ISSN: 2710-0588

Simulation Study on the Influence of Managers' Safety Attitude on the Safety Behavior of Construction Workers

Jianshe Zhang, Kai Zhang*

School of Civil Engineering, Henan Polytechnic University, Jiaozuo 454000, China

*212308020096@home.hpu.edu.cn

Abstract

Construction safety is a major challenge in the construction industry, and workers' unsafe behavior is one of the main causes of safety accident. Therefore, adopting scientific methods to motivate workers' safety behavior (WSB) has become the mainstream in the field. This study establish a priori model based on existing theories and literature to elucidate the relationship between managers' safety attitude(MSA), workers' safety awareness (WSA), trust in managers (WTM), and WSB. Develop a potential model using Netlogo software to investigate the impact of MSA on WSB. Conduct univariate and multivariate experiments to explore the influence of MSA on WSB. The research results indicate that MSA, WSA, and WTM can actively promote WSB. At the same time, MSA can further positively influence WSB through WSA and WTM. This study is helpful for building managers to construct a knowledge system of safety attitudes, which can provide reference for the improvement of laws and regulations in the construction industry.

Keywords

Manager's safety attitude, worker safety behavior, worker safety awareness, trusting managers, simulation experiment.

1. Introduction

The construction industry plays an indispensable role in the national economy, serving as a vital force in driving economic growth and addressing rural labor employment. However, safety incidents frequently occur due to complex construction processes and hazardous working conditions. Statistics show that in 2024 alone, China recorded 444 workplace accidents in housing and municipal engineering, resulting in 483 fatalities [1], causing significant casualties and property losses. Existing research indicates that over 80% of these accidents stem from unsafe worker behaviors. Therefore, investigating the root causes of worker safety violations and developing scientific strategies to incentivize safe practices have become urgent challenges for the construction sector.

Current research predominantly investigates antecedent variables of worker safety behaviors at individual and team levels [2], primarily focusing on safety climate [3], safety leadership [4], and leader-follower exchange dynamics. However, in practical project management, safety managers–as critical stakeholders ensuring engineering projects proceed safely, efficiently, and in compliance–play a pivotal role where their attitudes significantly influence management effectiveness. When managers demonstrate strong safety commitment, they not only ensure construction workers' safe operations through effective safety management practices, but also inspire and motivate employees by setting positive examples. This dual approach fosters the development of safety behaviors among workers. Therefore, managerial safety attitudes should be recognized as a significant antecedent for worker safety behaviors, warranting exploration of how these attitudes influence the process of worker safety behavior formation. However,

ISSN: 2710-0588

academic research remains inconclusive regarding the specific pathways through which managerial safety attitudes affect worker safety behaviors.

In light of this, this study investigates the formation of worker safety behaviors by examining managers 'safety attitudes, workers' safety awareness, and trust in managers. Grounded in existing theories and literature, we propose hypotheses and construct a conceptual model illustrating the relationships between managers 'safety attitudes, workers' safety awareness, trust in managers, and worker safety behaviors. A simulation model was developed using the NetLogo platform to validate this conceptual framework. The findings not only deepen academic understanding of the complex relationship between safety attitudes and behaviors but also provide practical guidance for safety management in construction enterprises.

2. Literature Review and Conceptual Model

2.1. Manager Safety Attitude and Construction Worker Safety Behavior

Attitude is fundamentally a kind of psychological state, which can affect people's memory, decision-making process and thinking mode to some extent, and produce corresponding guidance and restriction effects [5].In safety-related research, most scholars have primarily focused on construction workers 'safety attitudes. For instance, Chen [6] argue that workers' safety attitudes essentially represent a psychological state shaped by personal values and internal emotions within the construction industry. In contrast, discussions about managers 'safety attitudes remain relatively scarce. This paper defines managers' safety attitudes based on the definitions of worker safety attitudes and their safety practices, characterizing them as psychological tendencies and behavioral patterns exhibited by managers during safety management processes.

Worker safety behavior refers to a series of actions taken by workers in the process of work to protect their own and others' life safety, health and avoid property loss. These behaviors are aimed at preventing accidents, reducing the risk of accidents and ensuring the smooth progress of work [7].In the field of construction, the concept of worker safety behavior was first proposed by Griffin and Neal [8], which is further divided into two dimensions: safety compliance and safety engagement. Safety compliance emphasizes essential and core safety measures that workers must implement to ensure workplace safety. Safety engagement, on the other hand, refers to voluntary actions that, while not mandatory, actively contribute to enhancing overall site safety levels. This distinction not only deepens our understanding of safety behavior but also highlights the proactive and positive role workers play in maintaining a safe work environment.

A manager's safety attitude is a significant variable influencing workers' safety behaviors. Managers 'safety attitudes can shape their own conduct, which in turn affects workers' safety behaviors. Ye [9] pointed out that workers 'safety attitudes directly impact their safety behaviors. Given the close relationship between managers and workers, it can be inferred that managers' safety attitudes directly influence their own behavior.Burns[10] believes that managers 'behavior can directly affect workers' safety behavior; He [11] point out that project managers can also influence workers' safety behavior through emotional communication and sharing.

In daily construction operations, the frequent interactions between managers and frontline workers create an interconnected work environment. These close engagements significantly influence workers 'psychological states and daily safety behaviors. As project leaders and supervisors, managers' words and actions unconsciously set a model that subtly shapes workers 'attitudes and behaviors. When managers prioritize workplace safety and implement proactive measures to prevent and eliminate hazards, their persistent commitment to safety deeply inspires every worker. Workers sense the management's emphasis on safety, leading

ISSN: 2710-0588

them to voluntarily comply with regulations and proactively adopt protective measures to ensure personal and others 'safety. Therefore, it can be concluded that managers' positive safety attitudes positively influence construction workers' safety behaviors.

2.2. The Role of Workers 'Safety Awareness in the Process of Influencing Workers' Safety Behavior by Managers' Safety Attitude

The academic community has conducted in-depth analyses of safety awareness, yet no unified definition has been established. Song [12] define worker safety awareness as the ability and willingness of workers to identify, assess, prevent, and control safety risks in their work environment. Meanwhile, Yang [13] describe it as a comprehensive psychological process involving cognitive understanding, emotional responses, and coping strategies workers develop when facing potential hazards from surrounding personnel, objects, and environments during production operations. This study adopts the definition of worker safety awareness proposed by Song.

The proactive safety mindset of managers positively influences workers 'safety awareness through multiple mechanisms. Firstly, managers demonstrate leadership by making decisive safety decisions and adhering to safety protocols, consistently conveying the core values of safety culture to employees. This helps establish a clear safety baseline in workers' cognitive framework. Secondly, their proactive approach reinforces workers 'respect for safety standards. Through regular safety training, workers evolve from mechanical memorization to flexible risk assessment capabilities. Lastly, strict enforcement of safety measures enables workers to intuitively recognize the non-negotiable nature of safety regulations during daily operations. Over time, this cultivates instinctive risk-avoidance behaviors. Therefore, it can be concluded that positive managerial safety attitudes significantly enhance workers' safety consciousness.

Existing literature confirms that workers' safety awareness directly influences their safety behaviors. Xi [14] found that when workers demonstrate strong safety awareness, they are more likely to proactively adopt standardized operational practices, thereby promoting the development of safe behaviors. Conversely, Ye [9] revealed that weak safety awareness may lead to habitual or unconscious unsafe behaviors. Safety awareness serves as an intrinsic motivator that drives workers to engage in safe behaviors.When workers demonstrate strong safety awareness, they become more proactive in complying with safety regulations and implementing preventive measures to avoid or reduce workplace accidents. As project leaders, when management staff exhibit a proactive safety attitude, workers 'safety consciousness is further stimulated and reinforced. Workers perceive the management's emphasis on safety, which motivates them to enhance personal vigilance, strictly adhere to safety protocols, and take necessary precautions. This top-down safety culture transmission ensures that workers 'safety behaviors are not only governed by external regulations but also driven by internal safety awareness. Therefore, workers' safety consciousness serves as a crucial link between management's safety attitudes and worker safety behaviors, promoting the generation of safe practices. Based on this analysis, it can be concluded that workers' safety awareness directly positively influences their safety behaviors. Additionally, it can be inferred that managers 'safety attitudes help enhance workers' safety awareness while indirectly fostering safe behaviors.

2.3. The Role of Trust Managers in the Process of Managers 'Safety Attitudes Influencing Workers' Safety Behaviors

Trust management refers to the emotional trust and belief system that construction workers develop toward their supervisors. Zhang [15] integrated trust management with individual psychological states, defining it as a mental state where employees hold positive expectations

ISSN: 2710-0588

about management intentions. This psychological state manifests as a willingness to assume certain risks regarding both the supervisor's actions and potential shortcomings.

A manager's safety-oriented attitude is crucial for building trust between workers and supervisors. By demonstrating commitment to safety protocols and investing in protective measures, managers establish a foundation of trust, making employees perceive their accountability in safety matters. When managers take decisive action to address identified hazards or consistently prioritize life safety in resource allocation, workers develop trust through observation. This approach significantly enhances workers' acceptance of management decisions. Moreover, proactive responses to workers 'safety concerns further strengthen two-way trust-building, encouraging greater cooperation when following safety directives. Therefore, it's evident that positive managerial safety attitudes positively influence worker trust in supervisors.

It has been pointed out that trust managers affect workers' safety behavior. For example, Li [16] pointed out that employees 'trust in senior executives can effectively reduce employees' turnover behavior; Wei and Long [17] pointed out that subjective cognitive trust and affective trust both positively affect employees' behavior. Based on the above analysis, it can be inferred that trust managers have a positive impact on workers' safety behavior.

Based on the above conclusions, the following inferences can be drawn: When managers have a high safety attitude, workers are more likely to trust them. This trust will encourage workers to strengthen their own safety behaviors and thus avoid accidents.

Based on the above analysis, the conceptual model of this study is constructed, which serves as the basis of the simulation model, as shown in Figure 1.

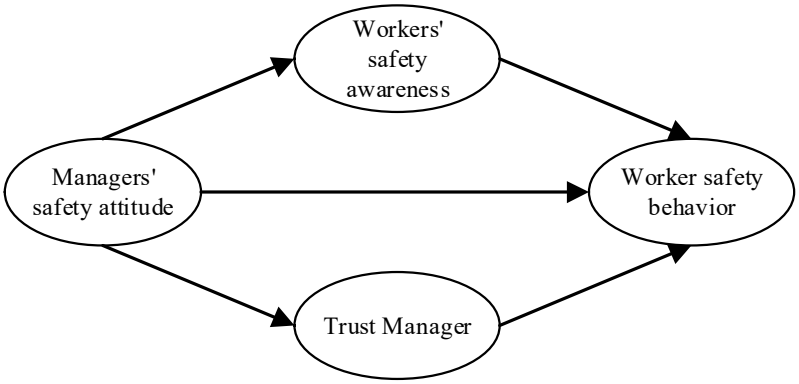

Figure 1. Conceptual model

3. Simulation Experiment Design

This study utilizes NetLogo6.4 to develop a simulation platform. As an integrated modeling and simulation environment for multi-agent systems, NetLogo is particularly suited for simulating time-evolving, structurally complex systems that accurately depict worker-environment interactions during construction. The platform provides comprehensive tools for monitoring simulations and generating outputs, enabling researchers to effectively explore the intrinsic connections between micro-level individual behaviors and macro-level phenomena arising from inter-individual interactions. In this research, we employ NetLogo's built-in scenarios to simulate construction site environments. By modifying the Turtle class to create Worker classes representing on-site workers, and reconstructing the Patch class to represent external environments, we achieve precise representation of both human-constructed structures and environmental conditions.

ISSN: 2710-0588

3.1. Simulation Process

In NetLogo, Turtle and Patch constitute the basic classes of the program. In order to reproduce how managers 'safety attitude affects workers' safety behavior, the Turtle class can be extended to represent workers, and the Patch class can be customized to depict the external environment.

During on-site construction operations, Workers (construction personnel) interact with Patch (representing external environmental factors). In this process, workers 'safety behavior tendencies are influenced by both external environmental changes and their own behavioral patterns, which may either enhance or diminish these tendencies. If no significant combined effect occurs, the system will restart the random interaction cycle. As workers' safety behavior tendencies accumulate over time, positive values indicate increased likelihood of implementing safety measures, while negative values trigger a new round of random interactions, as illustrated in Figure 2.

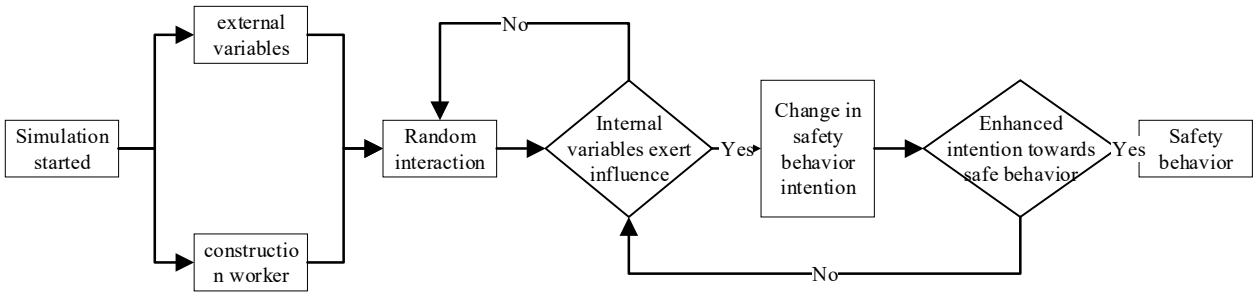

Figure 2. Simulation flow chart

3.2. Variable Parameter Setting

Model variables parameters mainly include external environmental variables and other related variables. As shown in Table 1 and Table 2.

Table 1. External environmental variable parameters

Variable naming	Programming code	Setting the value	Is it adjustable
Initial manager security attitude	initial_msa	0-10	Directly adjustable
Initial formal relationship	initial_fr	0-10	Directly adjustable
Initial informal relationship	initial_ir	0-10	Directly adjustable
Safety attitude of tile manager	patches_msa	N (initial_msa, 1)	Indirectly adjustable

Table 2. Other relevant variable parameters

Variable naming	Programming code	Setting the value	Is it adjustable
Total number of initial workers	initial_wn	0-100	Directly adjustable
Initial worker safety awareness	initial_wsa	0-10	Directly adjustable
Initial trust manager	initial_wtm	0-10	Directly adjustable
Initial worker safety behavior costs	initial_wsbc	0-100	Directly adjustable
Initial other safety behavior intentions	initial_osb	0-100	Directly adjustable
Workers' Safety Intentions	wsa	N (initial_wsa, 1)	Indirectly adjustable
Trust Manager	wtm	N (initial_wtm, 1)	Indirectly adjustable
Other workers' safety behavior intention	osb	N (initial_wsbi, 1)	Indirectly adjustable
Safety behavior generation coefficient	sb_index	B (n, 0.8)	Irreversible

Safety Attitude Attributes of Site Managers: Each manager's attribute is assigned a value within [0,10], with an initial value of 2. Higher values indicate greater emphasis on safety. Initial

ISSN: 2710-0588

Workforce Size: This parameter sets the number of workers at the construction site, ranging from [0,100] with an initial value of 50. Initial Worker Safety Awareness: This determines the baseline safety consciousness level of workers at the site, measured in [0,10] with an initial value of 2. Higher values reflect stronger safety awareness. Initial Trust in Managers: This metric indicates workers' trust in management, ranging from [0,10] with an initial value of 2. Higher values demonstrate greater trust. Initial Safety Behavior Cost: Set to [0,100] with a default value of 45. Higher values indicate workers 'willingness to comply with safety regulations. Additionally, a Safety Behavior Generation Coefficient is introduced to quantify how positively workers' safety intentions translate into actual compliance. While proactive safety behaviors are typically encouraged, factors like fatigue and stress may interfere. Therefore, the Safety Behavior Implementation Coefficient follows a binomial distribution (p=0.8) to reflect this reality.

4. Simulation Experiments

4.1. Single-variable Scenario Simulation

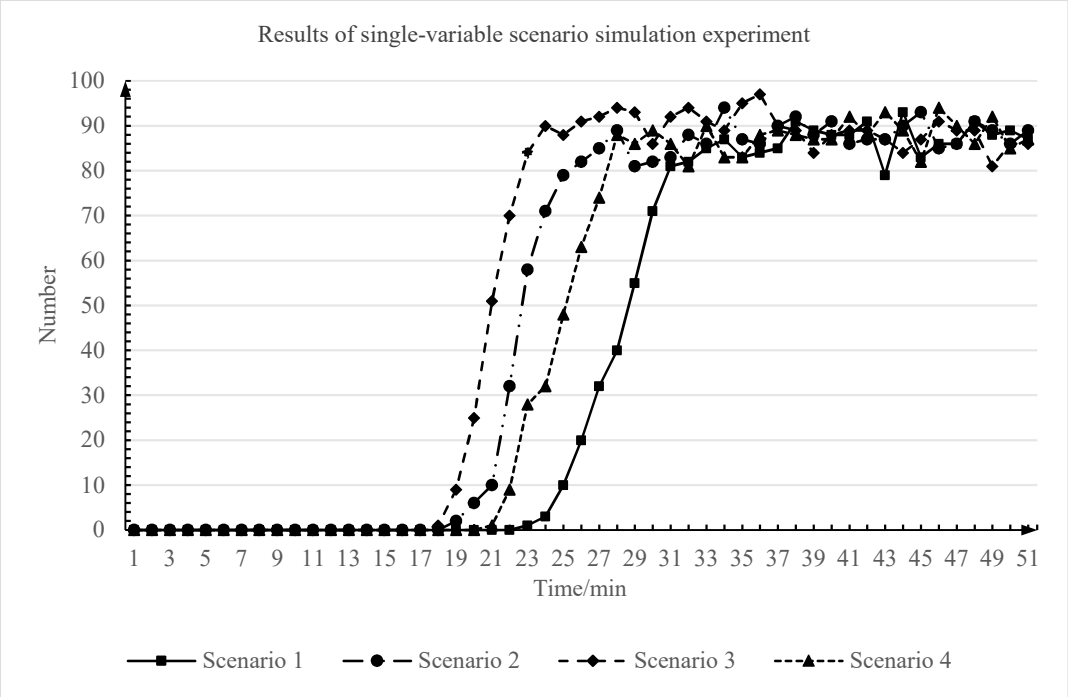

Figure 3. Simulation results of single variable experiment

Using managerial safety attitude (MSA), worker safety awareness (WSA), and trust in managers (WTM) as adjustable variables, four single-variable experimental scenarios were designed: (MSA, WSA, WTM) = (2,2,2) Scenario 1, (MSA, WSA, WTM) = (8,2,2) Scenario 2, (MSA, WSA, WTM) = (2,8,2) Scenario 3, and (MSA, WSA, WTM) = (2,2,8) Scenario 4. The experiment tracked the temporal changes of workers 'safety behaviors across these scenarios, as shown in Figure 3. In Scenario 1, where managers exhibited lower safety attitudes, workers began demonstrating safety behaviors around t=22. From t=32 onward, the number of workers adopting safety measures remained relatively stable. In Scenario 2, due to managers' high safety attitudes, workers started showing safety behaviors around t=18. From t=26 onward, the number of workers taking safety measures stabilized. Compared with Scenario 1, it is evident that managers 'high safety attitudes positively influenced workers' safety behavior formation. In Scenario 3, given workers' higher safety awareness levels, safety behaviors emerged around t=17, and from t=23 onward, the number of workers implementing safety

ISSN: 2710-0588

measures stabilized. Compared with Scenario 1, it can be inferred that a high level of worker safety awareness significantly promotes the formation of worker safety behaviors, meaning that worker safety awareness positively influences worker safety behaviors. In Scenario 4, when trust in managers is at a higher level, worker safety behaviors begin to emerge at t=20 and remain stable from t=27 onward. The comparison with Scenario 1 demonstrates that trust in managers has a positive impact on the formation of worker safety behaviors, indicating that trust in managers can positively influence workers' safety behaviors. As shown in Figure 3.

4.2. Multivariate Scenario Simulation

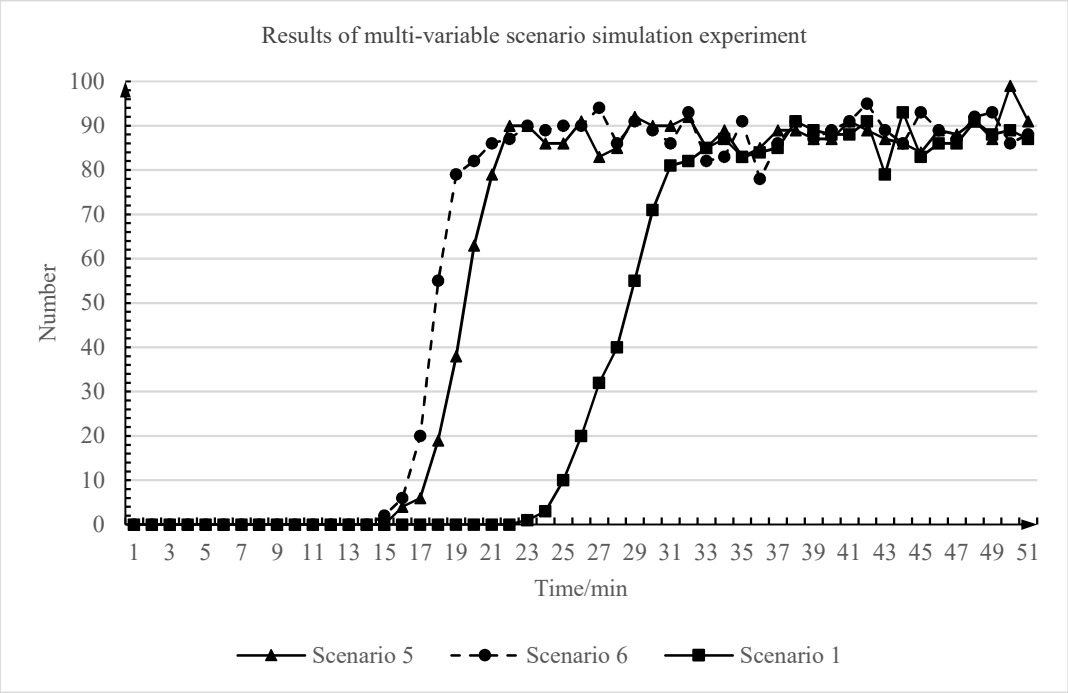

Figure 4. Simulation results of multivariable experiment Figure

Building upon the single-variable simulation framework, we designed experimental scenarios (Scenario 5: MSA, WSA, WTM) = (8,8,2) and (Scenario 6: MSA, WSA, WTM) = (8,8,8) to analyze how workers 'safety awareness and trust in managers influence the process through which managers' safety attitudes affect worker safety behaviors. The simulation results are illustrated in Figure 4. In Scenario 5, both managers 'safety attitudes and workers' safety competencies remained at high levels. Under these conditions, construction workers began adopting safety behaviors at t=14, with a relatively high peak in safety behaviors starting from t=21 followed by random fluctuations around this value. Comparing Scenario 1 and Scenario 3 reveals that when managers demonstrate positive safety attitudes and workers exhibit strong safety awareness, most construction workers take safety actions more promptly. This demonstrates that workers 'safety awareness acts as a mediating factor in how managers' safety attitudes influence worker safety behaviors – specifically, managers 'safety attitudes can enhance workers' safety awareness to further reinforce the positive impact on safety behaviors. In Scenario 6, managers 'safety attitudes, workers' safety awareness, and trust in managers all remained at high levels. Workers initiated safety behaviors at t=15, while those adopting safety behaviors from t=19 onward reached a relatively high peak with random fluctuations around this value. Comparing Scenario 4 and Scenario 5 reveals that when managers 'safety attitudes, workers' safety awareness, and trust in managers are all at high levels, most construction workers exhibit faster adoption of safety behaviors. This suggests that trust in managers positively influences the process through which managers 'safety attitudes affect workers' safety behaviors by providing additional pathways, meaning that managers 'safety attitudes

ISSN: 2710-0588

can further enhance their influence on workers' safety behaviors via trust. As shown in Figure 4.

5. Conclusion

(1) Establish the conceptual model of managers 'safety attitude, workers' safety awareness and trust in the safety behavior of managers and workers. Through the simulation software Netlogo, it is found that managers 'safety attitude, workers' safety awareness and trust in managers can positively affect workers' safety behavior during single-variable simulation.

(2) The single-variable simulation experiment shows that managers 'safety attitude, workers' safety awareness and trust in managers can positively affect workers' safety behavior.

(3) The multivariate simulation experiment shows that managers 'safety attitude can be enhanced through workers' safety awareness and trust in managers to further enhance the positive influence on workers' safety behavior.

(4) The study only analyzed the safety attitude of managers through simulation, and the safety awareness of workers and trust in managers affect workers' safety behaviors. Subsequent scholars can further explore the influence of other variables (safety leadership and safety atmosphere) on this process.

References

[1] Ministry of Housing and Urban-Rural Development. National Report on Production Safety Accidents in Housing and Municipal Engineering: Beijing: Ministry of Housing and Urban-Rural Development Press, [S]. Beijing: Ministry of Housing and Urban-Rural Development Press, 2024.

[2] XIA NN, LI DZ, YE G, et al. Research Progress and Prospects on Antecedents of Employee Safety Behavior in Construction Projects [J]. China Journal of Safety Science, 2021,31(06):44-55.

[3] ZHAO H, LIU HY, ZHENG JW, et al. The Impact of Informal Group Safety Atmosphere on Construction Workers' Safety Behavior [J]. China Journal of Safety Science, 2023,33(10):30-8.

[4] LI L, CAO LR, LI SY, et al. Analysis of Leadership Behavior on Unsafe Behavior Game Theory in Coal Mine Workers from the Perspective of Informal Organizations [J]. Journal of Xi'an University of Science and Technology, 2022,42(06):1088-95.

[5] SHI RH. Modern Social Psychology [M]. Shanghai: East China Normal University Press, 2007.

[6] CHEN XF & CHEN WT. Research on the Safety Attitude of Construction Workers and Its Influencing Factors [J]. Journal of Safety Science in China, 2017,27(04):31-6.

[7] BEUS J M, DHANANI L Y, MCCORD M A. A Meta-Analysis of Personality andWorkplace Safety: Addressing Unanswered Questions[[J]. Journal of AppliedPsychology, 2015.

[8] GRIFFIN M A, NEAL A. Perceptions of safety at work: a framework for linking safety climate to safety performance, knowledge, and motivation [J]. Journal of occupational health psychology, 2000, 5(3): 347-58.

[9] YE G, YUE HZ, YE X, et al. The Impact of Construction Workers' Implicit and Explicit Safety Attitudes on Safety Behaviors [J]. China Journal of Safety Science, 2024,34(12):2-7.

[10] BURNS C G, CONCHIE S M. Risk information source preferences in construction workers [J]. Employee Relations, 2013, 36: 70-81.

[11] HE C, JIA G, MCCABE B, et al. Relationship between leader–member exchange and construction worker safety behavior: the mediating role of communication competence [J]. International Journal of Occupational Safety and Ergonomics, 2021, 27(2): 371-83.

[12] SONG ZK. Research and Evaluation on Safety Consciousness of Construction Workers of Mountain Expressway [J]. Advances in Psychology, 2023, 13(2): 397-407.

[13] YANG CF, CHEN XB, SUN QB, et al. Exploration and Analysis of Influencing Factors on Employees' Safety Awareness in Enterprises [J]. Journal of Safety Science of China, 2015,25(01):34-9.

ISSN: 2710-0588

[14] XI YT, LIU RH, ZHANG QX, et al. The Impact of Safety Atmosphere on Pilot Safety Behavior: The Mediating Role of Safety Awareness [J]. Journal of Safety Science in China, 2020,30(09):15-21.

[15] ZHANG P, LI N, FANG D, [15] ZHANG P, LI N, FANG D, et al. Supervisor-Focused Behavior-Based Safety Method for the Construction Industry: Case Study in Hong Kong [J]. Journal of Construction Engineering and Management, 2017, 143(7): 05017009.

[16] LI Q, WANG YP, LIU XG, et al. The relationship between employees' trust in executives and their turnover intention: A study on the mediating effect of organizational commitment [J]. Soft Science, 2009,23(12):108-12.

[17] WEI HM & LONG LR. The Impact of Cognitive Trust and Affective Trust on Employee Behavior and Performance [J]. Journal of Psychology, 2009,41(01):86-94.