

Article

Research on the Impact of Managers' Safety Perception on Construction Workers' Safety Behaviors

Kongling Liu ¹, Xun Luo ², Jing Feng ¹, Hujun Li ^{3,*}, Baijian Liu ¹ and Yu Jian ³

¹ Department of Architecture Engineering, Hunan Institute of Engineering, Xiangtan 411104, China; konglingliu@hnie.edu.cn (K.L.); 20885@hnie.edu.cn (J.F.); liubaijian1998@outlook.com (B.L.)

² School of Medicine, Henan Polytechnic University, Jiaozuo 454000, China; luoxunphar@hpu.edu.cn

³ School of Civil Engineering, Henan Polytechnic University, Jiaozuo 454003, China; jy212408020088@outlook.com

* Correspondence: lihujunem@hpu.edu.cn

Abstract: The construction industry is replete with significant safety risks, underscoring the necessity to comprehend the factors that shape workers' safety behaviors for efficacious accident prevention. This study aims to investigate the impact of managers' safety perception (MSP) on construction workers' safety behaviors (WSBs), while also exploring the mediating roles of workers' safety awareness (WSA) and workers' safety competency (WSC). Utilizing a structural equation model (SEM), data were collected from 248 construction workers through a validated questionnaire. The findings indicate that MSP has a direct influence on WSBs (mean effect size = 0.065, $p < 0.01$) and an indirect effect on WSBs through enhanced WSA (effect size = 0.386, $p < 0.01$) and WSC (effect size = 0.392, $p < 0.01$). This research makes a contribution to the existing literature in several ways. First, it introduces a new measurement scale for MSP. Second, it highlights the direct and indirect effects on WSBs. Third, it emphasizes the importance of fostering safety awareness and competency among workers. In addition, the study offers practical implications for construction managers seeking to improve safety outcomes on-site.

Keywords: managers' safety perception; construction workers' safety behaviors; workers' safety awareness; workers' safety competency; influencing process; structural equation model



Citation: Liu, K.; Luo, X.; Feng, J.; Li, H.; Liu, B.; Jian, Y. Research on the Impact of Managers' Safety Perception on Construction Workers' Safety Behaviors. *Buildings* **2024**, *14*, 3467. <https://doi.org/10.3390/buildings14113467>

Academic Editor: Pramen P. Shrestha

Received: 3 September 2024

Revised: 26 October 2024

Accepted: 28 October 2024

Published: 30 October 2024



Copyright: © 2024 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

The construction industry plays a pivotal role in China's national economy, providing the necessary infrastructure for economic growth and employment opportunities, particularly for rural workers [1,2]. Despite the sector's substantial economic impact, it is marred by considerable safety concerns, largely due to its intrinsic complexities and the inherently hazardous outdoor working environment [3–7]. The Chinese government has reported a total of 584 safety accidents that occurred in 2023, resulting in 635 fatalities [8]. Similarly, in the United States, the construction industry recorded 1902 fatal injury cases in 2022, underscoring the global nature of safety challenges in this sector. Prior research has indicated that over 80% of safety accidents are linked to unsafe behaviors among workers [9,10], emphasizing the need to investigate the incentive mechanisms for workers' safety behaviors (WSBs) to prevent safety accidents in the construction industry.

To mitigate these risks, the Chinese government has implemented a comprehensive set of safety regulations and standards. For example, the "Regulations on the Management of Construction Project Safety Production" (2003) and the "Occupational Health and Safety Management Systems-Requirements with Guidance for Use" (GBT 45001-2020) set forth rigorous standards for safety protocols and training for workers in the construction sector [11,12]. Nevertheless, despite the existence of regulatory frameworks, the high rate of accidents in the construction industry indicates that existing policies may not be fully effective in motivating WSBs on site.

Previous scholars have examined the causes or influential factors affecting WSBs [3,13–15]. These factors have been classified into societal, project-related, organizational, team-based, and individual causes [16,17]. However, a significant gap remains in our understanding of the specific role that safety managers' individual characteristics play in influencing WSBs. Most studies have focused on leadership styles, such as safety leadership and leader-member exchange (LMX), in motivating worker safety compliance [18–22]. However, there has been little attention paid to how managers' safety perceptions (MSP) influence this process, despite emerging evidence that managers with a heightened awareness of safety tend to demonstrate superior knowledge and competency in guiding safe work practices [18,23].

Moreover, although workers' safety awareness (WSA) and worker' safety competency (WSC) have been identified as pivotal elements influencing their behaviors, the precise mechanisms through which these factors interact with MSP remain uncertain. The academic literature lacks a comprehensive theoretical framework that explains how MSP influences WSBs, either directly or indirectly, through mediators such as WSA and WSC. It is imperative that this gap be addressed, as an understanding of these relationships could provide new strategies for improving safety outcomes on construction sites.

In light of these considerations, the present study seeks to examine the influence of MSP on WSBs and the contributions of WSA and WSC to this influence. First, the paper puts forth research hypotheses that are firmly rooted in existing theories and literature. Furthermore, it establishes a conceptual model to describe the relationships between MSP, WSA, WSC, and WSBs. Second, structural equation models (SEMs) will be employed to test the conceptual model, thereby enabling conclusions to be drawn.

The findings of this research will make a significant contribution to both theoretical and practical knowledge. Theoretically, the study will establish a novel framework that links MSP with WSBs, thereby contributing to the existing safety management literature. From a practical standpoint, the findings will offer valuable insights to policymakers and construction managers seeking to develop more effective safety management strategies. By identifying the key drivers of WSBs, particularly the crucial role of MSP, the study will inform targeted interventions that enhance compliance with safety regulations, thereby reducing accident rates within the construction industry (see Section 5.1 for further discussion of the theoretical and practical contributions).

This study's main originality is its focus on a particular kind of safety manager individual trait, namely, MSP, and its examination of how MSP affects WSBs through the mediating effects of WSA and WSC. This study provides a fresh viewpoint by investigating managers' personal characteristics and their direct and indirect impacts on safety outcomes, in contrast to previous research that mostly focuses on leadership styles. Additionally, this study presents a recently validated measurement scale for evaluating MSP.

Despite its novelty, this study has two major limitations: (a) it only looks at the Chinese construction industry, which restricts how broadly the findings can be applied, and (b) other organizational and individual factors, like the safety climate and workers' attitudes, are not taken into account (more discussion on limitations is presented in Section 5.3).

2. Literature Review and Conceptual Model

2.1. Manager's Safety Perception

Safety perception refers to the individual or organizational mindset and behavior regarding their understanding of safety regulations, safety institutions, safety organizations, workplace hazards, and hazard prevention methods [24,25]. Safety perception for construction managers refers to how they view the previously described safety features of project construction and management procedures. This includes their knowledge of national safety laws and regulations, safety management goals, safety scenarios, organization-level or project-level safety management procedures, and associated safety technology and methods [26]. By addressing workers' safety concerns and establishing high-level safety management habits, MSP plays a critical role in comprehensive safety management. The

frequency of risky behaviors among construction workers can be considerably decreased by managers' daily safety knowledge and safety management techniques, which would lower the number of accidents related to safety [27].

2.2. Workers' Safety Awareness

There are differing opinions among academics as the building industry's academic community has not yet agreed upon a definition for WSA. According to Kim et al. [28], WSA includes the psychological functions of will, emotion, and cognition in relation to the risks in the workplace. In contrast, Hubbard et al. [29] defined WSA as the comprehension and use of safety concepts in industrial operations. Peterson [30] suggested that WSA involves the psychological defenses that employees use on a daily basis when performing production activities, which reflects their innate need for safety. Zhao [31] underlined that subjective cognition shapes WSA, which is impacted by a person's encounters with pertinent technologies and safety rules. For this investigation, we have utilized Hubbard et al.'s definition.

2.3. Workers' Safety Competency

WSC results from aligning safety tasks with their intrinsic characteristics, which are dynamic, adaptable, and individually based [24,32]. This concept refers to the ability and skills necessary to discern and address potential hazards during construction operations, leveraging available resources and the surrounding environment to mitigate personal injuries and property damage [33,34]. In the context of routine construction activities, WSC incorporates a range of elements, including prevention of accidents and the formulation of post-accident responses. This expansive safety competency is typically expressed as a combination of diverse qualities, which can be categorized into explicit knowledge and skills, as well as implicit attitudes and personal values. In a more limited sense, construction WSC is primarily concerned with the knowledge and skills related to safety [35,36], which is the definition of WSC adopted in this study.

2.4. Workers' Safety Behaviors

WSB was first introduced into the construction industry by Neal et al. [37,38], drawing upon the principles of behavior-based safety management [5,39]. Since its introduction, this concept has been widely accepted as an effective indicator for predicting the performance of construction safety management. The term is defined as a series of actions undertaken by workers to ensure their own safety and that of others during the construction process. These behaviors can be classified into two categories: safety compliance behaviors and safety participation behaviors [40]. Safety compliance behaviors are defined as actions undertaken by workers to adhere to safety rules, regulations, and organizational standard operating procedures within their work environment. To a certain extent, the responsibility for safety compliance behaviors is attributed to the workers themselves. In contrast, safety participation behaviors encompass voluntary safety-related actions that workers undertake to promote the safety of themselves and their colleagues, extending beyond their formal job duties. As posited by Neal and Griffin, construction workers' safety behaviors include obeying safety rules and regulations, correctly using protective equipment, and taking appropriate measures to ensure their own safety and that of others when confronted with potential hazards [41,42].

2.5. Manager's Safety Perception and Workers' Safety Behaviors

MSP can be defined as the knowledge, concepts, and cognitive frameworks that managers develop regarding safety-related issues through their own perceptions, memories, thoughts, and imaginations [25]. In context of daily construction activities, front-line managers are in close contact with construction workers, and their influence on workers' psychological and behavioral safety is significant. According to cognitive theory, when individuals engage in communication, particularly during periods of transition, they actively

process the messages they receive and generate cognitive responses [43]. The consequences of these cognitive responses ultimately determine whether particular behavior roles are adopted [43]. Safety managers occupy a pivotal role in the formation and development of WSBs, and their safety perception represents a vital factor influencing the quality and safety of operations. The extant literature on safety management in mines has identified MSP as a significant predictor of workers' safety behaviors. For instance, An et al. [44] have demonstrated that managers exert an influence on miners' unsafe behaviors through their safety knowledge and motivations. Additionally, MSP can impact workers' physical and psychological symptoms [45], which are prerequisites for their safety behavior according to the theory of planned behavior [46]. Moreover, the safety perceptions of construction workers' managers and foremen are key influential factors in their safety behavior. Project managers and foremen who possess a high level of safety perception are knowledgeable about various aspects of industrial safety, including the characteristics of safe practices, national and organizational safety laws and regulations, as well as management strategies for addressing safety hazards and risks. Such perceptions can effectively enable project safety managers and foremen to implement efficacious safety management strategies [26]. Consequently, it can be posited that MSP can positively influence WSBs.

2.6. Mediating Role of Workers' Safety Awareness

While prior research has not shown that MSP can directly affect WSA, foremen and safety managers who have a good safety perception can successfully communicate precise and comprehensive safety information to front-line employees. After passively absorbing this information, these workers may become more aware of safety issues and adopt safer practices [18,19,47,48]. Additionally, after developing a high level of safety awareness, construction workers are likely to adopt more standardized safety practices and are much more skilled at identifying potential safety hazards throughout the construction process [49]. Additionally, workers with heightened safety awareness are more inclined to recognize and address unsafe conditions, and a safe working environment is essential for encouraging safe behaviors. Conversely, previous research has indicated that when workers possess low safety awareness, they may engage in habitual and unconscious unsafe behaviors [38,50,51], such as leaving the electrical box open, letting cables soak in water, or storing flammable materials in the woodworking area. In contrast, when workers demonstrate higher degree of safety awareness, they are more predisposed to engage in safe behaviors. Based on the above analyses, we can speculate that MSP can positively influence WSA, which in turn affects WSBs. Additionally, WSA exerts a mediating effect on the relationship between MSP and WSBs.

2.7. Mediating Role of Workers' Safety Competency

Perception is a prerequisite for related behaviors, and managers' safety perception directly influences their safety-related actions. Managers are more likely to support safety training, invest in safety, and carry out safety inspections in compliance with industrial safety rules when they possess a higher degree of safety perception. These activities, i.e., safety training, safety investment, and safety inspection, have a significant impact on workers' safety competency [36]. Both formal and informal safety training enhance workers' knowledge and skills; safety investments provide the necessary financial support for developing these safety skills; and safety inspections ensure that safety competencies are effectively applied in on-site practices [52–54]. Therefore, we can presume that MSP can positively affect WSC.

Prior research on WSC has demonstrated that the variable has a major impact on WSBs. For instance, An et al. [44] argued that coal mine workers' safety abilities are a crucial variable affecting their safety behavior. Specifically, high levels of safety competency enable workers to identify unsafe conditions during construction activities and address them, thereby creating a safer environment for safety practices. Additionally, safety competency reflects the extent of workers' mastery of technical operations. The more skilled workers

are in these operations, the fewer mistakes they make, leading to an increase in safe behaviors [29,55]. For construction workers, the inherent temporality, complexity, and high risk of construction work necessitate a greater reliance on their safety competency to reduce damage. As such, WSC should have a more pronounced impact on WSBs in the construction industry. Therefore, we hypothesize that WSC can positively influence WSBs and exert a mediating effect on the relationship between MSP and WSBs. Accordingly, we established the conceptual model of this research (see Figure 1).

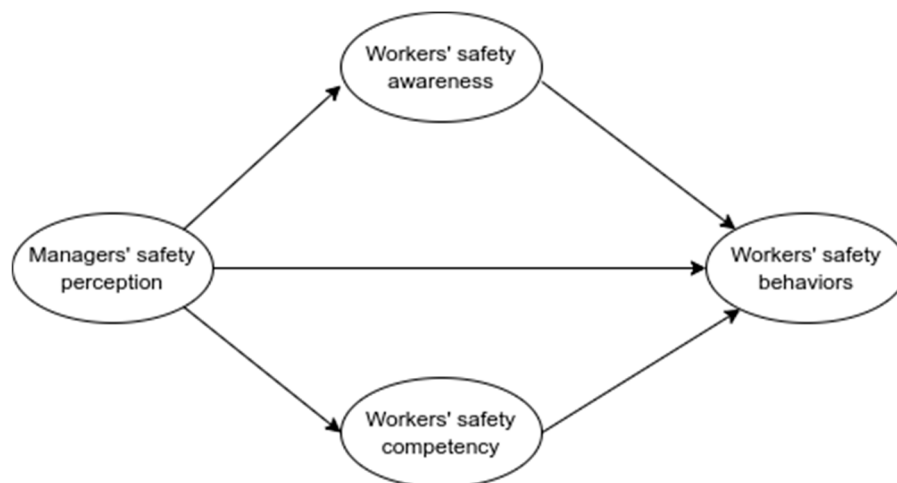


Figure 1. The conceptual model for this research.

3. Research Method

3.1. Measurement

We selected measurement scales to assess MSP, WSA, WSC, and WSBs. A multi-step approach was used to ensure the validity of these measurement scales, which allowed us to obtain reliable observational data.

Step 1 Development of initial measurement scales

The initial measurement scales for the above variables were derived from existing validated scales. A 5-point Likert scale was used to measure all the variables due to its widespread acceptance, with 1 indicating “strongly disagree” and 5 indicating “strongly agree.”

Managers’ safety perception Existing literature has not identified validated measurement scales for MSP, so the scale for measuring MSP was initially developed based on the workers’ safety perception proposed by Xiao et al. [56] and Loosemore et al. [57]. Three initial items were derived at this stage. One sample item is that “The project management personnel have a clear understanding of the major safety risk sources of this project”.

Workers’ safety awareness A 3-item measurement scale of WSA proposed by Zhao [31] was initially selected for this study. One sample item is that “I think safety should be given priority in work”.

Workers’ safety competency The measurement scales proposed by Yu [58] and Qi et al. [59] were selected to derive the scale of WSC in this study. After removing the duplicate items, a 5-item scale was initially developed. One sample item is that “I have rich experience in the work I am engaged in”.

Workers’ safety behaviors The 6-item measure scale developed by Neal and Griffin [40] was utilized in this research to assess WSBs. An example item is “I use all the necessary safety equipment to do my job”.

Step 2 Experts group evaluation

Initial MSP, WSA, and WSC scales were developed in this study. Subsequently, we organized a panel of experts to further evaluate these initial scales. Eleven experts, including six researchers and five field practitioners, were selected for this step, all of whom have ten

or more years of experience in safety management. These experts were first provided with definitions of the measured variables, after which they assessed or improved the scales based on their knowledge and experience. One item was then added to the initial MSP scale and one to the initial WSA scale.

Step 3 Pretest of six construction workers

Although all the adjusted initial scales were taken from the literature, we are unsure if the construction workers' low educational attainment will allow them to understand the items. Thus, we used six construction workers in a pretest. These workers were explicitly requested to help with scale adjustment and were carefully chosen for this pretest. To make sure that every participant understood the items, we reworded the scales following several rounds of pretesting and conversations. These procedures led to the development of the small-sample pretest measurement scales, which are shown in Table 1.

Table 1. Measurement scales used in this study.

Variables	Item Name	Measurement Items
Manager's safety perception	msp1	Project managers are very concerned about and familiar with the relevant norms of national or project safety management.
	msp2	The project management personnel attach great importance to and understand the special safety construction plan of this project.
	msp3	The project management personnel have a clear understanding of the major safety risk sources of this project.
	msp4	Project management personnel and teams believe that it is important to understand the level of workers' safe operation.
Worker's safety awareness	wsa1	I don't think the accident happened by chance, it's just that we didn't detect the hidden danger in advance.
	wsa1	I think safety should be given priority in work.
	wsa3	I believe that unsafe behavior during the construction process not only endangers myself, but also endangers other workers.
	wsa4	I think there are dangers everywhere on the construction site, so we need to be more vigilant.
Worker's safety competency	wsc1	I have rich experience in the work I am engaged in.
	wsc2	I can proficiently master the mechanical equipment used for works.
	wsc3	I can use safety protection equipment correctly.
	wsc4	I can correct my colleagues' mistakes and stop them.
	wsc5	I will proactively address safety hazards in the workplace **.
Worker's safety behavior	wsb1	I always strictly follow the safety rules and procedures to wear safety protective equipment (such as seat belts, helmets, safety shoes, protective gloves, etc.).
	wsb2	I strictly follow the safety management regulations when working.
	wsb3	I will strive to ensure my safety to the fullest extent possible **.
	wsb4	I will conduct a strict inspection of safety equipment before homework.
	wsb5	I will remind my colleagues when they are working unsafe or in unsafe areas.
	wsb6	I will actively participate in safety education **.

Notes: Items marked with ** are deemed to not meet the criteria and should be excluded.

Step 4 Small-sample pretest

We also performed a small-sample pretest to evaluate the validity of the measurement scales because they had never been tested in earlier research. For this pretest, we included 60 construction workers from two randomly chosen Changsha building sites. The collected data were imported into SPSS to evaluate the reliability and validity of the scales. We used

Cronbach's alpha and Cronbach's alpha if deleted item to test the reliability, and factor loadings from exploratory factor analyses to assess the validity of the scales. Both the MSP and WSA scales passed the reliability and validity test (with all Cronbach's alpha > 0.7, all Cronbach's alpha if item deleted < Cronbach's alpha, and all factor loading values > 0.7). One item was removed from the WSC scale and two items were removed from the WSBs scale because the values of Cronbach's alpha if deleted item are greater than Cronbach's alpha.

We acquired the measurement scales for the follow-up questionnaire (seen in Table 1) after completing the four previously described steps.

3.2. Procedure and Participants

There are two sections to the questionnaire. In the first part, we created questions to collect demographic data from the participants, such as gender, age, education, prior employment history, and current working hours. The measurement scales for the four variables, MSP, WSA, WSC, and WSBs, are shown in the second section. Construction workers were requested to provide responses to these questions.

A non-probability sampling approach was adopted for the selection of construction workers. Changsha and Zhengzhou were chosen as the target research sites due to existing collaborations with some construction companies and managers in these regions. This selection strategy made it easier to obtain high-quality data from workers. Two surveys were carried out in the two cities. We liaised with construction managers, who facilitated the completion of online questionnaires by front-line workers through WeChat. All survey responses were collected anonymously.

The online survey was conducted over a two-month period, from 1 October to 30 November 2023. A total of 286 questionnaires were collected, of which 248 deemed valid, resulting in a retention rate of 86.7%. The retained data are sufficient for further analysis, as the ratio of sample size to the number of variables exceeds 5. The sample included 225 male workers and 23 female workers. The age distribution of the respondents was as follows: 2 were under 30 years old, 156 were between 31 and 50, and 90 were 51 or older. The average duration of employment in the construction industry among the respondents was 17.62 years. Comprehensive demographic details of the surveyed construction workers are provided in Table 2.

Table 2. Demographic information on construction workers participants ($N = 248$).

Demographic Variable	Category	Numbles	Percentage (%)	Means	Standard Deviations
Gender	Male	225	91	1.09	4.57
	Female	23	9		
Age	20–30 years old	2	1	45.66	129.22
	30–40 years old	70	28		
	40–50 years old	86	35		
	>50 years old	90	36		
Education	Elementary school and below	10	4	2.13	9.39
	Junior High School	141	57		
	Senior High School	97	39		
	University and above	0	0		
Working years	<10 years	35	14	17.62	143.37
	10–15 years	120	48		
	15–20 years	12	5		
	>20 years	81	33		

Table 2. Cont.

Demographic Variable	Category	Numbles	Percentage (%)	Means	Standard Deviations
Current working hours	<0.5 years	38	15	1.40	10.77
	0.5–1 years	55	22		
	1–1.5 years	126	51		
	1.5–2 years	38	15		
	>2 years	29	12		
Project type	Residential buildings project	106	43	2.43	24.75
	Transportation project	48	19		
	Commercial residential building	28	11		
	Industrial factory building project	14	6		
	Other project	52	21		

3.3. Data Analysis Methods

First, the data were imported into SPSS 23 software to assess their normality and reliability. The skewness and kurtosis coefficients were utilized to evaluate normality. The criteria stipulate that the absolute values of the skewness coefficient should be less than 3, and the absolute values of the kurtosis coefficient should be less than 10. To test the reliability of the observed variables, Cronbach's alpha (CA), corrected item-total correlation (CITC), and Cronbach's alpha if deleted item (CADI) were employed [60]. The fundamental guidelines indicate that CA value should be greater than 0.7, CITC values should exceed 0.5, and the CADI value should be less than the CA.

Second, the data were processed using AMOS 23 to assess the validity of the measurement, which includes structural validity, convergent validity, and discriminant validity. Multi-round confirmatory factor analysis (CFA) was employed to evaluate the structural validity of the measure. We selected Chi-square/degree of freedom ratio (χ^2/df), comparative fit index (CFI), goodness of fit index (GFI), root mean square error of approximate (RMSEA), and p -value to demonstrate the fit of the models. Specifically, the χ^2/df should be less than 3, with smaller values indicating a better fit; CFI and GFI should be greater than 0.8, with higher values suggesting a better fit; and RMSEA should be less than 0.08, with smaller values indicating a better fit [61,62]. Additionally, factor loading (FL), composite reliability (CR), and average variance extracted (AVE) were utilized to assess the convergent validity. The criteria for these tests are that all FL values should exceed 0.5, CR should be greater than 0.7, and AVE should be greater than 0.5 [63]. Furthermore, the Fornell–Larcker criterion was applied to evaluate the discriminant validity, which stipulates that the AVE value of a variable must be greater than the Pearson correlation coefficients between that variable and other variables included in the models.

Third, the data were processed using AMOS 23 to validate the conceptual model proposed in the study. Three structural equation models (SEMs) were established to test both the main effect and the mediating effect. The fit of the model was assessed using χ^2/df , GFI, and RMSEA. Additionally, the Sobel test and significance tests of the path coefficients were employed to demonstrate the significance of both the main effect and the mediating effect.

4. Research Results

4.1. Data Reliability and Validity

The observational data were first imported into SPSS to test the normality. The absolute values of the skewness coefficients are between 0.055 and 2.650, which are less than the decision coefficient of 3. The absolute values of the kurtosis coefficients are between 0.744 and 5.905, which are less than the decision coefficient of 10, indicating that the observed data are subject to normal distribution.

The observed data were then processed to test reliability. As shown in Table 3, all the CITC values are greater than 0.5, all the CADI values are less than the corresponding CA

values, and all the CA values are greater than 0.7, indicating that the observed data have better reliability.

Table 3. Reliability analysis of the collected data.

Items	CITC	CADI	Overall CA
msp 1	0.975	0.931	0.971
msp 2	0.922	0.969	
msp 3	0.922	0.970	
msp 4	0.966	0.937	
wsa 1	0.782	0.933	0.934
wsa 2	0.924	0.890	
wsa 3	0.835	0.916	
wsa 4	0.844	0.914	
wsc 1	0.926	0.920	0.950
wsc 2	0.849	0.944	
wsc 3	0.910	0.928	
wsc 4	0.857	0.944	
wsb 1	0.918	0.962	0.968
wsb 2	0.881	0.963	
wsb 4	0.951	0.953	
wsb 5	0.918	0.962	

The KMO test yielded a value greater than 0.7, and the Bartlett test was statistically significant ($p < 0.05$), indicating that the observed data exhibited a strong correlation and were thus suitable for factor analysis. A confirmatory factor analysis (CFA) was conducted to examine the structure validity of the measures. As illustrated in Table 4, the four-factor model demonstrated a superior fit when compared to alternative models. Consequently, the structure validity of the measurement scale was validated by the observed data.

Table 4. Structural validity test by using confirmatory factor analysis.

Model	χ^2/df	CFI	GFI	RMSEA	p
Four factors (baseline model): managers' safety perception, workers' safety awareness, workers' safety competency and workers' safety behaviors	2.63	0.913	0.901	0.073	0.000
Three factors: combining workers' safety awareness and workers' safety competency	3.39	0.783	0.752	0.097	0.000
Three factors: combining managers' safety perception and workers' safety awareness	3.61	0.721	0.712	0.104	0.027
One factor: combining all studied variables	5.35	0.546	0.512	0.143	0.034

In accordance with the results of the baseline model, the convergent validity test is presented in Table 5. All paths are statistically significant ($p < 0.01$), all FL values are greater than 0.5, all CR values exceed 0.7, and all AVE values are greater than 0.5, indicating that the observed data demonstrate good convergent validity. The results of the discriminant validity test are presented in Table 6. They demonstrate that all the variables exhibit strong discriminant validity, as all correlations are less than the square root of the corresponding AVE values.

Table 5. Validity results of the observed data (FL, significance, CR and AVE).

Variables	Items	Unstd.	<i>p</i>	Std. (FL)	CR	AVE
MSP	msp 1	1.000		0.970	0.987	0.949
	msp 2	1.057	***	0.964		
	msp 3	1.023	***	0.985		
	msp 4	1.000	***	0.977		
WSA	wsa 1	1.000		0.816	0.937	0.788
	wsa 2	1.118	***	0.977		
	wsa 3	1.077	***	0.870		
	wsa 4	1.154	***	0.880		
WSC	wsc 1	1.000		0.960	0.953	0.835
	wsc 2	0.827	***	0.879		
	wsc 3	1.062	***	0.940		
	wsc 4	0.770	***	0.873		
WSBs	wsb 1	1.000		0.953	0.968	0.884
	wsb 2	0.969	***	0.895		
	wsb 4	1.083	***	0.972		
	wsb 5	0.984	***	0.957		

Notes: *** denotes the *p* values are less than 0.001.

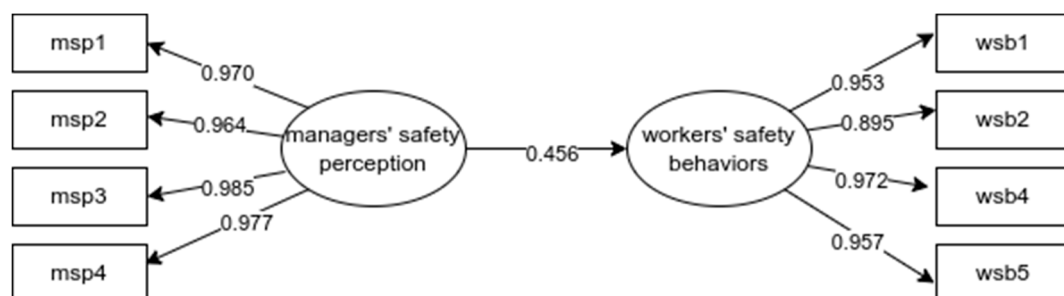
Table 6. The discriminant validity results.

Variables	MSP	WSA	WSC	WSBs
MSP	(0.974)			
WSA	0.576	(0.888)		
WSC	0.370	0.759	(0.914)	
WSBs	0.457	0.704	0.842	(0.940)

Notes: the values in parentheses are the square root of the AVE values.

4.2. Main Effect Validation

As previously argued, MSP has a potential to positively influence WSBs. We established SEM1 to test the significance of this path. SEM1 demonstrated a superior fit ($\chi^2/df = 2.412 < 3$, GFI = 0.912 > 0.8, and RMSEA = 0.052 < 0.08). The model results are presented in Figure 2. Moreover, the path coefficients are presented in Table 7, indicating that the path is statistically significant (with all *p* value less than 0.01). It can thus be concluded that managers' safety perception can positively influence workers' safety behaviors.

**Figure 2.** The validated influence of managers' safety perception on workers' safety behaviors.**Table 7.** Path coefficients of managers' safety perception influencing workers' safety behavior.

Influencing Path	Std.	S.E.	<i>p</i>
WSB ← MSC	0.456	0.061	***

Notes: *** denotes the *p* values are less than 0.001.

4.3. Mediating Effects Validation

As hypothesized, workers' safety awareness can exert a mediating effect on the relationship between MSP and WSBs. We established SEM2 to test the significance of this path. The results of SEM2 demonstrate a superior fit ($\chi^2/df = 2.502 < 3$, $GFI = 0.903 > 0.8$, and $RMSEA = 0.072 < 0.08$). The model result is presented in Figure 3. Moreover, the path coefficients are presented in Table 8, indicating that all the paths are significant (with all p value less than 0.01).

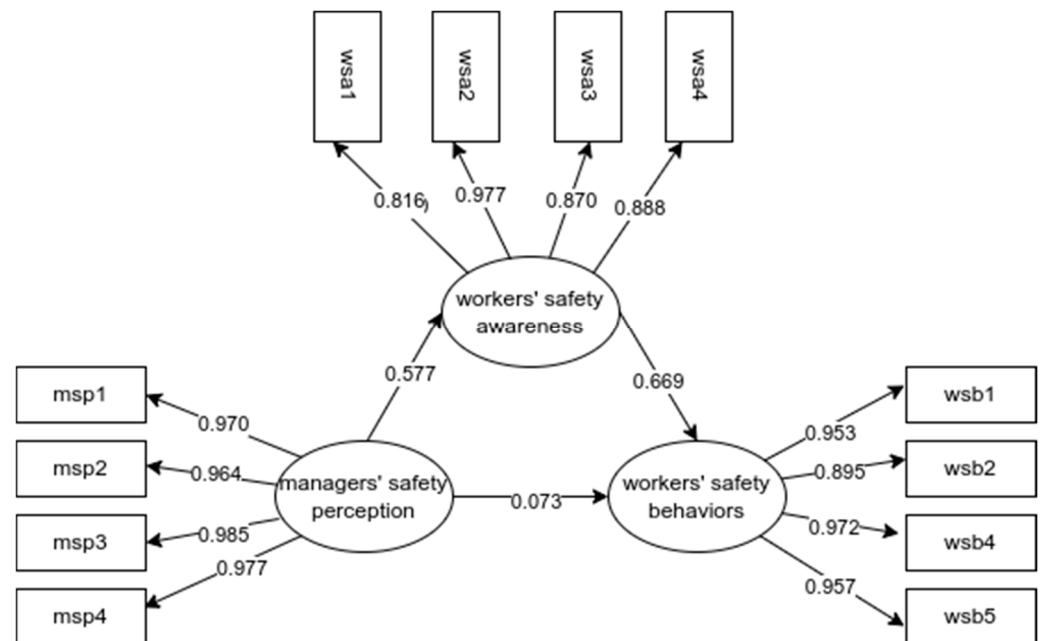


Figure 3. The validated mediating role of workers' safety awareness.

Table 8. Path coefficients of the mediating role of workers' safety awareness.

Influencing Paths	Std.	S.E.	p
WSA $\leftarrow$ MSC	0.577	0.031	***
WSB $\leftarrow$ WSA	0.669	0.122	***
WSB $\leftarrow$ MSC	0.073	0.062	***

Notes: *** denotes the p values are less than 0.001.

As evidenced in Table 8, the paths from MSP to WSA and from WSA to WSBs are both statistically significant, with all p -values for the path coefficients being less than 0.001. Moreover, the Sobel test value for the mediating effect was calculated to be 5.269, which exceeds the threshold of 1.96. This indicates that the mediating effect of WSA on the relationship between MSP and WSBs is significant, with an effect size of 0.386. Furthermore, the path from MSP to WSBs is also significant, with a path coefficient of 0.073 and a p -value of less than 0.001, suggesting that MSP can positively and directly influence WSBs.

As assumed previously, WSC can also exert a mediating effect on the relationship between MSP and WSBs. We established SEM3 to test the significance of this path. The results of SEM3 show a superior fit ($\chi^2/df = 2.673 < 3$, $GFI = 0.917 > 0.8$, and $RMSEA = 0.033 < 0.08$). The model results are presented in Figure 4. The path coefficients are presented in Table 9, indicating all the paths are significant (with all p value less than 0.01).

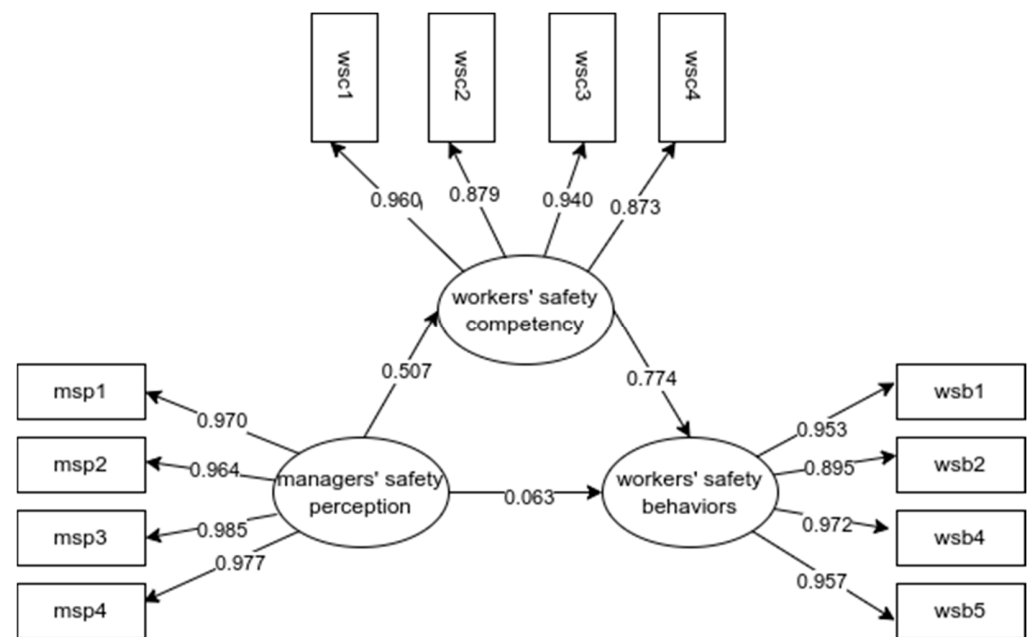


Figure 4. The validated mediating role of workers' safety competency.

Table 9. Path coefficients of the mediating role of workers' safety competency.

Influencing Path	Std.	S.E.	<i>p</i>
WSC ← MSP	0.507	0.055	***
WSB ← WSC	0.774	0.070	***
WSB ← MSP	0.063	0.065	***

Notes: *** denotes the *p* values are less than 0.001.

As shown in Table 9, the paths from MSP to WSC and from WSC to WSBs are significant, with all *p*-values for the path coefficients being less than 0.001. Additionally, the Sobel value for the mediating effect was calculated to be 7.080, which exceeds the threshold of 1.96. This indicates that the mediating effect of WSC on the relationship between MSP and WSBs is significant, with an effect size of 0.392. Therefore, MSP can indirectly and positively influence WSBs through WSC. Furthermore, SEM3 demonstrates that the positive and direct influence of MSP on WSBs is also significant, with a path coefficient of 0.063 and a *p*-value of less than 0.001. Moreover, based on the analysis above, while the direct effect is significant, the indirect effect of MSP on WSBs is greater, with a mean value of 0.389.

5. Discussion

The present study concentrated on the examination of the impact of MSP on WSBs among construction workers. Additionally, we investigated whether two key variables, WSA and WSC, mediate the relationship between MSP and WSBs. This study's distinctive contribution is its focus on the influence of managers' individual attributes in cultivating and molding construction workers' safety behaviors, particularly with regard to their safety perceptions. To explore these relationships, we proposed and validated a conceptual model that illustrates the interconnections among MSP, WSA, WSC, and WSBs. The findings indicate that MSP has a positive and direct influence on WSBs (average effect size = 0.065) and also exerts a positive and indirect influence through WSA and WSC. The mediating effects of these two variables on the relationship between MSP and WSBs are significant, with effect sizes of 0.386 and 0.392, respectively. It is noteworthy that the indirect effect of MSP on WSBs is greater than the direct effect.

5.1. Theoretical Contributions

This study fills a significant vacuum in the literature by presenting a number of theoretical advances, especially through the creation of a validated measurement scale for MSP. Only a few studies have looked at the roles of managers' individual psychological processes or their results, even though prior studies have mostly concentrated on safety leadership and leader-member exchange (LMX) in encouraging safe behaviors [64,65]. As a result, we stress the significance of MSP and have developed a new measurement scale for this concept. By addressing this gap, our study introduces a novel framework to quantitatively evaluate the impact of MPS on WSBs. In addition to improving theoretical clarity, this recently created scale offers a useful instrument for further study. It enables a more sophisticated comprehension of the role that managers' personal traits play in determining the safety outcomes of their employees, a topic that has received little attention in previous research [52,57].

Second, by showing that MSP directly and positively affects WSBs, this study significantly advances the field. Our work highlights a clear cognitive-behavioral connection, whereas previous research has mostly concentrated on indirect factors such as organizational safety culture and leadership styles [27,66]. This shift from leadership styles to manager individual safety perception represents a novel direction in the field. By identifying this direct pathway, we challenge previous assumptions that managerial influence on safety behaviors is always mediated by broader organizational factors. Our findings indicate that managers' safety perception alone can serve as a powerful determinant of workers' safety compliance and participation, providing a new theoretical perspective for understanding construction safety management [48,67].

Moreover, this research offers new insights by demonstrating that WSA plays a mediating role in the relationship between MSP and WSBs. The extant literature has not adequately addressed the question of how workers' safety awareness is influenced by managers' safety perception [63,68,69]. This study addresses this gap by illustrating that a manager's heightened safety perception can indirectly enhance workers' safety behaviors by improving their safety awareness. This finding underscores the pivotal role of managerial influence on workers' psychological processes, offering a novel perspective on the interplay between cognitive perception and behavior. Furthermore, it provides a foundation for new research on how workers' safety awareness can be systematically developed through targeted managerial interventions [38,52].

Lastly, the study introduces WSC as an additional mediating variable between MSP and WSBs. Although previous research has identified competency as a factor influencing safety behavior [70,71], the role of managers' perceptions in enhancing this competency has been largely overlooked. The findings of this study indicate that managers with strong safety perceptions can significantly improve workers' competency through targeted training and effective communication. This establishes a direct cognitive-to-competency link, which has not been emphasized in the existing literature. The discovery that safety competency mediates the relationship between perception and behavior offers a novel theoretical framework, contributing to a more comprehensive understanding of the determinants of construction workers' safety behaviors [33,55].

5.2. Management Implications

The findings of this research underscore that MSP can have both direct and indirect impacts on WSBs. It is imperative for managers to focus on nurturing safety perceptions and to enact subsequent strategic interventions. Initially, the establishment of comprehensive and appropriate safety education and training programs is crucial at the industrial, organizational, and project levels for individuals in safety management roles. These programs should delineate the training curriculum with clarity, and each tier should institute disciplinary measures for non-adherence to safety training protocols. Second, organizations must augment their focus on safety communication and the dissemination of safety-related knowledge. Stakeholders in the project, including designers, general contractors, and

subcontractors, should intensify the periodic examination and evaluation of safety risks. The insights gleaned from safety knowledge should be effectively conveyed to on-site management personnel. Third, management should conduct routine assessments of workers' safety attitudes and conditions to promote proactive safety measures and to ensure compliance with operational requirements.

The quantitative analyses presented herein reveal that WSA and WSC have a direct influence on WSBs, and both WSA and WSC act as mediators in the relationship between MSP and WSBs. Consequently, governmental officials and organizational managers should prioritize safety training to bolster WSA and WSC. First, the government should enact policies for worker safety training and establish foundational procedures, assessment criteria, and a system of incentives and sanctions within the construction sector. Second, corporate managers are tasked with formulating worker safety training schemes that are consistent with industrial policies and organizational goals, with a commitment to rigorous enforcement. Third, project management teams should conduct on-site safety training in line with industry and organizational policies. Additionally, the adoption of advanced technologies can be leveraged to enhance safety training, such as the use of safety production documentaries, software-based training, and virtual reality (VR) scenario-based instruction. Fourth, subcontractors may implement a "mentoring system" within worker teams, enabling experienced personnel to mentor novices. Furthermore, safety management professionals should gain a thorough understanding of the influence of MSP, WSA, and WSC on WSBs. They can coordinate the development of safety training programs and evaluation tools for both managers and workers to ensure congruence among MSP, WSA, and WSC.

5.3. Limitations and Future Directions

This study has several limitations that should be acknowledged. First, the research is confined to the construction industry within China, which may restrict the external validity of the findings for other sectors or national contexts. The construction context presents unique challenges and dynamics that may not be applicable in different cultural or industrial environments. Future research could explore similar relationships in diverse settings, such as manufacturing or service industries, to provide a broader understanding of how managers' safety perceptions influence workers' behaviors across various contexts.

Second, while this study emphasizes the role of MSP, other organization-level and individual-level factors, such as safety climate, leader-member exchange, workers' attitudes, risk tolerance, and external influences (e.g., peer behavior), were not extensively addressed. These factors could significantly impact safety behaviors and may mediate or moderate the relationships proposed in our model. Future studies should consider integrating these variables into the conceptual framework to develop a more comprehensive understanding of the dynamics of safety behavior.

Additionally, this research relies on self-reported data, which may introduce bias in measuring safety perceptions and behaviors. Future studies could employ observational methods or mixed-method approaches to validate self-reported data and obtain more comprehensive insights into the actual safety behaviors exhibited on construction sites.

Lastly, longitudinal studies are recommended to assess the stability of the relationships over time. Understanding how MSP and WSBs evolve can provide valuable insights into the long-term effectiveness of safety interventions and training programs. By addressing these limitations and exploring new directions, future research can further enrich the academic discourse on safety management and contribute to the development of effective strategies to enhance worker safety.

6. Conclusions

This study offers valuable insights into how managers' safety perceptions influence workers' safety behaviors in the Chinese construction industry. We developed a conceptual framework that identifies the mediating roles of workers' safety awareness and workers'

safety competency. The findings indicate that managers' safety perception directly affects workers' safety behaviors and influences them indirectly by enhancing workers' safety awareness and safety competency.

The research makes a significant contribution to the literature by introducing a new measurement scale for managers' safety perception, thereby addressing a critical gap in existing studies. It emphasizes the importance of construction managers prioritizing their safety perception and fostering a culture of safety awareness and competency among workers.

The study also has limitations, including its focus on the construction industry in China and its reliance on self-reported data. Subsequent studies can further explore these dynamics in various contexts and incorporate additional factors, ultimately contributing to the development of effective safety management strategies designed to enhance worker safety.

Author Contributions: Conceptualization and formal analysis, K.L. and B.L.; investigation and writing—original draft, X.L. and Y.J.; methodology and writing—review and editing, K.L., X.L. and H.L.; resources and supervision, J.F.; project administration, H.L.; validation, H.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Soft Science Foundation of Henan Province (grand number 242400410045), the Fundamental Research Funds for the Universities of Henan Province (grand number NSFRF230426), the Education Department Foundation of Hunan Province (grand number 21B0656, 23C0258), the Doctoral fund of Henan Polytechnic University (grand number B2022-23), and the Doctoral Research Initiation Fund of Hunan Institute of Engineering (grant number 21026R, 24032, 24033).

Data Availability Statement: The data are available by querying the authors.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Fu, H.; Xia, Z.; Tan, Y.; Guo, X. Education cues' influence on the safety hazard recognition of construction workers during safety training: Evidence from an eye-tracking experiment. *J. Civ. Eng. Educ.* **2024**, *150*, 04023009. [CrossRef]
2. Fu, H.; Xia, Z.; Tan, Y.; Peng, Y.; Guo, X. Fear Arousal Drives the Renewal of Active Avoidance of Hazards in Construction Sites: Evidence from an Animal Behavior Experiment in Mice. *J. Constr. Eng. Manag.* **2024**, *150*, 04024146. [CrossRef]
3. Cheng, B.; Wei, Y.; Li, H.; Huang, J.; Chen, H. Science Mapping the Knowledge Domain of Construction Workers' Safety Behavior. *Buildings* **2023**, *13*, 1365. [CrossRef]
4. Guo, X.; Liu, Y.; Tan, Y.; Xia, Z.; Fu, H. Hazard identification performance comparison between virtual reality and traditional construction safety training modes for different learning style individuals. *Saf. Sci.* **2024**, *180*, 106644. [CrossRef]
5. Fang, W.L.; Love, P.; Luo, H.B.; Ding, L.Y. Computer Vision for Behaviour-Based Safety in Construction: A Review and Future Directions. *Adv. Eng. Inform.* **2020**, *43*, 100980. [CrossRef]
6. Fang, W.L.; Ding, L.Y.; Love, P.; Luo, H.B.; Li, H.; Pena-Mora, F.; Zhong, B.T.; Zhou, C. Computer Vision Applications in Construction Safety Assurance. *Autom. Constr.* **2020**, *110*, 103013. [CrossRef]
7. Fu, H.; Tan, Y.; Xia, Z.; Peng, K.; Guo, X. Effects of Construction Workers' Safety Knowledge on Hazard-Identification Performance via Eye-Movement Modeling Examples Training. *Saf. Sci.* **2024**, *180*, 106653. [CrossRef]
8. China's Ministry of Housing and Urban-Rural Development China's National Engineering Quality and Safety Supervision Information Platform Public Service Portal_housing and Municipal Engineering Production Safety Accident Situation. Available online: <https://zlaq.mohurd.gov.cn/fwmh/bjxcjgl/fwmh/pages/default/index.html> (accessed on 3 April 2024).
9. Yang, J.; Ye, G.; Xiang, Q.; Kim, M.; Liu, Q.; Yue, H. Insights into the Mechanism of Construction Workers' Unsafe Behaviors from an Individual Perspective. *Saf. Sci.* **2021**, *133*, 105004. [CrossRef]
10. Zheng, J.; Gou, X.; Griffin, M.A.; Goh, Y.M.; Xia, N. Temporal Leadership, Attentiveness, and Safety Behaviors: The Moderating Roles of Abusive Supervision and Safety Consciousness. *Saf. Sci.* **2022**, *147*, 105633. [CrossRef]
11. Central People's Government of the People's Republic of China. Regulations on the Administration of Safe Production of Construction Projects. Available online: https://www.gov.cn/zwgg/2005-05/23/content_183.htm (accessed on 12 October 2024).
12. GB/T 45001-2020; Occupational Health and Safety Management Systems-Requirements with Guidance for Use. China National Institute of Standardization: Beijing, China, 2020. Available online: https://jgj.hangzhou.gov.cn/art/2023/5/4/art_1229717032_58902632.html (accessed on 11 October 2024).
13. Zhou, Z.; Goh, Y.M.; Li, Q. Overview and Analysis of Safety Management Studies in the Construction Industry. *Saf. Sci.* **2015**, *72*, 337–350. [CrossRef]
14. Guo, B.H.W.; Zou, Y.; Fang, Y.; Goh, Y.M.; Zou, P.X.W. Computer Vision Technologies for Safety Science and Management in Construction: A Critical Review and Future Research Directions. *Saf. Sci.* **2021**, *135*, 105130. [CrossRef]

15. Feng, J.; Gao, X.; Li, H.; Liu, B.; Tang, X. A Science Mapping Approach-Based Review of Construction Workers' Safety-Related Behavior. *Buildings* **2024**, *14*, 1162. [\[CrossRef\]](#)
16. Goh, Y.M.; Ubeynarayana, C.U.; Wong, K.L.X.; Guo, B.H.W. Factors Influencing Unsafe Behaviors: A Supervised Learning Approach. *Accid. Anal. Prev.* **2018**, *118*, 77–85. [\[CrossRef\]](#)
17. Xia, N.; Xie, Q.; Griffin, M.A.; Ye, G.; Yuan, J. Antecedents of Safety Behavior in Construction: A Literature Review and an Integrated Conceptual Framework. *Accid. Anal. Prev.* **2020**, *148*, 105834. [\[CrossRef\]](#)
18. Basahel, A.M. Safety Leadership, Safety Attitudes, Safety Knowledge and Motivation toward Safety-Related Behaviors in Electrical Substation Construction Projects. *Int. J. Environ. Res. Public Health* **2021**, *18*, 4196. [\[CrossRef\]](#)
19. Wu, C.; Yao, H.; Ning, X.; Wang, L. Emergence of Informal Safety Leadership: A Social–Cognitive Process for Accident Prevention. *Prod. Oper. Manag.* **2021**, *30*, 4288–4305. [\[CrossRef\]](#)
20. Huang, Y.H.; He, Y.; Lee, J.; Hu, C. Key Drivers of Trucking Safety Climate from the Perspective of Leader-Member Exchange: Bayesian Network Predictive Modeling Approach. *Accid. Anal. Prev.* **2021**, *150*, 105850. [\[CrossRef\]](#)
21. He, C.; McCabe, B.; Jia, G. Effect of Leader-Member Exchange on Construction Worker Safety Behavior: Safety Climate and Psychological Capital as the Mediators. *Saf. Sci.* **2021**, *142*, 105405. [\[CrossRef\]](#)
22. He, C.; Jia, G.; McCabe, B.; Sun, J. Relationship between Leader–Member Exchange and Construction Worker Safety Behavior: The Mediating Role of Communication Competence. *Int. J. Occup. Saf. Ergon.* **2021**, *27*, 371–383. [\[CrossRef\]](#)
23. Fang, D.; Huang, Y.; Guo, H.; Lim, H.W. LCB Approach for Construction Safety. *Saf. Sci.* **2020**, *128*, 104761. [\[CrossRef\]](#)
24. Li, S.; Fan, M.; Wu, X. Effect of Social Capital between Construction Supervisors and Workers on Workers' Safety Behavior. *J. Constr. Eng. Manag.* **2018**, *144*, 04018014. [\[CrossRef\]](#)
25. Baah, B.; Acheampong, A.; Osei-Asibey, D.; Afful, A.E. Assessing the Role of Respectable Engagement in Improving Construction Employee's Safety Perception. *Smart Sustain. Built Environ.* **2023**, *12*, 937–962. [\[CrossRef\]](#)
26. Namian, M.; Tafazzoli, M.; Al-Bayati, A.J.; Kermanshachi, S. Are Construction Managers from Mars and Workers from Venus? Exploring Differences in Construction Safety Perception of Two Key Field Stakeholders. *Int. J. Environ. Res. Public Health* **2022**, *19*, 6172. [\[CrossRef\]](#)
27. Sankar, S.S.; Anandh, K.S.; Prasanna, K. Safety Leadership: A Catalyst for Positive Safety Climate on Construction Sites. *Buildings* **2024**, *14*, 1806. [\[CrossRef\]](#)
28. Kim, M.; Jo, D.; Jeong, J. Evaluation of Mobile Risk Perception Training System for Improving the Safety Awareness of Construction Workers. *Buildings* **2023**, *13*, 3024. [\[CrossRef\]](#)
29. Hubbard, B.; Huang, Q.; Caskey, P.; Wang, Y. Safety Awareness Educational Topics for the Construction of Power Transmission Systems with Smart Grid Technologies. *Australas. J. Constr. Econ. Build.* **2013**, *13*, 114–127. [\[CrossRef\]](#)
30. Pedersen, S. UK Young Adults' Safety Awareness Online—Is It a “Girl Thing”? *J. Youth Stud.* **2013**, *16*, 404–419. [\[CrossRef\]](#)
31. Zhao, S. Study on Measurement of Construction Workers' Safety Awareness Based on SEM. Bachelor's Thesis, Xi'an University of Architecture and Technology, Xi'an, China, 2019. (In Chinese).
32. Li, S.; Wu, X.; Wang, X.; Hu, S. Relationship between Social Capital, Safety Competency, and Safety Behaviors of Construction Workers. *J. Constr. Eng. Manag.* **2020**, *146*, 04020059. [\[CrossRef\]](#)
33. Yilmaz, D.U.; Palandoken, E.A.; Ceylan, B.; Akbiyik, A. The Effectiveness of Scenario-Based Learning to Develop Patient Safety Behavior in First Year Nursing Students. *Int. J. Nurs. Educ. Scholarsh.* **2020**, *17*, 20200011. [\[CrossRef\]](#)
34. Nykänen, M.; Sund, R.; Vuori, J. Enhancing Safety Competencies of Young Adults. A Randomized Field Trial (RCT). *J. Safety Res.* **2018**, *67*, 45–56. [\[CrossRef\]](#)
35. Nykänen, M.; Puro, V.; Tiikkaja, M.; Kannisto, H.; Lantto, E.; Simpura, F.; Uusitalo, J.; Lukander, K.; Räsänen, T.; Heikkilä, T.; et al. Implementing and Evaluating Novel Safety Training Methods for Construction Sector Workers: Results of a Randomized Controlled Trial. *J. Safety Res.* **2020**, *75*, 205–221. [\[CrossRef\]](#) [\[PubMed\]](#)
36. Xie, X.; Hu, J.; Fu, G.; Shu, X.; Wu, Y.; Huang, L.; Shen, S. Investigation of Unsafe Acts Influence Law Based on System Dynamics Simulation: Thoughts on Behavior Mechanism and Safety Control. *Int. J. Environ. Res. Public Health* **2023**, *20*, 4733. [\[CrossRef\]](#) [\[PubMed\]](#)
37. Neal, A.; Griffin, M.A.; Hart, P.M. The Impact of Organizational Climate on Safety Climate and Individual Behavior. *Saf. Sci.* **2000**, *34*, 99–109. [\[CrossRef\]](#)
38. Li, H.; Chen, H.; Zhao, Z.; Hu, X.; Cheng, B.; Huang, J. Tunnel Construction Workers' Cognitive Biases and Unsafe Behaviors: The Mediating Effects of Risk Perceptions. *Adv. Civ. Eng.* **2020**, *2020*, 8873113. [\[CrossRef\]](#)
39. Aziz, F.S.A.; Abdullah, K.H.; Samsudin, S. Bibliometric Analysis of Behavior-Based Safety (BBS): Three Decades Publication Trends. *Webology* **2021**, *18*, 278–293. [\[CrossRef\]](#)
40. Neal, A.; Griffin, M.A. A Study of the Lagged Relationships among Safety Climate, Safety Motivation, Safety Behavior, and Accidents at the Individual and Group Levels. *J. Appl. Psychol.* **2006**, *91*, 946–953. [\[CrossRef\]](#)
41. Chen, H.; Gong, W.; Li, H.; Shi, S. Co-Workers' Guanxi and Construction Workers' Safety Behavior: The Mediating Role of Group Identification. *Front. Public Health* **2022**, *10*, 964514. [\[CrossRef\]](#)
42. Chen, H.; Chen, C.; Li, H.; Zhang, J.; Yang, Z. A Simulation Study on the Processes of Intra-Group Informal Interaction Affecting Workers' Safety Behaviors. *Int. J. Environ. Res. Public Health* **2022**, *19*, 10048. [\[CrossRef\]](#)
43. Liu, Y.; Ye, G.; Xiang, Q.; Yang, J.; Miang Goh, Y.; Gan, L. Antecedents of Construction Workers' Safety Cognition: A Systematic Review. *Saf. Sci.* **2023**, *157*, 105923. [\[CrossRef\]](#)

44. An, Y.; Wang, H.; Yang, X.; Zhang, J.; Tong, R. Using the TPB and 24Model to Understand Workers' Unintentional and Intentional Unsafe Behaviour: A Case Study. *Saf. Sci.* **2023**, *163*, 106099. [\[CrossRef\]](#)
45. Kiani, F.; Khodabakhsh, M.R. Preventing Injuries in Workers: The Role of Management Practices in Decreasing Injuries Reporting. *Int. J. Health Policy Manag.* **2014**, *3*, 171–177. [\[CrossRef\]](#) [\[PubMed\]](#)
46. Ajzen, I. The Theory of Planned Behavior. *Organ. Behav. Hum. Decis. Process.* **1991**, *50*, 179–211. [\[CrossRef\]](#)
47. Schwatka, N.V.; Goldenhar, L.M.; Johnson, S.K.; Beldon, M.A.; Tessler, J.; Dennerlein, J.T.; Fullen, M.; Trieu, H. A Training Intervention to Improve Frontline Construction Leaders' Safety Leadership Practices and Overall Jobsite Safety Climate. *J. Safety Res.* **2019**, *70*, 253–262. [\[CrossRef\]](#) [\[PubMed\]](#)
48. Zhang, L.; Chen, H.; Li, H.; Wu, X.; Skibniewski, M.J. Perceiving Interactions and Dynamics of Safety Leadership in Construction Projects. *Saf. Sci.* **2018**, *106*, 66–78. [\[CrossRef\]](#)
49. Ye, X.; Li, X.; Wang, Z. Safety climate and safety behavior—the mediating role of psychological capital. *Soft Sci.* **2014**, *28*, 86–90. [\[CrossRef\]](#)
50. Xie, Q.; Xia, N.; Yang, G. Do Family Affairs Matter? Work-Family Conflict and Safety Behavior of Construction Workers. *J. Manag. Eng.* **2022**, *38*, 04021074. [\[CrossRef\]](#)
51. Wang, D.; Sheng, Z.; Wang, X.; Griffin, M.A.; Zhang, Y.; Wang, Z. How Team Safety Stressors Affect Proactive and Prosocial Safety Behaviors: Felt Safety Responsibility and Affective Commitment as Mediators. *Saf. Sci.* **2022**, *147*, 105625. [\[CrossRef\]](#)
52. Zhang, P.; Li, N.; Jiang, Z.; Fang, D.; Anumba, C.J. An Agent-Based Modeling Approach for Understanding the Effect of Worker-Management Interactions on Construction Workers' Safety-Related Behaviors. *Autom. Constr.* **2019**, *97*, 29–43. [\[CrossRef\]](#)
53. Zhang, R.P.; Lingard, H.; Oswald, D. Impact of Supervisory Safety Communication on Safety Climate and Behavior in Construction Workgroups. *J. Constr. Eng. Manag.* **2020**, *146*, 04020089. [\[CrossRef\]](#)
54. Kaskutas, V.; Buckner-Petty, S.; Dale, A.; Gaal, J.; Evanoff, B. Foremen's Intervention to Prevent Falls and Increase Safety Communication at Residential Construction Sites. *Am. J. Ind. Med.* **2016**, *59*, 823–831. [\[CrossRef\]](#)
55. Hon, C.K.H.; Chan, A.P.C. Safety Management in Repair, Maintenance, Minor Alteration, and Addition Works: Knowledge Management Perspective. *J. Manag. Eng.* **2014**, *30*, 04014026. [\[CrossRef\]](#)
56. Xiao, Y.; Huang, Z.; Huang, S.; Cao, X.; Chen, X.; Liu, X.; Chen, W. Occupational safety attitude and behaviors in manufacturing workers Guangdong. *J. Environ. Occup. Med.* **2012**, *29*, 424–429. [\[CrossRef\]](#)
57. Loosemore, M.; Malouf, N. Safety Training and Positive Safety Attitude Formation in the Australian Construction Industry. *Saf. Sci.* **2019**, *113*, 233–243. [\[CrossRef\]](#)
58. Yu, B. Evaluation and Countermeasures of Safety Behavior Ability of Underground Workers in Coal Mine. Bachelor's Thesis, Anhui University of Science and Technology, Chuzhou, China, 2018. (In Chinese).
59. Qi, S.; Cheng, J.; Huang, Q.; Zhang, Y. Occurrence mechanism of safety attitude, safety capability and unsafety motivation to unsafe behavior for construction workers. *J. Huaqiao Univ. Nat. Sci.* **2018**, *39*, 669–674. (In Chinese)
60. Pallant, J. *SPSS Survival Manual: A Step by Step Guide to Data Analysis Using IBM SPSS*; Routledge: London, UK, 2016.
61. Byrne, B.M. *Structural Equation Modeling with Amos: Basic Concepts, Applications, and Programming*; Routledge: London, UK, 2016.
62. Loehlin, J.C. *Latent Variable Models: An Introduction to Factor, Path, and Structural Equation Analysis*; Routledge: London, UK, 2017.
63. Fung, I.W.H.; Tam, V.W.Y.; Sing, C.P.; Tang, K.K.W.; Ogunlana, S.O. Psychological Climate in Occupational Safety and Health: The Safety Awareness of Construction Workers in South China. *Int. J. Constr. Manag.* **2016**, *16*, 315–325. [\[CrossRef\]](#)
64. Gong, Y.; Zaman, U. Exploring Mega-Construction Project Success in China's Vaunted Belt and Road Initiative: The Role of Paternalistic Leadership, Team Members' Voice and Team Resilience. *Engineering. Constr. Archit. Manag.* **2024**, *31*, 3801–3825. [\[CrossRef\]](#)
65. Bentoy, M.; Mata, M.; Bayogo, J.; Vasquez, R.; Almacén, R.M.; Evangelista, S.S.; Wenceslao, C.; Batoon, J.; Lauro, M.D.; Yamagishi, K.; et al. Complex Cause-Effect Relationships of Social Capital, Leader-Member Exchange, and Safety Behavior of Workers in Small-Medium Construction Firms and the Moderating Role of Age. *Sustainability* **2022**, *14*, 12499. [\[CrossRef\]](#)
66. Chen, H.; Li, H.; Goh, Y.M. A Review of Construction Safety Climate: Definitions, Factors, Relationship with Safety Behavior and Research Agenda. *Saf. Sci.* **2021**, *142*, 105391. [\[CrossRef\]](#)
67. Cunningham, W.; Zelazo, P. Attitudes and Evaluations: A Social Cognitive Neuroscience Perspective. *TRENDS Cogn. Sci.* **2007**, *11*, 97–104. [\[CrossRef\]](#)
68. Yılmaz, F. Analysis of the Interaction between Safety Measures and Workers' Safety Awareness from the Construction Workers' Perspective. *Engineering. Constr. Archit. Manag.* **2023**, *30*, 41–55. [\[CrossRef\]](#)
69. Xi, Y.; Liu, R.; Zhang, Q.; Xuan, S. Impact of safety climate on safety behavior of maritime pilots: Mediation of safety consciousness. *China Saf. Sci. J.* **2020**, *30*, 15–21. [\[CrossRef\]](#)
70. Fansuri, I.; Arifuddin, R.; Latief, R.U. Evaluation of Comparison Performance of Construction Safety Competency Training Methods for Construction Workers. *Int. J. Eng. Trends Technol.* **2023**, *71*, 217–224. [\[CrossRef\]](#)
71. Biggs, H.C.; Biggs, S.E. Interlocked Projects in Safety Competency and Safety Effectiveness Indicators in the Construction Sector. *Saf. Sci.* **2013**, *52*, 37–42. [\[CrossRef\]](#)

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.