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Research on the relationship between safety leadership and safety climate in coalmines

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Abstract

The importance of leadership for effective safety management has been the focus of research attention in industry for a few years. However, safety leadership in relation to safety climate has rarely been examined. This study has investigated the relationship between safety leadership and safety climate in the context of coal mine. Self-administered questionnaires that included a safety leadership 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 three dimensions of safety leadership and four dimensions of safety climate. The structural equation modeling results suggest that the active management of safety leadership positively affects safety training of safety climate, the safety motivation of safety leadership positively affects the safety commitment and the safety involvement of safety climate, and the safety monitor of safety leadership positively affects the safety awareness of safety climate. The study findings also reveal positive associations among safety climate. The results of the statistical analysis indicated that coal mine leaders would do well to develop a strategy to change their leadership styles by which they improve the safety climates.

Keywords: safety leadership; safety climate; coal mine; structural equation modeling

1. Introduction

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 2000, the human factors accidents (including deliberate violation, management failures and design defects) accounted for 97.67% in all accidents. Many coal mines lack of the leading role of senior manager in health and safety, without senior managers' leading by example and commitment to safety, it can not really create a positive safety culture.

One way to decrease human error or incidents is effective safety leadership [2]. The importance of leadership for effective safety management has been the focus of research attention in industry for a number of years, especially in energy and manufacturing sectors [3]. The United Kingdom Health and Safety Executive (HSE) [4] has stated that without effective leadership one cannot have good safety performance. The increasing attention being paid to safety leadership in various industries is evidence of the assumption that safety leadership will result in increased organizational safety effectiveness. Developing and sustaining safety leadership is important to form positive safety culture and to reduce accidents. There is scant research on senior managers' leadership and safety climate in the context of coal mine, especially in China.

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Due to its crucial importance for a long-term safety culture, this study aims to evaluate workers' perceptions of safety leadership and its impact on safety climate in the context of coal mines in China.

1.1. Safety leadership

Leadership has been fully implicated in safety, with the majority of previous studies examining the full-range model of transformational and transactional leadership behaviors in managers and supervisors [5-6]. According to Bass and Avolio [7], transformational leadership is characterized by value based and individualized interaction, resulting in better exchange quality and greater concern for welfare. Transactional leader behaviors are related to monitoring and reward whereas transformational leader behaviors are directed towards inspiring and genuinely motivating the workforce [8]. Transformation leadership can elicits safety performance or behavior because effective transformational leaders encourage workers to subscribe to group and organizational goals in preference to immediate personal gain [3].

Several previous studies have examined the effects of safety leadership on safety climate [5-6,9]. Wu et al. [9] defined safety leadership as ''the process of interaction between leaders and followers, through which leaders can exert their influence on followers to achieve organizational safety goals under the circumstances of organizational and individual factors".

As previously mentioned, leadership behaviors have been grouped into two types: transformational and transactional. Transformational leadership focuses on future development, and has also been called relationship-oriented leadership. Transactional leadership focuses on the link between rewards and performance, and has also been called task-oriented leadership. Previous studies on safety leadership have tended to cover both types of leadership [2,9-10]. This study seeks to develop a safety leadership scale for coal mine which take into account both practical conditions and different aspects of transformational and transactional leadership. Three safety leadership dimensions are used in this study, namely: active management, safety motivation, and safety monitor. Active management and safety motivation are aspects of transformational leadership; safety monitor is closely linked to transactional leadership. Safety motivation relates to the extent to which a senior manager creates a motivation system to encourage workers' safety behaviors. Safety monitor refers to the extent to which a senior manager creates a clear mission, responsibility, and goal in order to set standards of behavior for employees; and sets up a safety system to correct workers safety behaviors.

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: Safety leadership is positively related to safety climate. This hypothesis means that the more positive the perceived safety leadership, the more positive the perceived safety climate.

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 relationship between safety leadership and safety climate in coal mine using a questionnaire as the instrument. The questionnaire was divided into three parts: general information, a safety leadership scale and a safety climate scale.

Referring to previous safety leadership measurement tools [6,9,15], we constructed a 20-item safety leadership questionnaire considering three factors: Active management, safety motivation and safety monitor.

Referring to previous safety climate measurement tools [14,16-18], 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 safety leadership 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 safety leadership 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 safety leadership scale

Factors	Number of Items	Eigenvalues	Accumulative Explained Variance (%)	Cronbach Alpha
Safety motivation	11	9.545	47.423	0.924
Safety monitor	4	1.446	54.952	0.837
Active management	4	1.074	60.323	0.782
Total	19	-	60.323	0.940

3. Results

3.1. Descriptive statistics

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

3.2. Test the relationship between safety leadership and safety climate

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

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

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

	Mean	SD	1	2	3	4	5	6	7
1. Active management	4.37	0.65	1						
2. Safety motivation	4.27	0.68	0.70**	1					
3. Safety monitor	4.47	0.63	0.59**	0.66**	1				
4. safety commitment	4.20	0.67	0.52**	0.67**	0.51**	1			
5. Safety training	4.41	0.54	0.43**	0.52**	0.51**	0.60**	1		
6. Safety involvement	4.10	0.78	0.43**	0.63**	0.39**	0.69**	0.53**	1	
7. Safety awareness	4.39	0.54	0.32**	0.32**	0.34**	0.37**	0.36**	0.35**	1

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

Table 5. Goodness-of-Fit statistics for optimal SEM model of safety leadership and safety climate

Model	χ^2 / df	*GFI*	*SRMR*	*RMSEA*	*CFI*
1	2.79	0.82	0.055	0.062	0.97
	1978.71/725				
2	2.87	0.81	0.075	0.065	0.97
	2107.65/733				
3	2.46	0.90	0.052	0.057	0.97
	1789.53/727				

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).

Model 1 (see Fig 1) assumed that each factor of safety leadership was inter correlated with each factor of safety climate. In the Fig 1, L_1, L_2 and L_3 indicate three factors of safety leadership where L_1 indicates active management, L_2 indicates safety motivation, L_3 indicates safety monitor. C_1, C_2, C_3 and C_4 indicate four factors of safety climate where C_1 indicates safety training, C_2 indicates safety commitment, C_3 indicates safety involvement, C_4 indicates Safety awareness. After run by Lirsel 8.7, the result showed that the path coefficients from L_1 to C_1, C_2, C_3 and C_4 were negative; and the path coefficient from L_3 to C_4 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. Based on Model 2, Model 3 added the path from C_2 to C_1 and the path from C_2 to C_3. The goodness-of-fit statistics for the optimal model (Model 3) suggested that this model was a good fit for the data (see Fig 2).

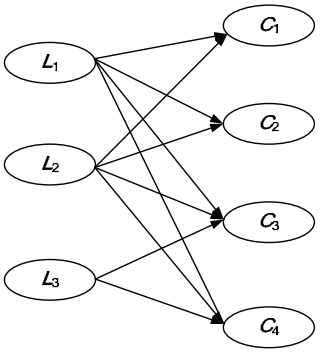

Fig. 1. Hypothesized causality model between safety leadership and safety climate.

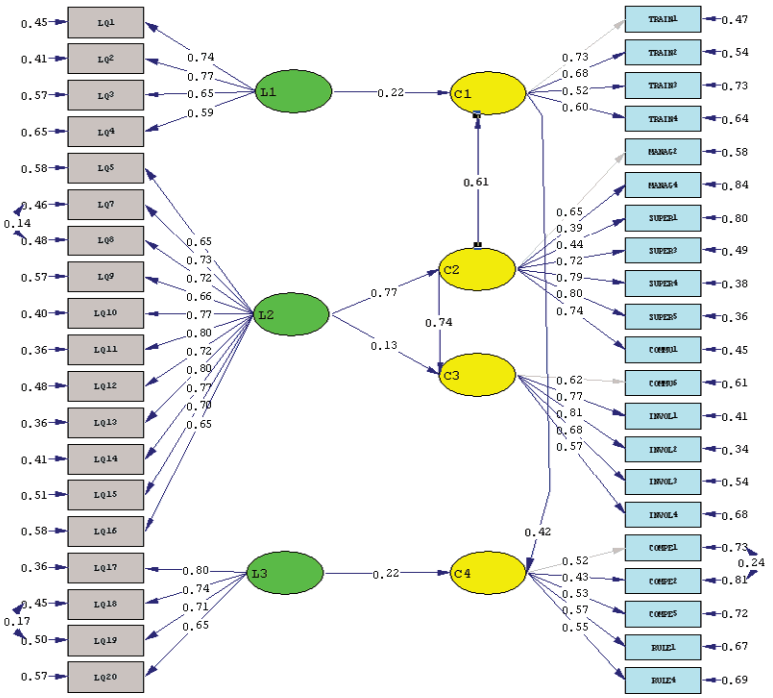

Fig. 2. Model 3 for structural equation modeling (SEM) analysis.

Fig 2 shows that the active management (L_1) of safety leadership positively affects safety training (C_1) of safety climate (path coefficient=0.22), the safety motivation (L_2) of safety leadership positively affects the safety commitment (C_2, path

coefficient=0.77) and the safety involvement (C_3, path coefficient=0.13) of safety climate, and the safety monitor (L_3) of safety leadership positively affects the safety awareness (C_4) of safety climate (path coefficient=0.22). Therefore, Hypothesis which specifies that safety leadership is positively related to safety climate is supported.

Additional finding in this study is that among safety climate, some factors predict other factors. Fig 2 shows that the safety commitment (C_2) affects the safety training (C_1, path coefficient=0.61) and the safety involvement (C_3, path coefficient=0.74), and the safety training (C_2) also affects the safety awareness (C_4, path coefficient=0.42).

4. Discussion

The focusing on safety leadership as an important issue in form positive safety climate has long been recognized in previous studies [2,9,15]. It is increasingly being recognized that senior managers play an important role in establishing the kind of safety environment which can encourage workers to be motivated to behave in a safer way.

The coal mine operation is one of the most risky operations in mining industry. Although coal mine workers attempt to ensure work safety, they are not completely successful in eliminating accidents. Safety should be a business of everyone especially in the top of coal mine. Effective health and safety performance comes from the top, senior managers have both collective and individual responsibility for health and safety; they need to examine their own behaviors, both individually and collectively. Failure to include health and safety as a key business risk in top decisions can have catastrophic results. Many high-profile safety cases over the years have been rooted in failures of leadership. We examined the importance of safety leadership to safety climate in the coal mine context and empirically evaluated safety leadership dimensions and safety climate dimensions.

5. Conclusions

Several implications can be drawn from the key findings of this study. First, safety leadership is an important factor influencing safety climate in coal mine that must be taken into consideration by coal mine managers. By understanding the differences between safety leadership dimensions, coal mine managers and officers can develop effective action plans to reduce unsafe behavior or human errors in coal mine. Second, the findings suggest that transformational leadership style (e.g., safety motivation and active management) is positively related to safety climate in coal mine, implying that this leadership style may play an important role in promoting safety climate.

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