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An Empirical Investigation of the Influence of Safety Climate on Safety Citizenship Behavior in Coal Mine

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Abstract

Safety citizenship behavior (SCB) is a higher-order construct consisting of various behaviors such as helping co-workers, promoting safety programmers, demonstrating initiative, suggesting changes for improving safety. Those behaviors are very importance for coal mine safety because of the dynamics of hazard in coal mine. However, safety climate in relation to SCB has rarely been examined. This study has investigated the influence of safety climate on SCB in the context of coal mine. Self-administered questionnaires that included a SCB scale and a safety climate scale were used to collect data in three coal mines in China. The number of returned valid questionnaires was 450, and the response rate was 88.2%. Exploratory factor analysis identified two dimensions of SCB and four dimensions of safety climate. The structural equation modeling results suggest that the safety climate positively affects SCB. The results of the statistical analysis indicated that coal mine leaders would do well to develop a strategy to improve the safety climate that can produce the highest levels of safety behavior.

Keywords: safety climate; safety citizenship behavior; exploratory factor analysis; structural equation modeling

1. Introduction

Safety is a major concern in high-risk/high-consequence industries such as coal mine due to the high human and property costs. In recent years, coal mine safety in China has made remarkable achievements, the number of accident fatalities and million tons death rate greatly decreased, but the coal mine safety situation remains serious, major accidents still occur, occupational hazards are very severe. Research from Chen Hong etc. [1] indicated that in the major accidents of China's coal mines between 1980 and

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2000, the human factors accidents (including deliberate violation, management failures and design defects) accounted for 97.67% of all accidents.

The traditional approach of safety management was narrowly focused on technical factors such as design of equipment, safety policies and programmers. Recently there has been increasing focus on improving compliance behavior in terms of following safety rules and regulations [2]. However, safety researchers soon realized that compliance was not sufficient to minimize the risk of adverse events [3]; and that individuals need to be proactive in dealing with safety issues. This drive to improve safety is demonstrated in behaviors like helping co-workers, promoting safety programmers, demonstrating initiative, suggesting changes for improving safety, and can be collectively known as safety citizenship behavior (SCB) [4].

The dynamics of hazard in coal mine determines that safety inspection is impossible to eliminate all risks; a normal risk management should encourage employees to participate in the safety management, actively look for information on potential accidents, risks and increase their motivation to report the risk information. The core behavior of SCB should be reporting risk information or accident, which is the main content Reason [5] model of safety culture.

Safety climate has been seen as a sign of employees' work attitude toward and perception of safety [2] . Among the tactics used in dealing with this issue are ergonomic and psychosocial approaches. However, there have been scant researches addressing the psychological effects of safety climate on safety citizenship behavior in the context of coal mine, especially in China. This study aims to evaluate workers' perceptions of safety climate and its impact on SCB in the context of coal mines in China.

1.1. SCB

In the past, researchers have proposed constructs similar to SCB such as safety initiatives and safety participation, which have shown a positive correlation with lower frequency of accidents [6]. SCB, however, is a higher-order construct consisting of various behaviors such as stewardship, voicing one's opinions, helping co-workers, whistle-blowing (reporting unsafe acts), initiating workplace change and civic virtue (keeping informed). SCB stems from organizational citizenship behaviors (OCB). Therefore, just like OCB, SCB can be defined as behaviors that are discretionary, not directly or explicitly recognized by the formal reward system, and that in the aggregate promote the effective functioning of the organization. The concept of citizenship behavior is based on the principle of reciprocity i.e. employees tend to reciprocate a high-quality relationship with their supervisor (i.e. relationship based on trust, support and fairness) by engaging in behaviors valuable to the organization. Since it is well known that safety is a valued behaviors in a high-risk industry, it is likely that employees would choose to perform safe behaviors [4].

In order to understand SCB, it is important to understand its counterpart, safety compliance behavior. Safety compliance involves following rules and regulations, wearing protective clothing, avoiding risky practices, etc. The significance of compliance stems from the fact that procedural protection often serves as the choice strategy despite known weaknesses because it is less costly, immediately available, and readily adaptable by comparison with structural protection [5].

SCB complements compliance in two important ways. First, procedures can rarely cover all possible contingencies, except for highly standardized operations and equally reutilized work. Second, in practice, compliance often fails because shortcuts offer immediate benefits that are rarely offset by personal costs, turning such shortcuts into a utility-maximizing choice [7]. The available research indicates that commitment offers better prediction of safety outcomes than compliance [4][8]. At the same time, because discipline and compliance provide reliability in routine situations while initiative and citizenship improve the capacity for safe conduct in less predictable circumstances, safety management programs must include both [9][10] .

According to Zohar's opinion [9], safety citizenship should develop when the discretionary proactive orientation to work due to high work-ownership climate is accompanied by a high-safety climate, while safety compliance will develop in organizations characterized by low work-ownership climate coupled with high-safety climate.

1.2. Safety climate

It is generally accepted that safety climate is a 'snapshot' of workforce perceptions about safety [11]. However, researchers are in less agreement regarding which safety climate factors or dimensions are most important in influencing behaviors at work. The multiple definitions of safety climate in the literature [12][13] have determined to a large extent what variables research teams have incorporated when developing measures of safety climate. Even though a great deal of research has been conducted on this topic, the number of dimensions remains in dispute, and it remains unclear what kind of antecedents (factors) promote a favorable climate/culture [14].

Based on foregoing review of previous study findings reported in the literature, the following hypotheses were proposed: Perceptions of safety climate will be positively related to SCB.

2. Method

2.1. Sample

The study was conducted at two underground coal mines in Henan province and one underground coal mine in Anhui province. As the research focus on the underground first line workers, the underground departments were selected as the subject, including drifting excavation team, coal team, ventilation team, gas extraction team, transport team, etc. Then random sampling procedure was conducted to select individual workers in each team. 510 questionnaires were distributed and 475 questionnaires were retrieved. After careful examination, 25 questionnaires were abandoned because of incomplete information, identical handwriting and identical answers. The total valid response rate was 88.2%. Table 1 is the demographics of study sample. Table 1 shows that 21.6% of workers had been subjected to occupational injuries, and nearly half (47.5%) of workers had experienced accidents, which means that coal mine in china is a high risk industries in China.

Table 1. Demographic characteristics of sample (N=450)

Characteristic		Numbers	Percentage (%)
Age(years)	<20	4	0.9
	21-30	101	22.4
	31-40	181	40.2
	41-50	146	32.4
	>50	13	2.8
	missing	5	1.1
Educational level	Middle school	165	36.6
	High school	233	51.8
	Junior college	40	8.9
	Bachelor's degree	8	1.8
	missing	4	0.8
Have you suffered injury before?	Yes	94	20.9
	No	354	78.7

	Missing	2	0.4
Have you ever seen any accident?	Yes	212	47.1
	No	234	52
	missing	4	0.9

2.2. Instrument

The aim of this study was to investigate the influence of safety climate on SCB in coal mine using a questionnaire as the instrument. The questionnaire was divided into three parts: general information, a SCB scale and safety climate scale.

Referring to the Hoffman's SCB scale [4], we constructed a 14-item SCB questionnaire considering three factors: Helping co-workers, safety communication and demonstrating initiative.

Referring to previous safety climate measurement tools [14-17], complying with the principle of scale development, considering the factors of safety commitment, safety involvement, safety training and safety awareness, we constructed a 30-item safety climate questionnaire.

In order to assess the extent to which the instrument represents the content of safety practice, the investigators asked a number of experts to examine the content validity of the scales. The experts reviewed the items to confirm the definitions of SCB and safety climate; the reviewers also evaluated the items' relevance, clarity and conciseness. Moreover, exploratory factor analysis and internal consistency analysis were also used in the process of developing these scales. The SCB scale and safety climate scale encompassed primarily items in 5-point Likert-type scales ranging from 1 (strongly disagree) to 5 (strongly agree), Kaiser's rule (eigenvalues >1) or screen plots to decide factor numbers, factor loading estimated by principal components analysis, and factor rotation with orthogonal rotation and varimax. Analysis showed that two scales possess very good construct validity and internal consistency (see Tables 2-3).

Table 2. Validity and reliability of the SCB scale

Factors	Number of Items	Eigenvalues	Accumulative Explained Variance (%)	Cronbach Alpha
Demonstrating initiative	6	5.682	43.704	0.845
Help co-workers	6	1.582	55.877	0.838
Total	12	-	60.323	0.883

Table 3. Validity and reliability of the safety climate scale

Factors	Number of Items	Eigenvalues	Accumulative Explained Variance (%)	Cronbach Alpha
Safety involvement	4	6.520	31.046	0.810
Safety commitment	7	2.124	41.162	0.817
Safety training	5	1.296	47.334	0.680
Safety awareness	5	1.042	52.295	0.678
Total	21	-	52.295	0.881

2.3. Data Analysis Methods

First, descriptive statistics, exploratory factor analysis and item total correlation analysis were used to summarize the large number of SCB and safety climate into smaller, manageable sets of underlying factors or dimensions. The structural equation modeling approach was used to explore the relationship between SCB and safety climate. All analyses were carried out using SPSS 16.0 and Lisrel 8.7 software.

3. Results

3.1. Descriptive Statistics

Table 4 shows the means, standard deviations, and correlations for all variables in the study.

Table 4. Means, standard deviations and correlations for all variables in the study (N=450)

	Mean	SD	1	2	3	4	5	6
1. Safety training	4.41	0.54	1					
2. safety commitment	4.20	0.67	.604**	1				
3. Safety involvement	4.10	0.78	.530	.697	1			
4. Safety awareness	4.39	0.54	.367	.377	.354	1		
5. Help co-workers	4.43	0.56	.520	.433**	.492	.362**	1	
6. Demonstrating initiative	4.49	0.52	.649**	.640	.623	.402	.564	1

Note: **Correlation is significant at the 0.01 level (2-tailed).

3.2. Test the influence of safety climate on SCB

In order to explore the relationship between safety climate and SCB, structural equation model (SEM) analysis was performed. Two models were assessed for goodness of fit (see Table 5).

Table 5. Goodness-of-fit statistics for optimal SEM model of safety climate and SCB

Model	χ^2 / df	GFI	SRMR	RMSEA	CFI
1	3.16 1518.47/481	0.83	0.061	0.069	0.96
2	2.71 1302.13/480	0.91	0.059	0.062	0.97

Note: GFI= goodness of fit index (values greater than 0.90 indicate good fit). SRMR= standard root mean square residual (values greater than 0.95 indicate good fit). RMSEA = root mean square error of approximation (values less than 0.05 indicate good fit). CFI = comparative fit index (values greater than 0.95 indicate good fit).

The Model 1(see Fig. 1) assumed that each factor of safety climate was inter correlated with each factor of SCB. In the Fig. 1, C1, C2, C3 and C4 indicate four factors of safety climate where C1 indicates safety training, C2 indicates safety commitment, C3 indicates safety involvement, C4 indicates safety awareness. B1 and B2 indicate two factors of SCB where B1 indicates helping co-workers, B2 indicates demonstrating initiative. After run by Lirsel 8.7, the result showed that the path coefficients from C2 to B1 were negative; and the path coefficient from C1 to B2 was not statistical significant; and the goodness-of-fit statistics suggested a poor fit of the full model to the study data. So Model 1 need to be modified, the modified model is called Model 2. Based on Model 1, the positive path coefficients were kept, and the negative and no significant level path were deleted. The goodness-of-fit statistics for the optimal model (Model 2) suggested that this model was a good fit for the data (see Fig. 2).

Fig. 2 shows that the safety training (C1) of safety climate positively affects the helping co-workers (B1) of SCB (path coefficient=0.32), the safety commitment (C2) of safety climate positively affects the demonstrating initiative (B2, path coefficient=0.33) of SCB, and the safety involvement (C3) of safety climate positively affects the helping co-workers (B1, path coefficient=0.22) and the demonstrating initiative (B2, path coefficient=0.19) of safety climate, and the safety awareness (C4) of safety climate positively affects the helping co-workers (B1, path coefficient=0.35) and the demonstrating initiative (B2, path coefficient=0.48) of safety climate. Therefore, Hypothesis which specifies that safety climate is positively related to SCB is supported.

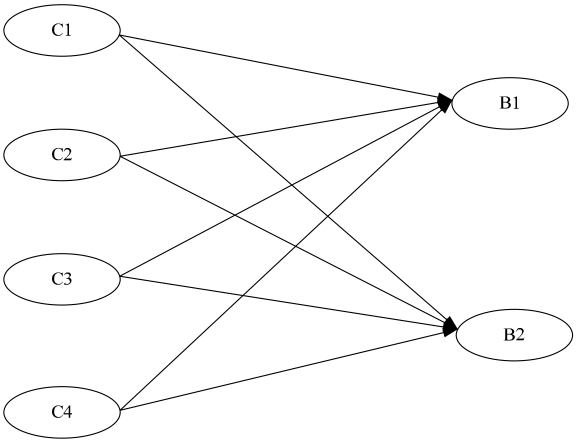

Fig. 1. Hypothesized causality model between safety climate and SCB

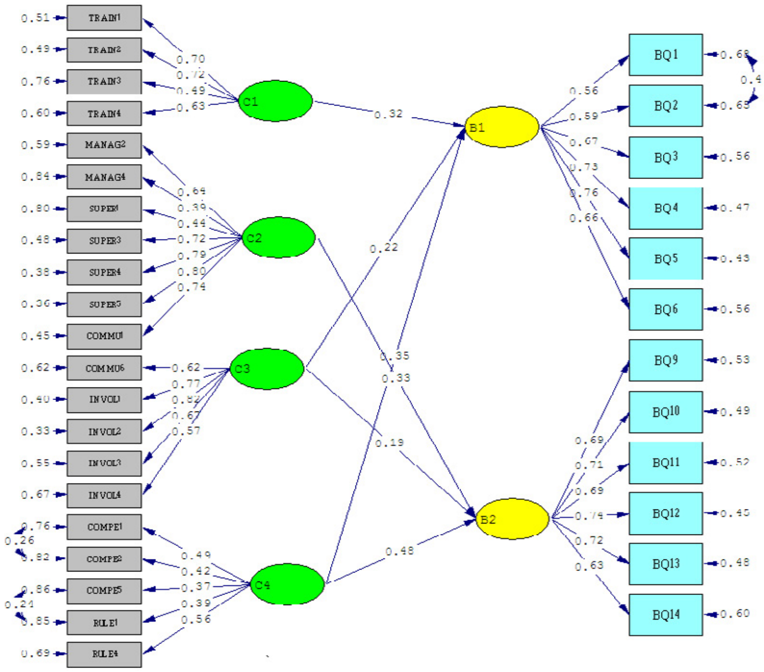

Fig. 2. model 2 for structural equation modeling (SEM) Analysis.

4. Discussion and conclusions

This study developed a model to explain the influence of safety climate on SCB. The model is important because it provides a link between the safety climate and special individual behaviors related to safety. The data analysis results in this study statistically confirmed the impact of safety climate on SCB. This finding is noteworthy because early studies were likely to focus on the ergonomic effect, without placing suitable emphasis on the psychological effect of safety climate on SCB. Importantly, this study is of value because of the empirical evidence that draws attention to the significant roles played by the psychological effect.

This study present evidence that safety climate perception in coal mine settings can be reliably measured with a 21-item questionnaire, loading on four factors: safety involvement, safety commitment, safety training and safety awareness. The safety climate dimensions of this study are a little different from a previous study [18][19]. Flin et al. [12] found a large range of variation in the number of factors identified: from 2 to 19 in the studies that they reviewed. As Flin et al. [12] point out the dimensions of climate measures vary considerably in terms of criteria, statistical analysis, size and composition of workers and industry. Thus drawing comparisons between the measures is difficult not only because of the methodological differences outlined but also because of language and cultural variations. Zohar [9] point out that the field of safety-climate research needs to continue and develop beyond the operationalization and measurement stage, merely developing more measurement scales and re-testing climate-behavior relationships will hold back scientific progress. At the same time the SCB items and dimensions of this study are very different from the study of Hoffman etc. [4], which different may be due to language and cultural variations.

It is necessary to be somewhat cautious in the conclusions. The main threat to the conclusions concerns the validity of the outcome variable, SCB, which was self-reported. We do not know to what extent people really do what they claim to do. The ultimate outcome variable is, of course, accidents. However, the research question on how safety climate affects accident outcome requires great samples and is methodically difficult for several reasons. For example, a better safety climate can also be expected to affect reporting degree of accidents. It would be valuable in future research to validate measures of self-rated safety behavior, as well as explore the effects of accidents on safety climate and safety behavior.

With the above caution in mind, the present study strengthens the hypothesis of a causal relationship between safety climate and SCB. The results of this study suggest that coal mine leaders must create a safety climate that emphasizes and stresses the importance of safety. As such, the goal for safety researchers and practitioners is to impress on coal mine that a continued emphasis on safety are necessary to produce the highest levels of safety behavior.

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