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THE EFFECTS OF GROUP SAFETY CLIMATE ON CONSTRUCTION PERSONNEL'S SAFETY BEHAVIOR: A CROSS-LEVEL INVESTIGATION

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ABSTRACT

Safety climate can be conceptualized at both the individual and group levels, and there is no consensus as to its operationalization. In the construction safety research, rare efforts have been made to investigate the effects of both individual differences and contextual factors on safety outcomes. To fill the knowledge gap, this paper takes group safety climate (safety climate at the group level) as a contextual factor and examines its impact on construction personnel's safety behavior, along with construction personnel's individual attributes. Data were collected from 157 construction personnel nested in 33 work crews in an ongoing railway project, and then analyzed with the ordinary least squares regression technique. The findings show that members within the same group develop shared safety climate perceptions and members of different groups have significantly different safety climate perceptions. Group safety climate level predicts individual safety behavior, controlling for individual attributes. Group safety climate level also predicts group safety behavior.

KEYWORDS

Safety Climate, Safety Behavior, Construction Personnel, Cross-level.

INTRODUCTION

Since 1980 when the first empirical study (Zohar 1980) on safety climate was published, the construct of safety climate has received wide attention from academia and industry. One likely reason is its versatility. It is a tool to solicit employees' perceptions of safety policy, procedure and practice in the workplace and diagnose problems in safety management practice (Cooper and Phillips 2004; Huang et al. 2013; Zhang et al. 2015). Safety climate serves as both a leading and lagging indicator of safety outcomes (Beus et al. 2010; Christian et al. 2009; Nahrgang et al. 2011; Payne et al. 2009), although it is a better leading indicator than lagging one (Payne et al. 2009). It can predict safety activity and indicate an organization's temporal "state of safety" (Cheyne et al. 1998). Contemporary work environment features an ever-increasing complexity, and a socio-

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technical perspective is necessary for looking into systems design and safety. In this respect, Kleiner et al. (2015) suggest that safety climate should be used to assess the degree of joint optimization between organizational and technical subsystems.

Safety climate can be conceptualized as a psychological, a psychosocial, or a socio-cultural construct, and operationalized at the individual, group, organization, or higher levels. When safety climate is operationalized at the individual level, it is called psychological safety climate. Most of the extant safety climate research in construction investigates the impact of psychological safety climate on safety outcomes at the individual level. What is missing in safety research, however, is studies which focus on both individual differences and contextual factors (Christian et al. 2009). To expand the safety climate research in construction, this study operationalizes safety climate at the group level and takes the group safety climate as a contextual factor which is assumed to affect both individual and group safety behavior. In other words, this study investigates the effects of group safety climate on construction personnel's individual and group safety behavior. It attempts to advance our understanding of how safety climate effects across two levels (i.e., individual and group).

Before going any further, two points are worthy of mentioning. First, this study uses work crew as the unit of analysis. On construction sites, a foreman-led work crew is the basic unit to which a worker belongs. Hence, group safety climate is the safety climate perceptions shared by members in a work crew. Second, group safety climate has two properties, i.e., level and strength (Lingard et al. 2010). Group safety climate level refers to the relative priorities placed upon safety in a group perceived by group members. Group safety climate strength refers to the degree of consensus about climate perceptions within group members. Therefore, this study examines the effects of both group safety climate level and strength on safety behavior.

LITERATURE REVIEW

SAFETY CLIMATE IN ORGANIZATION AND MANAGEMENT RESEARCH

Although Guldenmund (2000) traces the earliest literature on safety climate to Keenan et al. (1951), it was Dov Zohar who first introduced the term safety climate to his work (Zohar 1980), which measured workers' perceptions of various aspects of the work environment in manufacturing organizations with high and low accident rates. In the work, Zohar defines safety climate as "a summary of molar perceptions that employees share about their work environments [in relation to safety]" (p. 96). Later on, Zohar (2003) refines the definition and related safety climate to "shared perceptions with regard to *safety* policies, procedures, and practices" (p. 125). The formal safety policies and procedures are established at the top management level, and then implemented through supervisory context-specific action directives at the group level. Hence, Zohar conceptualizes the construct of safety climate at both group and organization levels. The safety climate construct, however, can also be conceptualized at the individual level. Neal and Griffin (2006) distinguish psychological safety climate from group safety climate. They refer psychological safety climate to individual perceptions of policies, procedures, and practices relating to safety in the workplace, and group safety climate to the aggregated and shared perceptions of the group as a whole. The evidence indicates that safety climate can be conceptualized at multiple levels, including individual, group and organization levels.

How to operationalize the safety climate construct, however, is open to debate. In a review of 18 safety climate scales, Flin et al. (2000) find that the most often assessed safety climate dimensions relate to management, safety system, risk, work pressure, and competence. Neal and Griffin (2004) propose a categorization scheme which sorts first-order safety climate indicators into two levels. At the organizational level, the first-order indicators relate to management commitment, human resource management practices, and safety systems. At the group level, the first-order indicators are supervisor support, internal group processes, boundary management, risk, and work pressure. Using this scheme, Christian et al. (2009) locate studies involving all these first-order indicators except boundary management.

SAFETY CLIMATE RESEARCH IN CONSTRUCTION

Safety climate is viewed as key to reducing injuries, illnesses and fatalities on construction sites. However, researchers and practitioners are still divided on how to define and measure safety climate, and which safety climate interventions are likely to succeed. To better understand safety climate in construction and its impact on construction safety and health, Gillen et al. (2014) convened a construction-focused workshop June 11-12, 2013. The workshop invited 72 construction stakeholders from contractors, employer associations, labor organizations, research institutes, consultants and insurance firms. The workshop derived a definition of safety climate based on participants' consensus. In particular, they defined organizational safety climate as "the shared perceptions of safety policies and procedures by members of an organization at a given point in time, particularly regarding the adequacy of safety and consistency between actual conditions compared to espoused safety policies and procedures. Homogeneous subgroups tend to develop shared perceptions while between-group differences are not uncommon within an organization" (p. 14). Furthermore, they defined project safety climate as "perceptions of occupational safety and health on a particular construction project at a given point in time. It is a product of the multiple safety climates from the different organizations involved in the project including the project owner, construction manager/general contractor, and subcontractors. Project safety climate may be heavily influenced by local conditions such as project delivery method, schedule and planning, and incentives" (p. 14).

Safety climate research in construction has also attempted to identify valid safety climate indicators. Gillen et al. (2014) identify specific characteristics of the construction industry, including a mobile and transient workforce, craft acculturation and norms, distinct craft cultures, multi-employer worksites, project delivery methods, the segmentation of the construction industry, and the preponderance of small employers. Given these specific characteristics, they propose a number of safety climate indicators, including supervisory leadership, safety as a value/safety alignment, management commitment, employee empowerment/involvement, accountability, communication, training, and owner/client involvement. Accordingly, they propose numerous interventions which address each of the above mentioned indicators. For example, to enhance supervisory leadership, the project management team is supposed to include safety in the strategic planning process, define safety roles and responsibilities, encourage supervisors to lead by example, promote a continuous learning environment, hold people accountable for safety, have senior leaders visible on safety issues, and encourage safety communications from leadership and supervisors to “walk the talk”. However, there are many barriers which hinder the implementation of these interventions, including construction schedules, perceived lack of time and resources, company size, short-term perspective, lack of supervisor expertise and knowledge, low bid contracting, complacency, misperception that safety hurts profits, and lack of management support. In a safety climate survey with a road construction organization, Glendon and Litherland (2001) identify six safety climate indicators, including communication and support, adequacy of procedures, work pressure, personal protective equipment, relationships, and safety rules. In a case study of a Hong Kong construction enterprise, Fang et al. (2006) propose ten practically significant safety climate indicators, including safety attitude and management commitment, safety consultation and safety training, supervisor’s role and workmate’s role, risk taking behavior, safety resources, appraisal of safety procedure and work risk, improper safety procedure, worker’s involvement, workmate’s influence, and competence.

CROSS-LEVEL STUDY OF SAFETY CLIMATE

As mentioned above, the safety climate construct can be conceptualized at both the individual and group levels, and the operationalization of safety climate is open to debate. In the construction research, safety climate is often studied at the individual level (Shen et al. 2015). Multilevel conceptualizations can provide a more expansive, integrative perspective of organizational phenomena such as organizational climate (Mossholder and Bedeian 1983), and therefore it is imperative to investigate the cross-level effects of safety climate in the construction domain.

The cross-level effects of safety climate, however, has been investigated in other domains. In the manufacturing sector, Zohar and Luria (2005) recognize the significance of cross-level relationships between organization and group-level climates, and find that the effect of organization climate on safety behavior is fully mediated by group climate level. In the Korean manufacturing sector, Lee and Dalal (2014) find that organizational safety climate strength moderates the relationships between employee conscientiousness and two forms of employee safety behavior. In the nursing service environment, Chowdhury and Endres (2010) find that unit-level safety climate moderates the partially mediated relationship between client variability and injury through occupational strain. Also in the nursing service environment, Weng et al. (2012) explore the cross-level effects of the four dimensions of patient safety climate (i.e., managerial practices regarding patient safety, patient safety procedures, patient safety information flow, and patient safety priority) on nursing innovation, and find that only patient safety information flow has a significantly positive cross-level impact on nursing innovation.

HYPOTHESIS DEVELOPMENT

The core meaning of climate relates “to socially construed indications of desired role behavior” (Zohar and Luria 2005) (p.616). That is, climate indicates desired role behavior. A sound safety climate, therefore, breeds safety behavior. Numerous studies in a variety of sectors (Choudhry et al. 2009; Cigularov et al. 2010; Clarke 2006; Gillen et al. 2002; Lingard et al. 2010; Mohamed 2002; Pousette et al. 2008; Shen et al. 2015;

Siu et al. 2004; Zhou et al. 2008) support the notion that safety climate predicts safety behavior. Safety climate has two properties, i.e., strength and level (Lingard et al. 2010). This paper examines the cross-level effects of both safety climate strength and level on both individual and group safety behavior.

Group safety climate has impact on individual safety behavior. According to Kapp (2012), through daily observations and interactions with the supervisor, group members perceive and understand the relative value the supervisor places on safety. When determining how to carry out their jobs, group members make reference to this perception and understanding for decision making. Group safety climate is shared perceptions of safety policy, procedure, and practices. These shared perceptions are supposed to determine the shared safety behavior, i.e. group safety behavior.

Individual attributes influence individual safety behavior. According to Fang et al. (2006), personal characteristics, such as age, gender, marital status and education level, influence individual safety behavior. Smith et al. (2016) explain how individual differences in age and experience influence an employee's safety behavior and provide several examples of behavior related to such individual differences. Therefore, this study postulates that group safety climate level and strength impact individual safety behavior controlling for individual attributes (Hypothesis 1), and group safety climate level and strength affect group safety behavior (Hypothesis 2). Figure 1 features the two hypotheses.

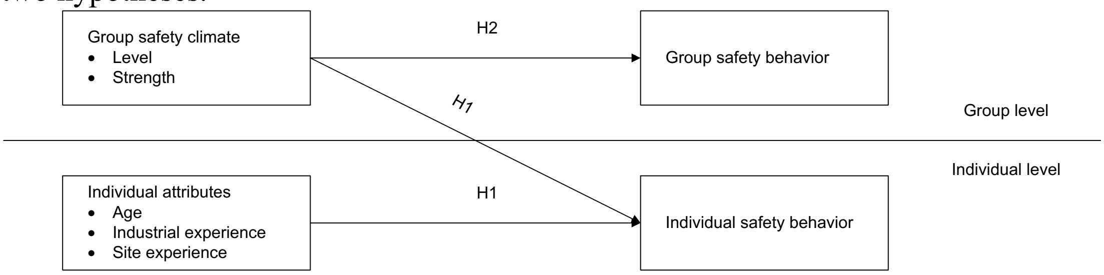

Figure 1: Cascading effects of safety climate

RESEARCH APPROACH AND METHODS

INSTRUMENT

A questionnaire survey was used to collect data. The questionnaire has three parts. The first part solicits respondents' individual attributes, including employer's age, industry experience and the duration of working on the current site. The second part measures respondents' safety climate perceptions using a 24-item scale. The scale is developed and validated by the research team based on valid responses from a large scale survey with construction personnel in Hong Kong. Readers are suggested to refer to Rowlinson et al. (2016) for more information. The third part measures safety behavior using two items. The first item asks respondents to indicate how often they themselves follow all of the safety procedures on the job, and the second one asks them to indicate how often their coworkers follow safety procedures on the job.

SAMPLE

The research team accessed a convenience sample of construction personnel in a local railway construction project, and finally secured valid response from 157 construction personnel nested in 33 teams. The respondents were plant & equipment operators, carpenters, scaffolders, mechanics & fitters, electricians, tunnel workers, general laborers, bar benders & fixers, waterproof workers, plasterers, works supervisors, safety officers, engineers, site agents, project managers, construction managers, and quantity surveyors. The average number of respondents in each group is 4 (minimum = 2, maximum = 14). These crew sizes are not unusual, because self-employed subcontractors usually have small crews in the Hong Kong construction industry. The majority of the sample is male (95.5%), have been working in construction for more than two years (89.3%), and on the current site for more than three months (83.9%). 89.5% of the sample is in the age range of 26—55. 67.8% of the sample does not receive tertiary education.

DATA AGGREGATION AND TESTS OF HYPOTHESES

To ensure that the constructs of safety climate and safety behavior are meaningful at the group level and aggregation is statistically appropriate, three validation criteria need to be met (Zohar 2003). First, the members of each group report similar scores for the group on a given construct. Second, the groups have significant between group variance for the given construct. Third, the groups should correspond to natural social units. In order to meet the first two criteria, four complementary measures were used: the median $r_{wg(j)}$, the F-statistic from a one-way analysis of variance (ANOVA), and intraclass correlation coefficient ICC(1) and ICC(2). $r_{wg(j)}$ measures the degree to which individual responses within a group are interchangeable, with values of .70 or greater suggesting acceptable agreement among individual responses on a scale. A significant F-statistic resulting from a one-way ANOVA with group membership as the independent variable and safety climate as the dependent variable suggests that responses differ between respondents in different groups. ICC(1) and ICC(2) measure homogeneity and are calculated from a one-way ANOVA in which group membership is the independent variable and safety climate is the dependent variable. ICC(1) indicates the proportion of total variance that is explained by group membership with values between .05 and .30 being most typical. It is calculated as ICC(1) = (MSB-MSW)/{MSB+[(k-1)*MSW]}, where MSB is between-group mean square, MSW is within-group mean square, and k is average group size. ICC(2) gives an overall estimate of the reliability of group means, with values equal to or above .70 being acceptable in most cases. It is calculated as (MSB-MSW)/MSB. The closer it is to 1.0, the more reliably groups can be distinguished based on respondents' safety climate perceptions. The third criterion is satisfied, because each group in the sample is a work crew in a natural setting. For example, in one group there are carpenters working as a work crew on site.

In this study, the one-way ANOVA with group membership as the independent variable and safety climate as the dependent variable has a highly significant F-statistic (F = 2.595, $p < .01$). The ICC(1) value for safety climate is .285. The ICC(2) value is .62. Given the exploratory nature of this study, we believe the value of .62 is acceptable. Every group in the sample has an $r_{wg(j)}$ value greater than .688, with a median value of .947. These statistics support aggregating safety climate perceptions from the individual level to the group level.

The Likert scale is very popular, but there is no agreement as to the number of scale points to be used. A shorter scale may reduce the fatigue in responding, while a longer scale may detect more significant relations among interested constructs (Leung 2011). In the survey, we used 4-point Likert scales to measure the constructs of safety climate and safety behavior, because less fatigue is entailed in responding to a 4-point Likert scale than a longer one. In analyzing data we extended the two scales from 4 to 7 points with a formula, $y = 2x – 1$, where x is the score gained using the 4-point scale, and y is the corresponding score in the 7-point scale. This transformation has little impact on the constructs' internal structure (e.g., means, standard deviations, item-item correlations, item-total correlations, Cronbach's alpha, or factor loadings) and criterion-related validity (Leung 2011). Group safety climate level is operationalized as the mean score for all items loading on the safety climate construct across the group. Group safety climate strength is operationalized as the inter-rater agreement (IRA), which is used to measure the absolute consensus in scores between group members.

Hypothesis 1 concerns the cross-level effects of group safety climate on individual safety behavior. There are two approaches which can deal with the cross-level effects, i.e., ordinary least square (OLS) regression and hierarchical linear modelling (HLM) (Hofmann and Gavin 1998). Given the time limits, authors used OLS regression to test Hypothesis 1. Hypothesis 2 concerns the effects of group safety climate on group safety behavior, and ordinary least square (OLS) regression was used to test the hypothesis. Table 1 shows OLS regression analysis of the effects of group safety climate level, strength and individual attributes on individual safety behavior. Table 2 shows OLS regression analysis of the effects of group safety climate level and strength on group safety behavior.

Table 1. OLS regression analysis of the effects of individual attributes, group safety climate level and strength on individual safety behavior

Variables	**Individual safety behavior**	
	Model	
	a	b
	Standardized Coefficients Beta	Standardized Coefficients Beta
Age	-.302**	-.245*
Industrial experience	.155	.073
Site experience	.080	.116
Group safety climate level		.27**
Group safety climate strength		-.126
R^2	.075	.166
Adjusted R^2	.055	.135
ANOVA (F)	3.722*	5.359**

Notes: * $p < .05$; ** $p < .01$.

Table 2. OLS regression analysis of the effects of group safety climate level and strength on group safety behavior

Variables	Group safety behavior
	Standardized Coefficients Beta
Group safety climate level	.460**
Group safety climate strength	-.182
R^2	.243
Adjusted R^2	.192
ANOVA (F)	4.809*

Notes: *$p<.1$; **$p<.05$

To test Hypothesis 1, we first ran model a (Table 1) with only the control variables as predictors. Only age (Beta = -.302, $p < .01$) significantly predicts individual safety behavior and together with the other control variables explains 5.5% of variance. Then we ran model b (Table 1). The results suggest a highly significant relationship between group safety climate level and individual safety behavior (Beta = .27, $p < .01$). Thus, Hypothesis 1 is partially supported.

To test Hypothesis 2, we ran a model (Table 2) with group safety climate level and strength as predictors. Only group safety climate level (Beta = .46, $p < .01$) significantly predicts group safety behavior and together with group safety climate strength explains 19.2% of variance. Therefore, Hypothesis 2 is partially supported.

CONCLUSIONS

This study is expected to make two primary contributions to the safety research. First, it furthers understanding of the complex relationships between safety climate and safety behavior. While most of extant literature highlights the importance of psychological safety climate in predicting individual safety behavior, this study shows that the operationalization of safety climate at the group level impacts both individual safety behavior and group safety behavior. Second, this study shows that group safety climate level is a significant predictor to individual and group safety behavior. Therefore, it is important to enhance the safety climate level, which can be achieved through project management team and group supervisors placing a high priority on safety and demonstrating a strong safety leadership. Third, this study shows that members within the same group develop shared safety climate perceptions, and members of different groups have significantly different safety climate perceptions. This is supported by the four above mentioned measures, i.e., a sufficiently large value of $r_{wg(j)}$ in each group, a significant F-statistic resulting from one-way ANOVA, and both ICC(1) and ICC(2) with acceptable values.

This study has several limitations, however. First, we used OLS regression, instead of HLM, to test Hypothesis 1 which concerns cross-level effects. Although OLS regression can deal with cross-level analysis, the standardized errors associated with the tests of the group-level variables may be underestimated compared with HLM (Hofmann & Gavin, 1998). Second, in order to save respondents' efforts in making choices, this study used 4-point Likert scales to solicit respondents' safety climate perceptions and the frequency that they engage in safety behavior. In order to detect more significant relations among interested constructs, authors extended the scales from 4 to 7 points. Although the transformation has little impact on constructs' internal structure and criterion-related validity, it deserves special attention when interpreting the findings. Third, the sample size is relatively small, which impedes generalization of the findings. Future research is recommended to use a larger number of workgroups to further analyze the cross-level effects of safety climate.

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