resulted in an injury but did not) that they had experienced during the past year (Goldenhar et al., 2003).

Injuries and near misses represent low base-rate and count variables, therefore, Poisson regression was often used to analyze this type of data (Hofmann and Mark, 2006). In the following Hierarchical linear modeling (HLM), Poisson distribution of outcome type was chosen to analyze the count variables.

Table 3
Descriptive, individual-level inter-correlations, and internal consistency reliability.

Variable	M	SD	1	2	3	4	5	6
1. PCSK/B	5.68	0.78	*0.77*					
2. Safety climate	4.76	1.00	0.55**	*0.93*				
3. Safety compliance	4.83	0.82	0.23**	0.03	*0.75*			
4. Safety participation	4.33	0.94	0.25**	0.13**	0.63**	*0.78*		
5. Injury	1.97	2.39	−0.06	−0.19**	0.01	−0.11*	–	
6. Near miss	0.50	0.90	−0.06	−0.16**	0.13**	0.08	0.28**	–

Note: Cronbach's alphas are in italics on the diagonal. PCSK/B: perceived colleagues' safety knowledge/behavior.

* $p < 0.05$.

** $p < 0.01$.

Table 4
HLM results: effects of unit-level safety climate and PCSK/B on safety behavior.

Model	Parameter estimates										
	γ_{00}	γ_{01}	γ_{02}	γ_{03}	γ_{04}	γ_{10}	γ_{11}	σ^2	τ_{00}	τ_{11}	Deviance
Model C1 $L1: SBC_{ij} = \beta_{0j} + \beta_{1j}(PCSK/B_{ij}) + \gamma_{ij}$ $L2: \beta_{0j} = \gamma_{00} + \gamma_{01}(UnitSC) + \gamma_{02}(dummy_j) + \mu_0$ $L2: \beta_{1j} = \gamma_{10} + \mu_1$	5.26***	−0.11	−0.92***			0.31***		0.36	0.03***	0.01	1073.89
Model C2 $L1: SBC_{ij} = \beta_{0j} + \beta_{1j}(PCSK/B_{ij}) + \gamma_{ij}$ $L2: \beta_{0j} = \gamma_{00} + \gamma_{01}(UnitSC)$ $+\gamma_{02}(dummy_j) + \gamma_{03}(Mpcskb)$ $+\gamma_{04}(Mpcskb \times UnitSC) + \mu_0$ $L2: \beta_{1j} = \gamma_{10} + \gamma_{11}(UnitSC) + \mu_1$	5.25***	−1.17	−0.91***	−0.68	0.19	0.32***	0.14*	0.36	0.04***	0.00	1076.49
Model P1 $L1: SBP_{ij} = \beta_{0j} + \beta_{1j}(PCSK/B_{ij}) + \gamma_{ij}$ $L2: \beta_{0j} = \gamma_{00} + \gamma_{01}(UnitSC) + \gamma_{02}(dummy_j) + \mu_0$ $L2: \beta_{1j} = \gamma_{10} + \mu_1$	4.62***	−0.02	−0.68***			0.35***		0.66	0.04**	0.04	1386.84
Model P2 $L1: SBP_{ij} = \beta_{0j} + \beta_{1j}(PCSK/B_{ij}) + \gamma_{ij}$ $L2: \beta_{0j} = \gamma_{00} + \gamma_{01}(UnitSC)$ $+\gamma_{02}(dummy_j) + \gamma_{03}(Mpcskb)$ $+\gamma_{04}(Mpcskb \times UnitSC) + \mu_0$ $L2: \beta_{1j} = \gamma_{10} + \gamma_{11}(UnitSC) + \mu_1$	4.62***	−2.15	−0.64***	−1.89	0.41	0.38***	0.18	0.66	0.05***	0.01	1388.79

Note: (1) L1: Level 1; L2: Level 2. (2) PCSK/B: perceived colleagues' safety knowledge/behavior; UnitSC: unit-level safety climate; SBC: safety compliance; SBP: safety participation. Mpcskb: group mean of PCSK/B; Dummy code representing organizational membership. (3) Deviance is a measure of model fit. The smaller the deviance is, the better the model fits.

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

2.3. Level of analysis

Our theoretical model (see Fig. 1) consists of constructs both at the individual-level and unit-level, therefore HLM analyses were conducted to test the hypotheses in the current study. HLM can simultaneously test the effects of factors at different levels on individual-level outcomes (Bryk and Raudenbush, 1992). When testing incremental effects of level 2 variables, the grand-mean centering approach can lessen multi-collinearity in level 2 estimation and separate out the level 1 effects; while for cross-level interaction effects, the group-mean centering is more appropriate (Hofmann and Gavin, 1998; Hofmann et al., 2000). The concept of perceived colleagues' safety knowledge/behavior is at the individual-level, unit-level safety climate is aggregated by data collected from individuals.

3. Results

3.1. Aggregation issue

Researchers have proposed guidelines to determine whether aggregation is viable (Bliese, 2000; Zohar and Luria, 2005). Between-group variance and within-group homogeneity should meet the criteria. $R_{wg(j)}$ was developed to assess within-group homogeneity. If $R_{wg(j)}$ is greater than or equal to 0.70, there is sufficient within-group agreement (James et al., 1984). R_{wg} of two units was lower than 0.70, thus data from the two units were not taken into later multilevel analysis. Average $R_{wg(j)}$ of the leaving units was 0.92 (from 0.70 to 0.99). To further assess homogeneity, intraclass correlation coefficient (ICC) was estimated. ICC2 is an estimate of the reliability of means (Bryk and Raudenbush, 1992), if ICC2 is greater than or equal to 0.70, we can assume means are reliable indicator of work-unit scores. One way analysis of variance was conducted with unaggregated data, ICC2 = 0.92, which indicated that safety climate exhibited significant between-group variance: $F(20, 524) = 12.69$, $p < 0.001$. On the basis of above discussion, we aggregated individual-level safety perception to the unit-level safety climate.

3.2. Bivariate relationship

Initial support for our hypotheses can be gained by examining bivariate relationships. Hypothesis 1b was supported.

PCSK/B is positively related with safety compliance ($r = 0.23$, $p < 0.01$) and safety participation ($r = 0.25$, $p < 0.01$). The relationship between unit-level safety climate and safety compliance is not as expected, which needs further analyses. Unit-level safety climate is positively related with safety participation ($r = 0.13$, $p < 0.01$).

3.3. HLM results

Table 4 presents the HLM results testing the effect of unit-level safety climate and PCSK/B on safety behavior.

Hypothesis 1 predicts that PCSK/B and unit-level safety climate are positively related to safety compliance and participation. The results in Model C1 revealed that PCSK/B significantly predicted safety compliance ($\gamma = 0.31$, $p < 0.001$), but unit-level safety climate did not show this trend ($\gamma = -0.11$, $p > 0.05$). The results in Model P1 revealed in PCSK/B significantly predicted safety participation ($\gamma = 0.35$, $p < 0.001$), but unit-level safety climate showed an opposite trend ($\gamma = -0.02$, $p > 0.05$). This result of relationship between unit-level safety climate and safety participation seemed unreasonable, we need wait to see their real relationship after cross-level effect being examined. Therefore, Hypothesis 1b was supported, but Hypothesis 1a was not supported.

Hypothesis 2 proposes unit-level safety climate moderates the effect of PCSK/B on safety behavior. The results in Model C2 revealed cross-level interaction was significant ($\gamma = 0.14$, $p < 0.05$), which indicated unit-level safety climate moderating the relationship between PCSK/B and safety compliance. The results in Model P2 revealed cross-level interaction was marginally significant ($\gamma = 0.18$, $p = 0.07$). Specifically, when unit-level safety climate was high, the effects of PCSK/B on safety behavior were stronger. When unit-level safety climate was low, the effects of PCSK/B on safety behavior were weaker (Figs. 2 and 3). Therefore, Hypothesis 2 was supported.

Table 5
HLM results: effects of unit-level safety climate and PCSK/B on safety-related outcomes.

Model	Parameter estimates						
	γ_{00}	γ_{01}	γ_{02}	γ_{10}	γ_{20}	γ_{30}	τ_{00}
Model I1 $L1: E(\text{Injury}\|\beta) = \lambda$ $L1: \log[\lambda] = \eta$ $L1: \eta = \beta_0 + \beta_1(PCSK/B)$ $L2: \beta_0 = \gamma_{00} + \gamma_{01}(\text{UnitSC}) + \gamma_{02}(\text{dummy}_j) + \mu_0$ $L2: \beta_1 = \gamma_{10}$	0.77**	0.09	−0.83**	−0.15***			0.26***
Model I2 $L1: E(\text{Injury}\|\beta) = \lambda$ $L1: \log[\lambda] = \eta$ $L1: \eta = \beta_0 + \beta_1(PCSK/B) + \beta_2(\text{SBC}) + \beta_3(\text{SBP})$ $L2: \beta_0 = \gamma_{00} + \gamma_{01}(\text{UnitSC}) + \gamma_{02}(\text{dummy}_j) + \mu_0$ $L2: \beta_1 = \gamma_{10}$ $L2: \beta_2 = \gamma_{20}$ $L2: \beta_3 = \gamma_{30}$	0.85***	0.11	−1.05**	−0.03	−0.14*	−0.18***	0.26***
Model N1 $L1: E(\text{Near miss}\|\beta) = \lambda$ $L1: \log[\lambda] = \eta$ $L1: \eta = \beta_0 + \beta_1(PCSK/B)$ $L2: \beta_0 = \gamma_{00} + \gamma_{01}(\text{UnitSC}) + \gamma_{02}(\text{dummy}_j) + \mu_0$ $L2: \beta_1 = \gamma_{10}$	−0.46*	−0.15	−1.36**	−0.15			0.27***
Model N2 $L1: E(\text{Nearmiss}\|\beta) = \lambda$ $L1: \log[\lambda] = \eta$ $L1: \eta = \beta_0 + \beta_1(PCSK/B) + \beta_2(\text{SBC}) + \beta_3(\text{SBP})$ $L2: \beta_0 = \gamma_{00} + \gamma_{01}(\text{UnitSC}) + \gamma_{02}(\text{dummy}_j) + \mu_0$ $L2: \beta_1 = \gamma_{10}$ $L2: \beta_2 = \gamma_{20}$ $L2: \beta_3 = \gamma_{30}$	−0.44	−0.16	−1.37**	−0.13	−0.06	0.07	0.26***

Note: (1) L1: Level 1; L2: Level 2. (2) PCSK/B: perceived colleagues' safety knowledge/behavior; UnitSC: unit-level safety climate; SBC: safety compliance; SBP: safety participation; dummy code representing organizational membership.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

The main effect of PCSK/B on safety compliance and safety participation was constantly significant (Model C2, $\gamma = 0.32$, $p < 0.001$, Model P2, $\gamma = 0.38$, $p < 0.001$). While the main effect of unit-level safety climate on safety compliance and safety participation was not significant (Model C2, $\gamma = -1.17$, $p > 0.05$, Model P2, $\gamma = -2.15$, $p > 0.05$).

Hypothesis 3 proposes that safety behavior mediates the relationship between PCSK/B and safety-related outcomes. Possion distribution of outcome type was chosen in the HLM setting when analyzing injuries and near misses. We followed three-step test procedure for mediation and controlled for unit-level safety climate in the analyses (Baron and Kenny, 1986). In the first step, PCSK/B needs to be related to injuries, the result of Model I1 was supported ($\gamma = -0.15$, $p < 0.001$). In the second step, PCSK/B needs to be related to safety behavior, which was supported in our testing of Hypothesis 1 above. In the third step, we included both PCSK/B and safety behavior in the regression (Model I2). We found that both safety compliance ($\gamma = -0.14$, $p < 0.05$) and safety participation ($\gamma = -0.18$, $p < 0.001$) were significantly related to injuries, and the effect of PCSK/B was not significantly related to injuries and the value was down from 0.15 to 0.03 ($\gamma = -0.03$, $p > 0.05$). So the indirect effect of safety behavior on relationship between PCSK/B and injuries exists. While for near misses outcome, Model N1, Model C1, Model P1 and Model N2 indicated that safety behavior did

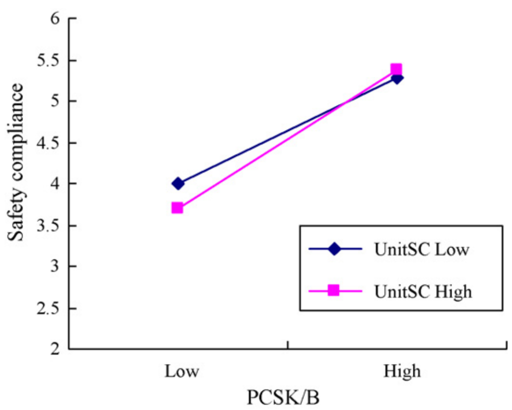

Fig. 2. Safety climate as a moderator of the relationship between PCSK/B and safety compliance.

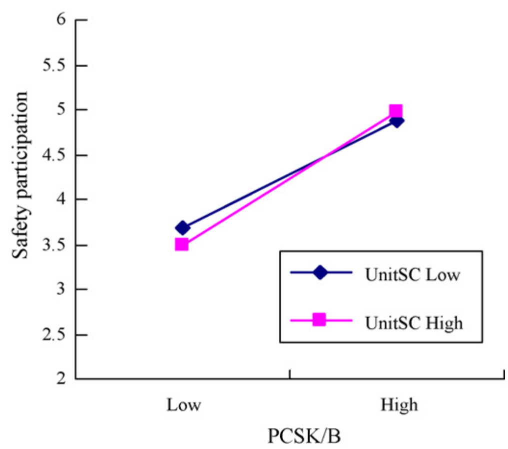

Fig. 3. Safety climate as a moderator of the relationship between PCSK/B and safety participation.

not mediate the relationship between PCSK/B and near misses. So Hypotheses 3a and 3b were partially supported (Table 5).

4. Discussion

This study tested a multilevel model based on an integrated model of safety climate–behavior–outcome relationship, covering unit-level and individual-level analysis. The results revealed that PCSK/B can predict safety behavior in the individual level. And cross-level interaction effect between unit-level safety climate and PCSK/B can predict safety behavior (safety compliance and safety participation). Furthermore, both safety compliance and participation were related to injuries. Safety behavior mediated the influence of PCSK/B on the safety outcomes.

4.1. Theoretical implications

Our findings regarding cross-level interaction effect on safety behavior contribute to the safety literature in several ways. First, we followed Zohar's (2002) suggestion paying attention to largely overlooked cross-level processes (for exception, see Hofmann et al., 2003) and examined the cross-level interaction of unit-level safety climate and individual PCSK/B on safety behavior Specifically, at least in Chinese context, the previously demonstrated influence of unit-level safety climate on safety behavior (Neal and Griffin, 2006; Wallace et al., 2006) is interacted with the individual-level construct PCSK/B. The unit-level safety climate cannot effectively predict individuals' safety behavior independently. We believe that the results have implications for safety research. The effect of colleagues or peer on safety issues has captured the attention of the researchers (e.g., Zohar and Tenne-Gazit, 2008), while the empirical studies related to this topic are limited so far. Our findings add to this emerging literature, suggesting that unit-level climate, and perception of colleagues' safety knowledge and behavior can have a significant impact on safety performance.

Second, our finding pertaining to the constant significant main effect of the new individual concept PCSK/B on safety behavior, indicating that employee's safety behavior are influenced by perceptions about others' beliefs and observation of others' behavior, which are consistent with the finding of social psychology: people from Eastern Asian like Chinese are more concerned with contextual factors rather than rules, thinking holistically instead of analytically (Nisbett et al., 2001; Peng et al., 2005). So just like the results obtained in other cross-cultural studies (e.g., Venkatesh and Davis, 2000), Chinese employees will concern the contextual factors such as important others (like co-workers) too. Work contextual factors have also been mentioned in Western studies, which said "Perceived safety at work was directly influenced by various work situational factors independent of safety climate" (DeJoy et al., 2004). Thus concerning the important effect of individual PCSK/B in Chinese working settings, PCSK/B might also have their potential influence on safety behavior in Western settings. In consumer study, the relationship between normative factors and behavior intentions were showing the strongest with Chinese participants (Bagozzi et al., 2000), further cross-culture study in safety field would be helpful to understand the effect of cultural factors on the norms–behavior relationship. Furthermore, Neal and Griffin (2000, Neal and Griffin, 2006) modeled that motivation and knowledge can directly influence safety behavior, so it is essential to do further research to examine the mechanism of safety motivation and knowledge on the relationship between perception of other employees' behavior influences and their own safety behavior in future.

Finally, safety behavior mediated the relationship between PCSK/B and injuries. This finding suggests that organizations should take more actions to encourage employee safety behavior, through which employees' personal health and safety can be improved. While the lacking evidence of the predictors and near misses relationship suggests that to improve workplace safety, individual-level safety behavior is only a precursor, the most proximal variable, and there are many other underlying process variables or conditions that affect the safety outcomes. The combination of unit-level safety climate and all the colleagues' safety behavior can make a great effect on the workplace safety.

4.2. Managerial implications

The results of our study have several managerial implications. First, given the significant effect of PCSK/B on safety performance in current investigation, managers should consider advocating the restructure of descriptive norms to improve PCSK/B, as employees in the same unit can become one another's behavioral model. Descriptive norms approach as a kind of informal social control has been recognized valid in improving pro-environmental (Cialdini, 2007; Lapinski et al., 2007) and health behavior (Real and Rimal, 2007). Specifically, for example, offering employees opportunities to observe colleagues' safety behavior in routine tasks, establishing regular peer communication about their safety practices or any other approach which can modify perceived prevalence of safety behavior might be helpful to the improvement of safety behavior. Additionally, according to the "Hawthorne study", when employees realize that others pay attention to their behavior in daily working life, and they are important than they thought (their behavior will affect others' behavior), it is possible for them to control and improve their safety behavior, which in turn, can improve self and colleagues' safety performance.

Second, unit-level safety climate exists within the same organization, which is consistent with existent literature (Glendon and Litherland, 2001; Zohar, 2000). The effect of cross-level interaction on safety performance suggests within positive safety climate individuals are more easily influenced by PCSK/B. Therefore, organizations should pay attention to both unit-level and peer-level influences. Based on normative restructuring approach to improve PCSK/B, measurement of safety climate is thought to be a useful diagnostic tools to provide an early warning of potential safety system failure(s) (Cooper and Phillips, 2004), a proactive action Safety intervention (Siu et al., 2004). So both levels' formal safety training can provide employees opportunities to share their ideas and opinions, thus easing the way to improved climate.

In the two typical state-owned companies attending to this study, the concepts of safety climate and safety culture have just been imported in recent years. It is essential to increase the relative training to make the employees systematically understand the factors affecting safety performance, which are important preconditions to ensure the good safety performance of the whole corporation. Our findings based on state-owned companies might also benefit private companies and joint-venture companies, too. As qualitative studies suggested employees in private companies are more dependent on personal connections than employees in state owned or collective hybrid companies (Xin and Pearce, 1996). Therefore, employees in other types of companies may even more influenced by PCSK/B. Future research should examine whether our findings can be replicated in private or international companies.

4.3. Limitations

The study had several limitations. One of the limitations was the cross-sectional design, which prevents drawing any causal inferences. It is possible that employees experienced injuries might show high safety performance (Clarke, 2006). Only the longitudinal design can help to explain it.

A second limitation concerns that dependent variables were self-reported behaviors, injuries and number of near misses. The results might be criticized for common method bias. For safety researches, Hofmann and Stetzer (1996) stated that variance on safety-related outcomes would be suppressed. People would probably tend to underreport injuries and near misses due to social desirability. Thus the relationship between these variables and their predictors would be attenuated (Probst and Brubaker, 2001). And in order to examine whether the bias would account for all the relationships among the variables, we followed Harman's single factor test (Podsakoff et al., 2003), which is checking if all the items involved belonging to one factor, and if it is the case, the significant relationship could be attributed to the bias, or it can be concluded that the significant relationship are real to some extent. The unrotated exploratory factor analysis showed one factor did not account for the majority of the covariance. Thus, common method bias could not account for all the relationships among variables. Future studies can try to get multi-resources data, such as objective records, behavioral observation to examine and validate the suggested relationships of present study.

A third limitation concerns the unit-level sample. We sampled 23 units, which were relatively small in HLM studies. The limited unit sample could potentially impact the generalizability of our findings. Kreft (as cited in Hofmann, 1997) suggested a 30/30 rule of thumb in HLM studies, however, this sample size is greater than what is typically seen in organizational research (Scandura and Williams, 2000), and in many organizational studies there are typically less than 30 higher level units in a study (Scherbaum and Ferreter, 2009). Moreover, there seems to be a tradeoff between sample sizes of Level 2 and Level 1. Hofmann (1997) stated: "If a large number of groups is present, then the number of observations required per group is reduced. Conversely, with fewer groups, one needs more individuals within each group to obtain sufficient power." With the limited units (23), we tried to get more observations, and finally obtained 631 valid data, with an average 27.4 observations per group. Due to the sample limitation at unit level, the results reported here were only based on generalized least squares (GLS) standard errors. As researchers suggested higher levels of power are achieved with larger samples at Level 2 than at Level 1, it is very essential to collect more data over more groups (Scherbaum and Ferreter, 2009).

5. Conclusion

The study presents a multilevel model based on an integrated model of safety climate–behavior–outcome relationship. The findings of the current study suggest that the effect of PCSK/B on safety behavior is moderated by unit-level safety climate. PCSK/B can more effectively predict safety behavior in positive safety climate than negative safety climate. The influence of PCSK/B on injuries is operating through safety behavior. Safety-priority organizations should not only solid their safety climate but also focus on the social interaction between employees to facilitate their safety behavior.

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