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Impact of Safety Climate on Construction Workers' Safety Behavior: Mediating Effect of Self-efficacy

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Abstract. Unsafe behavior is the most cited cause of construction accidents. However, to further reduce accidents unsafe behavior should be taken as effect instead of cause. Among others, unsafe behavior can be driven by the work environment and the systems in place. Safety climate reveals the priority of safety assigned by the work environments and extant research suggests that a sound safety climate is a catalyst for safe behaviors. However, the way in which safety climate influences safety behavior needs to be further explored. After reviewing the literature about safety climate, self-efficacy and safety behavior, this paper introduced self-efficacy as a mediating variable into the effect of safety climate on safety behavior, and hence developed a " safe climateself-efficacysafe behavior " model. To validate the model, a large scale survey with construction workers was conducted. Using 110 valid responses, the model was estimated with the structural equation modeling technique with partial least squares (PLS-SEM). Results showed that self-efficacy plays a mediating role between safety climate and safety behavior. Suggestions were given accordingly.

Keywords: Safety Climate; Self-efficacy; Safety Behavior; Partial Least Squares; Construction workers.

1. Introduction

Due to long work period, overlapping hazard sources, and exposure to the natural environment, construction projects are notorious for a disproportionately high rate of accidents. Therefore, how to reduce accidents has been on top of the agenda for academics and practitioners in construction for a long time. Previously, human errors including workers' unsafe behavior have been most often cited as the immediate cause. [1] questioned this view and suggested instead of cause, human errors should be taken as "an effect of failure deeper inside the systems in which people work" (p.212). Particularly, he maintained that "[H]uman error is systematically connected to features of peoples' tools, tasks, and operating environment. Progress on safety comes from understanding and influencing these connections" (p.212). Safety climate, defined as "shared perceptions with regard to safety policies, procedures, and practices" [2] (p.125), and hence reflects the priority of safety assigned by their work environments.

Relevant research shows that a constructive safety climate can stimulate of construction workers' behavior. However, the mechanism whereby safety climate stimulates safety behavior needs more exploration, so that more actionable measures are proposed. Numerous studies have applied social cognitive theory to organizational management. Self-efficacy, as an important part of individual cognitive process, has a significant impact on employee performance. Regrettably, few studies have applied self-efficacy in the field of construction projects. Therefore, this study constructs an intermediary model of self-efficacy to illustrate the a possible path through which construction workers' safety climate perceptions influence their subsequent safety behavior.

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2. Theoretical foundation and hypothesis development

2.1 Concept definition and operationalization

Although a common definition seems to be accepted, different operationalizations of the safety climate concept emerge. Management's safety attitudes and relevance of safety to job behavior are two dimensions of safety climate. [3] believed that safety climate is a series of beliefs held by employees or groups on specific situations. [4] believed that safety climate is the organizational climate that affects employees' attitude towards safety risk, which represents employees' views on safety ethics in the organization or working environment. [5] applied safety climate theory to the coal mining industry, and described safety climate as workers' attention to safety. Generally, safety climate originates from the individual perception of how much importance the organization places on safety. When the individual perception of the members of the organization reaches agreement, the organizational safety climate will emerge. Otherwise, the safety climate remains at the individual level.

Research on safety behavior can be traced back to research on job performance. Initially, job performance only means task performance, used to evaluate the completion of the task. [6] believed that job performance, in addition to requiring employees to complete the designated work on time, should also include employee autonomy. [7] defined this spontaneous behavior as contextual performance, which together with task performance constitute job performance. [8] applied job performance in safety management and believed that safety performance is the evaluation of employees' active completion of safety work, including safety behavior and safety outcome. Safety behavior can be measured by the two dimensions, i.e., safety compliance and safety participation. Safety compliance represents the necessary behavior of employees to ensure the safety of the working environment, such as observance with safety rules and regulations, the correct use of operating tools during operations; safety participation refers to employees' behavior to help organizations and other members on the basis of ensuring their own safety, such as providing safety advice to superiors and actively providing safety assistance to co-workers.

Social cognitive theory claimed that individual cognition has a significant impact on the generation and change of behavior. Self-efficacy and outcome expectation are the two most important parts of individual cognitive process. Self-efficacy refers to an individual's ability, assessment and belief in completing a task [9]. It has nothing to do with the individual's real ability, but is a subjective judgment of his/her ability. This judgment has a certain impact on behavior choice, effort and work performance [10].

Self-efficacy can be either specific or general. It is specific and changes as the activity areas vary [9]. [11] believed that self-efficacy is a general concept that is not affected by the surrounding environment or specific behavior. The view of general self-efficacy has been accepted by more scholars [12, 13] than that of specific self-efficacy. Therefore, the concept of general self-efficacy is adopted in this study. [14] conducted a survey of college students in Hong Kong using a simplified version of General Self-efficacy Scale (GSES), which was establishedby [15], in both English and Chinese. The results of the two samples both showed that boys' self-efficacy is better than girls, confirming that thisscale was suitable for the study of local samples.

2.2 Safety climate and safety behavior

Studies indicate that a positive safety climate can stimulate individual safety behavior. [16] verified through empirical research that safety climate can prompt safety behavior indirectly through two variables, namely, safety knowledge and motivation. [17] determined the dimension of safety climate after seven months of investigation, and found that safety climate could anticipate safety behavior within a controllable range. [18] conducted a long-term follow-up survey of workers in a construction project, and found that safety climate has a lagging impact on safety behavior, that is, the previous safety climate had a certain impact on the next safety behavior. [19] used Data Envelopment Analysis to explore the transformative relationship between safety climate

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and safety behavior. [20] measured safety climate with environment, employee safety awareness and managerial commitment, and concluded that safety climate was positively correlated with safety behavior, and management commitment played an important role in the correlation. Therefore, the following hypothesis is proposed:

H1: Safety climate is positively correlated with safety compliance.

H2: Safety climate is positively correlated with safety participation.

2.3 Safety climate and self-efficacy

As an individuals' perceptions of organizational working environment, safety climate has an impact on their self-efficacy. [21] studied researchers' self-efficacy and found that researchers' perception has a positive effect on their self-efficacy. [22] constructed a self-efficacy model, confirming that individual cognition of the surrounding environment is a significant principle affecting self-efficacy. Some studies have shown that a certain dimension of safety climate can predict self-efficacy. For example, the management encouragement and support for workers mirrors that the organization values and cherishes workers, which is thereby conducive to improving their confidence and stimulating their enthusiasm for work [23]. The communication between construction workers can make the information flow within the organization, which is conducive to accessing safety knowledge and information related to themselves, and enhance their confidence in completing the task. Therefore, the following hypothesis is proposed:

H3: Safety climate is positively correlated with self-efficacy.

2.4 Self-efficacy and safety behavior

Self-efficacy can affect individual emotion, work motivation, effort and behavior choice [9]. In case of emergency in construction, high self-efficacy workers can solve problems actively and take safety actions promptly, while low self-efficacy workers tend to panic and worry and hence undermine their abilities to act. Workers with higher level of self-efficacy are more likely to exhibit safety behavior [24]. [25] employed the method of computer simulation and found that self-efficacy can predict job performance, and high-level self-efficacy can produce high job performance. [26] explored the role of self-efficacy in the communication between superiors and subordinates, and found that employees' self-efficacy had positively correlated to their voice behavior. Additionally, individuals with more self-efficacy have a stronger sense of safety and are more willing to work safely. They can communicate with their superiors and peers proactively and achieve safety goals on schedule [27]. Therefore, the following hypotheses are proposed:

H4: Self-efficacy is positively correlated with safety compliance.

H5: Self-efficacy is positively correlated with safety participation.

2.5 The mediating effect of self-efficacy

The above research hypotheses demonstrate that safety climate has impact on both safety behavior and self-efficacy. Self-efficacy is also highly associated with safety compliance and safety participation of construction workers. Therefore, the following hypotheses are proposed:

H6: Self-efficacy plays a significant mediating role in the effect of safety climate on safety compliance.

H7: Self-efficacy plays a significant mediating role effect between safety climate and safety participation.

2.6 Structural model

Figure 1 depicts the hypothesized structural model.

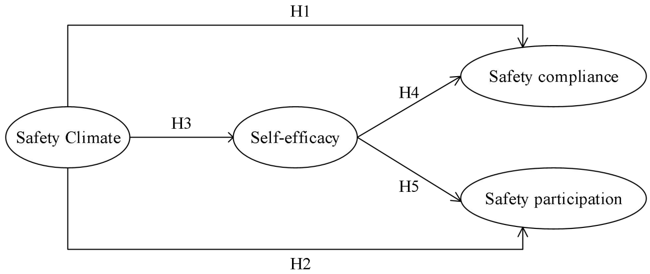

Figure 1. Hypothesized structural model

3. methods

3.1 participants and procedures

The population of the survey is construction workers. Two rounds of survey were carried out. The first round aimed to obtain reliable and valid measures. In the first round, 60 questionnaires were distributed to construction workers. After deletion of invalid responses, 53 valid questionnaires were obtained. The valid data were analyzed by exploratory factor analysis with SPSS, and problem items were revised or deleted.

In the second round of survey, questionnaires were regularly distributed in Shanghai and Shandong (sum total=125). 118 responses were secured, with the response rate at 94.1%. After deleting invalid questionnaires, 110 valid questionnaires were finally retained. Demographic information is shown in Table 1.

3.2 Questionnaire design

This study measured safety climate with a scale employed by [28], which has four items. Safety behavior was measured by a two-dimensional scale developed by [16], which has eight items. Self-efficacy was measured by a simplified version of GSES developed by [14], which has four items.

The scales of the above three constructs had five response categories, with 5 indicating totally agreement and 1 indicating totally disagreement.

Table 1. Demographic characteristics of respondents

Characteristics		Frequency	Percentage (%)
Age (years)	19-29	38	34.5
	30-39	32	29.1
	40-49	23	20.9
	50-60	17	15.5
Sex	Male	93	84.5
	Female	17	15.5
Marital status	Married	80	72.7
	Single	30	27.3
Educational level	Primary	10	9.1
	Junior high school	19	17.3
	Senior high school	19	17.3
	Technical secondary school	40	36.4
	College or higher	22	20.0
Industrial experience (years)	<=1	14	12.7
	1-3	24	21.8
	4-6	17	15.5
	7-9	24	21.8
	>10	31	28.2

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3.3 Tools of data analysis

This study tested the hypotheses with PLS-SEM for two reasons. First, PLS-SEM is primarily used for exploratory research and developing theories [29]. The theoretical framework of the model developed in this study was not mature. Furthermore, the relationships among safety climate, self-efficacy and safety behavior need to be further explored by empirical research. Second, PLS-SEM works efficiently with small sample sizes and makes no distributional assumptions [29]. The number of valid samples in this study was relatively small, and data would probably not follow normal distribution. Therefore, this study used SmartPLS, the most widely applied PLS-SEM software, to estimate the mediating effect model of self-efficacy.

4. Results

4.1 Measurement model evaluation

As suggested by [29], indicators with low factor loadings (usually below 0.4) should always be candidate to eliminate from the construct. The indicators and their loadings are shown in Table 2. All the loadings are above 0.7, suggesting that the indicator reliability was acceptable.

The composite reliability (CR) is more suitable than Cronbach's alpha to evaluate scale's reliability [29]. As shown in Table 2, all of CR values are larger than 0.7, indicating a satisfactory level of reliability for each construct.

As shown in Table 2, all average variance extracted (AVE) values are higher than 0.5. This indicates that each construct can explain more than half of the variance sum of its indicators, and hence secures satisfactory convergent validity [30].

Additionally, to obtain satisfactory discriminant validity, the square root of the AVE of each construct is supposed to be higher than its highest correlation with any other construct [30]. According to Table 3, the requirement for discriminant validity is satisfied, suggesting that the constructs are different from each other.

Table 2. Construct reliability and validity

Latent variable	Manifest variable	Outer loadings	Cronbach's Alpha	CR	AVE
Safety climate	SC1	0.774	0.801	0.870	0.626
	SC2	0.787			
	SC3	0.756			
	SC4	0.844			
Safety compliance	SB1	0.937	0.943	0.959	0.854
	SB2	0.929			
	SB3	0.923			
	SB4	0.908			
Safety participation	SB5	0.884	0.912	0.938	0.791
	SB6	0.927			
	SB7	0.893			
	SB8	0.852			
Self-efficacy	SE1	0.948	0.908	0.936	0.785
	SE2	0.893			
	SE3	0.857			
	SE4	0.842			

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Table 3. Discriminant validity

	Safety climate	Safety compliance	Safety participation	Self-efficacy
Safety climate	0.791			
Safety compliance	0.761	0.924		
Safety participation	0.678	0.739	0.889	
Self-efficacy	0.711	0.831	0.744	0.886

4.2 Structural model evaluation

4.2.1 Path coefficients

The PLS-SEM path coefficient is shown in Figure 2. The path coefficient on the internal model path represents the hypothetical relationship between latent variables. Figure 2. Estimation results for the PLS-SEM algorithm, where inner model shows path coefficient, and outer model shows outer loadings. Numbers inside circles represent R^2 values for the corresponding constructs.

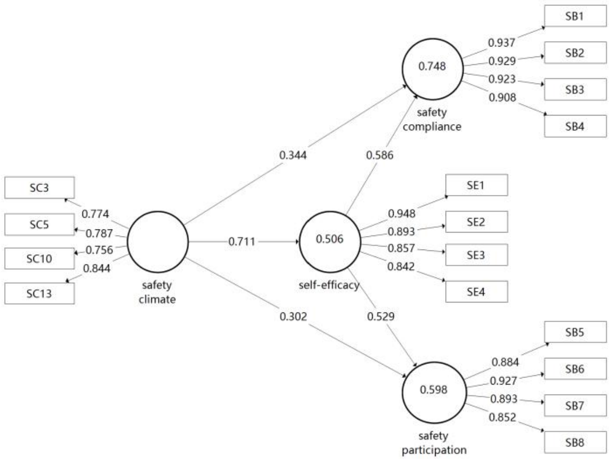

Figure 2. Hypothesized structural model

4.2.2 Bootstrapping

The bootstrapping technique is always used to test the significance level of all structural model path coefficients. Following suggestions by [29], this study used the bias-corrected and accelerated (BCa) bootstrap method with 5,000 bootstrap samples. The test results are shown in Table 5. As can be seen, all the p values of the path coefficients are far less than 0.05, indicating that the path coefficients are significant. Therefore, hypotheses H1-H5 are supported.

4.2.3 Structural model evaluation

The R^2 values of safety compliance, safety participation and self-efficacy are 0.748, 0.598 and 0.506, respectively. These values are all higher than 0.5, suggesting that the structural model had a relatively high level of predictive power [31].

The Stone-Geisser's Q^2 value is to measure the structural model's predictive relevance, and is obtained by the blinding procedure [32, 33]. The Q^2 of safety compliance, safety participation and self-efficacy are 0.595, 0.429 and 0.366, respectively. These values are all greater than 0, suggesting that the model's predictive relevance for all of them.

Effect size f^2 is used to evaluate the impact of an exogenous construct on an endogenous construct. As a rule of thumb, the f^2 values of 0.02, 0.15, and 0.35 represent small, medium, and large effects respectively [29, 31]. As shown in Table 4, safety climate has medium effect on safety compliance (f^2=0.232), small effect on safety participation (f^2=0.112) and large effect on self-efficacy (f^2=1.024). Meanwhile, self-efficacy has large effect on safety compliance (f^2=0.675), and medium effect on safety participation (f^2=0.344) [31].

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Table 4. Evaluation index of structural model

		Safety compliance	Safety participation	Self-efficacy
R^2		0.748	0.598	0.506
Q^2		0.595	0.429	0.366
f^2	Safety climate	0.232	0.112	1.024
	Self-efficacy	0.675	0.344	

4.3 Hypothesis testing

To evaluate the mediating effect of self-efficacy, the bootstrap confidence intervals for significance testing were employed. As shown in Table 6, both indirect effects are existent since neither of the 95% confidence intervals includes zero. Furthermore, p values for each indirect effect are less than 0.001. Therefore, the indirect effect is significant [29], supporting H6 and H7. In other word, self-efficacy plays a mediating role in the relationship between safety climate and safety compliance, and between safety climate and safety participation as well.

Table 5. Significant testing results of path coefficients

	Original sample(O)	Sample mean(M)	Standard deviation(STDEV)	T statistics	P values
Safety climate → Safety participation	0.302	0.316	0.091	3.336	0.001***
Safety climate → Safety compliance	0.344	0.350	0.090	3.823	0.000***
Safety climate → Self-efficacy	0.711	0.711	0.059	12.083	0.000***
Self-efficacy → Safety participation	0.529	0.513	0.104	5.090	0.000***
Self-efficacy → Safety compliance	0.586	0.574	0.091	6.463	0.000***
*<0.5, **<0.01, ***<0.001					

Table 6. Significance test of indirect effects

	Indirect effect	T statistics	95% Confidence Interval	P values	Support
Safety climate → Self-efficacy → Safety participation	0.078	4.847	[0.232, 0.524]	0.000***	Yes
Safety climate → Self-efficacy → Safety compliance	0.071	5.852	[0.291, 0.552]	0.000***	Yes
*<0.5, **<0.01, ***<0.001					

5. Discussion and conclusion

The construction sector has been plagued with accidents. Practitioners' unsafe behavior is the most often cited cause. Hence, to cultivate more safety behavior is conducive to reducing accidents. Research and practice indicate that a sound safety climate is a catalyst for safe behavior, but the

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mechanism needs more exploration. This paper introduced self-efficacy as a mediating variable between safety climate and safety behavior, and the results are reported below.

Safety climate is positively associated with safety compliance and safety participation. The stronger the construction safety climate is, the more likely the construction workers adhere to safety rules and regulations, and actively promote safety on sites. Conversely, workers are less likely to exhibit safety behavior.

Measurement model evaluation results show that safety policy, safety training, management commitment and safety communication have sound predictive power for safety climate. Therefore, construction enterprises can further improve safety rules and regulations, improve the form of safety training through intuitive methods such as scenario simulation, and establish smooth safety communication channels. Corporate managers should encourage and commend safe production practices, and share safety experience with workers regularly to show their commitment to safety.

The mediating effect of self-efficacy in the relationship between safety climate and safety behavior is supported. Construction enterprises should raise construction workers' self-efficacy by setting reasonable and practicable goals, so that workers can complete tasks with due effort, and hence enhance their self-efficacy through successful experience consecutively. Enterprises need to carry out regular psychological training to construction workers, empower them to conduct ability assessment so as to enhance safety compliance and participation.

The results should be interpretated with at least three limitations in mind. First, the study employed a cross-sectional research design, and hence a causal relationship between safety climate and safety behaviors cannot be concluded. Second, self-efficacy can be either general or specific, and either outcome-based or process-based. Using a general self-efficacy scale, this study cannot provide specific and process-based self-efficacy raising measures. Third, this study addressed only one way to cultivate safety behavior. To curb unsafe behavior, however, needs a systematic effort, because it can be driven by the work environment and the systems in place, the culture of the organization, relationships with managers and co-workers, poor management, badly designed machinery and equipment, production pressure, inadequate human and physical resources and a whole range of other intervening variables. Future research efforts should take systems thinking in reducing unsafe behaviors.

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