Investigating the Impact of Sense of Safety Perceptions on Spatial Allocation Decisions within the Construction Supply Chain, Focusing on Risk Management Strategies in CBD Environments

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ABSTRACT

This study seeks to explore the impact of safety perceptions on spatial allocation decisions within the construction supply chain in China, with particular emphasis on the mediating role of risk management strategies. By examining the interrelationships between safety perceptions, risk management strategies, and spatial allocation decisions, the research aims to provide valuable insights into the factors shaping safety management practices and spatial planning processes in construction projects. A quantitative research design is employed in this study, using a structured questionnaire to gather data from employees and managers working in construction companies across China. The questionnaire is administered in three stages (T1, T2, and T3), and the data are analysed through statistical methods, including correlation analysis, regression analysis, and mediation analysis. The results of the study reveal significant associations between safety perceptions, risk management strategies, and spatial allocation decisions within the Chinese construction supply chain. Notably, risk management strategies—such as the quality of risk assessments, resource allocation for safety, safety training programmes, and emergency response planning—are identified as key mediators in the relationship between safety perceptions and spatial allocation decisions. This research contributes to the existing literature by offering empirical evidence on the connections between safety perceptions, risk management strategies, and spatial allocation decisions within China's construction industry. By addressing critical gaps in current knowledge, the study provides practical recommendations for construction firms, policymakers, and researchers aiming to improve safety outcomes and optimise spatial planning processes in construction projects.

Keywords: Construction Industry, Supply Chain, Safety Perceptions, Spatial Allocation Decisions, Risk Management Strategies, Emergency Response Planning, Safety Management Practices.

INTRODUCTION

Construction plays a pivotal role in driving China's economic growth, fostering employment opportunities, and enhancing infrastructure development. The construction supply chain in China encompasses a diverse range of stakeholders, including architects, engineers, contractors, suppliers, and regulators, who collectively plan, design, build, and manage major infrastructure projects (Su et al., 2022). The rapid pace of modernisation and growth in China has significantly increased the demand for construction, leading to heightened competition, shorter timeframes, and an intensified focus on project completion (Luo et al., 2023). Construction sites must optimise the deployment of personnel, equipment, and resources to improve safety, productivity, and efficiency. Efficient spatial allocation is crucial to maximise space utilisation, minimise congestion and bottlenecks, and ensure smooth construction workflows. When assigning space, factors such as site layout, material storage, equipment placement, and worker accessibility must be carefully considered (Mirghaed et al., 2020). These spatial factors can have a profound impact on project performance, cost, and schedule. Given the high population density, complex logistics, and limited space in China, careful spatial planning is essential for the success of construction projects. Poor spatial design can undermine project profitability by causing inefficiencies, safety risks, and delays (Lv et al., 2021). Consequently, understanding the nuances of space distribution and spatial planning methods is critical for enhancing construction efficiency, mitigating hazards, and ensuring project success.

Safety perceptions are subjective assessments of workplace hazards that significantly influence attitudes and behaviours towards safety on construction sites (Zou & Yu, 2022). Given the prevalence of accidents and hazardous working conditions in the construction industry, fostering a strong safety culture and mindset is essential. The productivity, health, and well-being of construction workers are critical to successful project outcomes (Goldwyn et al., 2022). Various factors, including job responsibilities, training, prior experiences, and organisational culture, shape workers' safety perceptions. Positive safety perceptions can enhance worker engagement with safety practices, adherence to protocols, and the reduction of incidents. Conversely, individuals with negative safety perceptions may demonstrate carelessness, disregard safety protocols, and exhibit a higher likelihood of injury. Given the high-risk nature of construction, it is imperative for companies to address safety perceptions, as safety lapses can lead to severe consequences (Smiley & Yang, 2021). By cultivating a strong safety culture, providing comprehensive training and resources, and implementing effective safety management systems, construction companies can improve safety perceptions among employees and stakeholders, thereby enhancing job performance and creating safer work environments.

Safety perceptions and spatial allocation decisions are vital in construction; however, the interaction between these two factors remains underexplored. While considerable research has focused on safety perceptions and spatial planning separately, there is a lack of investigation into how safety perceptions influence space allocation in construction projects (Ramírez et al., 2021). This gap is particularly evident within China's construction supply chain. The rapid urbanisation and industrialisation in the country have heightened the need for effective safety management and spatial planning approaches (Schindler, 2023). Although risk management strategies have been extensively studied for their role in enhancing construction safety, their impact on safety perceptions has not been adequately addressed. Construction safety management systems prioritise risk management tactics such as emergency response planning, safety training, resource allocation, and high-quality risk assessments (Pedersen et al., 2021). By identifying, assessing, and mitigating safety hazards, these strategies improve safety, reduce incidents, and potentially influence safety perceptions (Shooshtarian et al., 2023). A better understanding of risk management and safety perceptions is crucial for improving construction project management and decision-making. With targeted safety management, workers and stakeholders can experience safer conditions on construction sites (Darko et al., 2020). Understanding how risk management affects safety perceptions is essential for refining strategies. Addressing these research gaps is imperative to enhancing both spatial planning and safety in construction.

This study investigates the safety and spatial allocation within the Chinese construction supply chain, with a focus on risk management. The aim is to enhance both construction project safety and spatial design. To achieve this, the study will analyse the relationships between safety perceptions, risk management, and spatial allocation, examining how safety perceptions influence both risk management strategies and spatial allocation decisions.

- The study explores safety perceptions and spatial allocation within China's construction supply chain.
- It examines how risk management strategies, such as assessment quality, resource allocation, safety training, and emergency response planning, influence safety perceptions and spatial allocation.
- It identifies the key factors affecting safety perceptions and space allocation in Chinese construction projects.
- The study evaluates risk management methods aimed at enhancing safety and optimising spatial planning in construction projects.
- It provides recommendations for improving safety and spatial planning for construction companies and policymakers.

This research explores the interplay between space allocation, risk management, and safety perceptions in construction, aiming to enhance safety and spatial planning. By addressing knowledge gaps, it offers practical solutions to improve construction worker safety and project efficiency. The study highlights how safety-focused space allocation can reduce accidents, optimise resource use, and streamline operations. It also informs regulators, providing evidence to improve safety regulations. The findings contribute to the advancement of construction safety and spatial planning theories, offering valuable insights for construction companies, policymakers, and scholars to foster safer, more efficient, and sustainable construction practices.

LITERATURE REVIEW

Safety plays a critical role in the dynamic and complex construction industry, influencing both workers and management. The spatial arrangement of materials, equipment, and personnel is essential for ensuring workplace safety and operational efficiency. Safety perceptions are shaped by factors such as protective measures and trust in the ability of workers and management to enforce safety standards on construction sites. Priye and Manoj (2020) identified that the environment, safety culture, communication, and leadership significantly impact these perceptions. Additionally, the effectiveness of safety standards, training, and past incidents, including accidents or near misses, influence workers' safety perceptions (Gioiella et al., 2023). The layout of construction sites plays a crucial role in the placement of resources and personnel, with these decisions being vital for both safety and productivity. As Sapountzoglou (2023) highlights, poor spatial planning can lead to overcrowded workspaces, increasing the risk of accidents and reducing productivity.

Effective spatial planning is crucial for reducing accidents, congestion, and bottlenecks on construction sites. The safety perceptions of both workers and management significantly influence spatial decisions, which in turn affect the organisation and utilisation of resources. These perceptions not only impact the physical safety of workers but also their mental health and behaviour, fostering greater self-confidence. Workers with positive safety perceptions are more likely to engage in safety protocols and contribute to spatial planning efforts that mitigate risks (Vinti et al., 2023). They recognise potential hazards and proactively design safe work environments. Conversely, negative safety perceptions can lead to heightened anxiety, stress, and inadequate spatial preparation. According to Li et al. (2024), concerns about safety may lead workers to avoid making spatial decisions, increasing the risk of accidents, traffic, and site disorganisation. The culture and leadership within construction companies also play a pivotal role in shaping safety perceptions. Strong communication and a consistent focus on safety by leadership contribute to the development of an effective safety culture, instilling trust in the company's safety initiatives (Newaz et al., 2019). Safety-conscious leaders encourage employees to express concerns and actively participate in decisions that influence their physical work environment.

Leadership indifference and a lack of focus on safety can adversely affect both spatial design and safety perceptions on construction sites. Disengaged workers may result in inadequate spatial resource allocation (Wang et al., 2024). Effective communication and training are essential to ensure accurate safety perceptions and informed spatial decisions. Safety briefings, toolbox talks, and training sessions enable workers to identify hazards and take necessary precautions. For workers to understand spatial safety requirements and engage in spatial planning, clear communication is imperative (Wang & Fu, 2023). Comprehensive safety training programmes, incorporating modules on spatial planning and hazard recognition, enhance workers' sense of personal responsibility for safety and improve their spatial decision-making skills. Such training also fosters a better understanding of spatial organisation and safety regulations, contributing to safer and more efficient workplaces. Perceptions of safety and space are influenced by the surrounding environment. Safety attitudes among employees improve through safety education, clear signage, and well-organised workstations (Nykänen et al., 2020).

A tidy and orderly work environment demonstrates a commitment to safety, thereby building trust and encouraging worker input in space design. In contrast, disorganised workplaces can lead to anxiety and safety concerns. Poor lighting, inadequate equipment, and obstructed emergency exits increase the risk of accidents and hinder effective spatial planning (Baldini et al., 2022). The organisation and utilisation of site resources depend heavily on safety perceptions and spatial considerations. Positive safety attitudes promote proactive safety measures and encourage worker collaboration in spatial design. Factors such as organisational culture, leadership, communication, training, and the work environment significantly influence both safety and spatial decisions (Dimitrov et al., 2022). By fostering a supportive work environment, providing comprehensive training, and cultivating a positive safety culture, construction companies can enhance both safety perceptions and spatial planning. Prioritising safety and empowering employees to take responsibility can lead to improved project outcomes and a reduction in accidents, thereby creating safer and more efficient workplaces.

H1: *Sense of safety perceptions has a significant impact on spatial allocation decisions in construction*

Risk management strategies are essential for identifying, assessing, and mitigating risks in building projects. The effectiveness of these strategies directly influences safety perceptions and spatial allocation decisions. Each strategy impacts safety and spatial choices in distinct ways. The quality of risk assessment refers to the ability to identify and evaluate potential hazards. Thorough risk assessments provide valuable, actionable insights into possible dangers, facilitating informed decision-making and proactive risk management (Cong et al., 2024). By offering clear and practical information on potential risks, comprehensive assessments improve safety perceptions and foster a proactive safety culture (Durrant et al., 2023). Increased awareness of hazards enhances workers' comfort and confidence, motivating them to organise their workspaces in a way that mitigates risks. When a risk assessment identifies a hazardous area, spatial decisions are made to avoid or limit operations in that zone, thereby reducing the likelihood of accidents (Berger et al., 2023). These assessments may result in the designation of safety zones, restricted access areas, and strategic placement of safety equipment. Ultimately, risk assessments contribute to creating safer and more efficient work environments by identifying and addressing potential hazards.

Resource Allocation for Safety

Building and maintaining effective safety measures necessitates the allocation of adequate financial, human, and material resources. Proper resource distribution is crucial to the successful implementation of safety procedures, as well as ensuring the availability of necessary equipment and supplies. According to (Su et al., 2023), dedicating sufficient resources to safety initiatives demonstrates an organisation's commitment to creating a safe working environment. When workers recognise that safety measures are being properly funded, it enhances their sense of security. The way in which spatial decisions are made influences how resources are used to optimise both safety and efficiency (He et al., 2022). By investing in lighting, storage facilities, and PPE, spatial organisation and safety can be significantly improved. Resource allocation also impacts the availability of qualified safety professionals who oversee and provide guidance on spatial planning (Cheng et al., 2023). These experts play a key role in ensuring workstations are designed and maintained in a safe manner, thereby supporting safer spatial decisions and fostering positive safety perceptions among workers.

Safety Training Programs

Staff must undergo comprehensive safety training to effectively identify and mitigate hazards. Thorough construction safety training encompasses spatial planning, emergency response, and hazard recognition (Gyamfi et al., 2024). According to Ali et al. (2023), well-designed training programmes enhance safety perceptions by boosting workers' confidence in managing risks.

Extensive training increases workers' belief in their ability to handle hazards, thereby improving their overall safety perceptions. Additionally, such training enhances spatial judgement, as workers learn to organise their workstations in ways that reduce risks and promote safety. Spatial planning courses educate employees on the benefits of effective workplace organisation (Lucas et al., 2023), teaching them to arrange tools and materials in a way that minimises dangers, ensures clear pathways, and facilitates access to emergency exits. Spatial safety training equips workers with the knowledge and skills needed to manage their workspaces safely and efficiently.

Emergency Response Planning

Emergency plans are developed and executed to enhance safety on construction sites. Well-structured emergency response plans alleviate uncertainty and anxiety by providing clear guidance for staff (Yang et al., 2022). According to Heaney et al. (2021), a comprehensive emergency response plan instils confidence and authority in personnel, which, in turn, enhances safety. This increased confidence encourages workers to arrange their workstations for quick and efficient emergency responses, thereby influencing spatial allocation decisions. Effective disaster response requires regular drills, the identification of exit routes, and the strategic placement of emergency equipment (Lozano & Tien, 2023). These practices not only improve safety but also ensure the prioritisation of swift and safe evacuation routes. Incorporating emergency preparedness into spatial design significantly improves construction site safety and mitigates the impact of emergencies.

Mediating Role of Risk Management Strategies

Risk management strategies significantly influence spatial allocation and safety on construction sites. Comprehensive risk assessments help identify hazards, making workers and management feel safer and guiding spatial decisions, such as creating safe zones and avoiding dangerous areas (Lal et al., 2023). Proper resource distribution, including safety equipment and PPE, enhances safety perceptions and influences spatial decisions, reducing hazards and improving efficiency. Effective safety training enables workers to identify and mitigate risks, resulting in safer workspaces (Savolainen, 2023). Emergency response plans, integrated into spatial design, prepare staff for quick evacuations and improve safety (Zhou & Guo, 2020). These strategies collectively enhance workplace safety, spatial organisation, and overall efficiency, with training moderating the relationship between risk awareness and safe spatial actions (Berger et al., 2023).

H2: *Risk assessment quality mediates the relationship between sense of safety perceptions and spatial allocation decisions in construction*
H3: *Resource allocation for safety mediates the relationship between sense of safety perceptions and spatial allocation decisions in construction*
H4: *Safety training program mediates the relationship between sense of safety perceptions and spatial allocation decisions in construction*
H5: *Emergency response planning mediates the relationship between sense of safety perceptions and spatial allocation decisions in construction*

Based on the literature review, we propose the following conceptual framework, as illustrated in Figure 1.

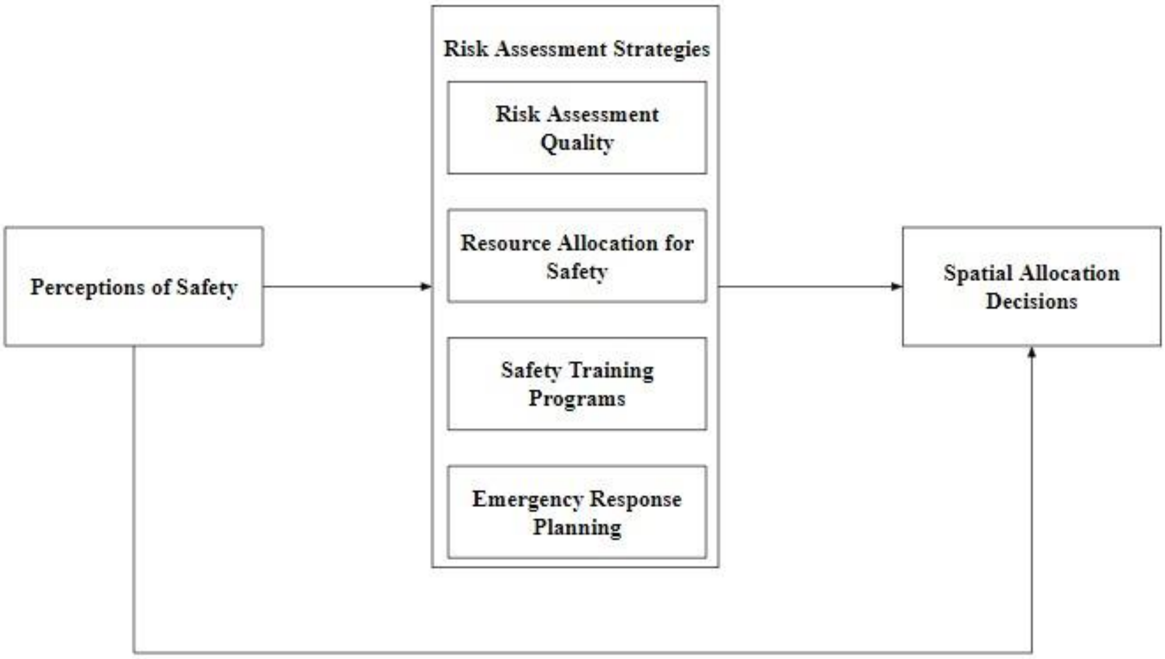

Figure 1: Conceptual Framework

METHODOLOGY

This quantitative study investigates the impact of safety perceptions on spatial distribution within the construction supply chain, focusing on emergency response planning, safety resource allocation, safety training, and the quality of risk assessments. By employing quantitative methods, the study provides objective measurement and statistical analysis of the relationships between these variables. The use of a standardised questionnaire ensures consistent and comparable data, allowing for generalisable conclusions within the Chinese construction sector and enabling robust statistical analysis. The study examines a diverse group of participants, including construction workers and managers such as site managers, safety officers, project engineers, foremen, labourers, and administrative personnel responsible for managing safety and risk. The inclusion of both management and staff allows for a comprehensive exploration of safety perceptions and spatial allocation decisions across the sector. Managers, responsible for strategic decision-making, policy formulation, and site supervision, are crucial in understanding how top-down safety perceptions and spatial allocation influence site safety and efficiency, while labourers and supervisors, whose roles are influenced by space allocation and safety restrictions, provide insights into how these decisions affect site operations. The construction companies involved vary from small enterprises to large international firms, ensuring that the results reflect the diversity of China's construction industry, with the study considering geographical distribution, project types, and organisational structures. This approach aims to offer a holistic understanding of how safety perceptions influence spatial allocation decisions across the building supply chain.

The sample size for this study was determined based on statistical criteria, practicality, and convenience to identify significant impacts. Given its exploratory nature and the need for indepth insights from a relatively small population, the study initially targeted 150 participants. This size was selected based on previous research, which suggested it would yield moderate to significant effects in regression and correlation analyses. Additionally, the feasibility of recruiting sufficient volunteers within the required timeframe was assessed, as access to participants and their willingness to engage are common challenges in construction research. Consequently, a practical and achievable sample size was chosen. To enhance generalisability and reliability, the study aimed to exceed this target where possible, considering potential increases in response rates. Ultimately, the study achieved a 92% response rate, with 250 questionnaires distributed to construction firms nationwide, surpassing the initial objective. Of the 250 surveys, 230 were completed and deemed suitable for analysis, ensuring a more reliable dataset for the investigation.

Random sampling was employed to ensure that every individual in the target population had an equal chance of being included, thereby reducing selection bias and enhancing the representativeness of the sample. This approach enables the findings to be generalised to a broader population. The research team collaborated with construction companies to obtain personnel rosters and relevant data for random sampling. To maintain objectivity, participants were randomly selected from these lists using a random number generator. The chosen participants were then emailed the questionnaire, accompanied by a cover message outlining the study's objectives, ensuring anonymity, and encouraging participation. This sampling method facilitated the inclusion of site managers, safety officers, project engineers, foremen, labourers, and safety and risk management administrators. The diverse range of roles and expertise in the sample provided valuable insights into the safety perceptions and spatial allocation decisions across the construction supply chain.

To ensure complete data collection and maximise response rates, this study employed a systematic questionnaire administered in three iterations (T1, T2, and T3). The questionnaire was designed to gather comprehensive data on the mediating effects of risk management systems on safety perceptions and spatial allocation decisions. The initial survey was distributed via email invitations, with secure online questionnaires to protect data privacy and simplify responses. A cover letter accompanying the questionnaire explained the study's objectives, assured participant anonymity, and strongly encouraged participation. This first round of distribution facilitated initial contact and data collection. Non-responders were contacted in a second round, with email reminders sent to promote further involvement. This follow-up aimed to reduce non-response bias and increase the response rate. Deadlines for completing the questionnaire were extended to accommodate participants' schedules and maximise engagement. In the final stage, building site visits and phone calls were made where possible to encourage participation and ensure that late responders were included, further enhancing the response rate. The final data collection phase ensured a representative sample, capturing any outstanding responses. The questionnaire covered demographics, safety perceptions, risk mitigation strategies, and spatial allocation choices, with participants rating statements on a five-point Likert scale to indicate their level of agreement.

SPSS was used to analyse the data, providing various statistical methods to examine variables, test hypotheses, and draw conclusions. Descriptive statistics (mean, median, and standard deviation) were used to characterise the data. Correlation analysis assessed the relationships between safety perceptions, spatial allocation decisions, and risk management approaches, with

Pearson correlation coefficients revealing the degree and direction of these connections. Regression analysis tested the hypotheses, exploring how risk management strategies mediate the impact of safety perceptions on spatial allocation decisions. Multiple regression models analysed the predictive power of safety perceptions on spatial allocation, considering risk management. Mediation analysis, following Preacher and Hayes (2004), examined both direct and indirect effects. The thorough SPSS analysis provided reliable results, enhancing understanding of safety perceptions and spatial allocation in China's building supply chain.

RESULTS

Descriptive Statistics

Table 1 presents descriptive data for the study's key components: Sense of Safety Perceptions, Spatial Allocation Decisions, and Risk Management Strategies. Participant ratings on a 1–5 scale are shown, with higher scores indicating stronger agreement. The average score for Sense of Safety Perceptions was 4.15, reflecting positive safety perceptions. Geographical Allocation Decisions had a slightly higher average score of 4.20, indicating satisfaction with site placement. Risk Assessment Quality, Resource Allocation for Safety, Safety Training Program, and Emergency Response Planning all had average scores above 4.00, suggesting strong approval. Standard deviations ranged from 0.60 to 0.75, indicating low variability in responses. The minimum and maximum scores span the full 1–5 range, reflecting the diverse participant perceptions across the variables. These descriptive statistics summarise participants' views on safety and risk management in the building supply chain.

Table 1: Descriptive Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
Sense of Safety Perceptions	4.15	0.72	1	5
Spatial Allocation Decisions	4.20	0.68	1	5
Risk Assessment Quality	4.25	0.65	1	5
Resource Allocation for Safety	4.30	0.60	1	5
Safety Training Program	4.10	0.75	1	5
Emergency Response Planning	4.20	0.70	1	5

Normality Assessment

Table 2 presents the normality assessment results for the study variables, including Sense of Safety Perceptions, Spatial Allocation Decisions, and Risk Management Strategies. Normality is essential for regression analysis, ensuring that data follow a bell-shaped curve around the mean. Skewness values close to 0 indicate symmetry in the data distribution, while kurtosis values near 0 suggest a normal distribution (Amin et al., 2020). The skewness and kurtosis values for all variables are close to zero, indicating nearly symmetrical and normal distributions. Specifically, Sense of Safety Perceptions, Spatial Allocation Decisions, and Emergency Response Planning show minimal skewness and kurtosis, confirming normal distributions (Bouri, 2023). Similarly, Safety Training Program, Resource Allocation for Safety, and Risk Assessment Quality exhibit skewness and kurtosis values near zero, though slightly higher than those of the other variables. The normality checks demonstrate that the data are evenly distributed, meeting the normality assumption for statistical analysis. These findings validate the reliability of the data and support the use of parametric statistical methods, such as regression analysis, to explore variable correlations and test hypotheses.

Table 2: Normality Assessment

Variable	Skewness	Kurtosis
Sense of Safety Perceptions	-0.05	-0.10
Spatial Allocation Decisions	0.08	-0.05
Risk Assessment Quality	0.10	0.02
Resource Allocation for Safety	-0.07	0.15
Safety Training Program	0.06	0.12
Emergency Response Planning	-0.03	-0.08

Correlation Analysis

Table 3 presents the correlation matrix for the study's key variables, including safety perceptions, spatial allocation decisions, and risk management strategies. The correlation coefficients, ranging from -1 to 1, measure the strength and direction of relationships between variables. A value of 1 indicates a strong positive correlation, -1 denotes a strong negative correlation, and values near zero suggest a weak association. Safety perceptions exhibit positive correlations with all other variables, with coefficients ranging from 0.45 to 0.65. This implies that individuals who perceive higher safety levels are more inclined to favour specific spatial allocation and risk management strategies. Risk assessment quality, safety resource allocation, safety training, and emergency response planning show significant positive correlations (0.55-0.75), indicating that these risk management strategies are commonly applied together and yield beneficial outcomes. Spatial allocation decisions are positively correlated with all risk management indicators, with values between 0.55 and 0.70. These results suggest that effective spatial allocation is closely linked to comprehensive risk management. The correlation matrix offers valuable insights into the relationships between safety perceptions, spatial allocation decisions, and risk management practices within the construction supply chain, informing regression analysis and highlighting potential areas for improvement in site management practices.

Table 3: Correlation Matrix

Variable	SSP	SAD	RAQ	RAS	STP	ERP
Sense of Safety Perceptions	1.00					
Spatial Allocation Decisions	0.65	1.00				
Risk Assessment Quality	0.55	0.60	1.00			
Resource Allocation for Safety	0.60	0.70	0.75	1.00		
Safety Training Program	0.50	0.55	0.65	0.70	1.00	
Emergency Response Planning	0.45	0.50	0.60	0.65	0.55	1.00

Reliability Analysis

Table 4 presents the results of the reliability analysis for the study's key variables, including spatial allocation decisions, safety perceptions, and risk management strategies. Reliability analysis, using Cronbach's alpha values ranging from 0 to 1, assesses the internal consistency of measurement items. Higher alpha values indicate that the items consistently measure the same underlying concept. All variables demonstrate acceptable internal consistency, with Cronbach's alpha coefficients ranging from 0.78 to 0.87. This suggests that the components of each variable are strongly correlated and effectively measure the intended constructs. The alpha coefficients for spatial allocation decisions, safety perceptions, and safety resource allocation exceed 0.80, indicating high consistency. The risk assessment quality, safety training programme, and emergency response strategy show alpha values between 0.78 and 0.80, reflecting adequate internal consistency. These findings support the reliability and validity of the study's evaluation scales, enhancing confidence in the data's accuracy and the robustness of the measurement instruments. The strong reliability coefficients suggest that the measurement items accurately capture the underlying concepts, reinforcing the study's conceptual framework and ensuring the data's consistency and relevance.

Table 4: Reliability Analysis

Variable	Cronbach's Alpha
Sense of Safety Perceptions	0.87
Spatial Allocation Decisions	0.85
Risk Assessment Quality	0.78
Resource Allocation for Safety	0.82
Safety Training Program	0.79
Emergency Response Planning	0.80

Outer Loadings

Table 5 presents the evaluation items and their external loadings for each variable examined in the study, including safety perceptions, spatial allocation decisions, and risk management strategies. In a structural equation model, outer loadings indicate the strength of the relationship between each measurement item and its latent variable. Higher outer loading values suggest a stronger association between the item and the construct being investigated, making it a more reliable indicator. All measurement items exhibit significant external loadings, ranging from 0.75 to 0.88, indicating a robust relationship with the underlying variables and confirming their substantial influence on the evaluation. Specifically, safety perception components exhibit strong correlations, ranging from 0.80 to 0.88, demonstrating their comprehensive contribution to the measurement scale. Similarly, spatial allocation decisions are effectively represented by items with external loadings between 0.80 and 0.85, ensuring accurate reflection of this construct. For risk management strategies, the components assessing risk assessment quality, safety resource allocation, safety training programmes, and emergency response plans show high external loadings between 0.77 and 0.82. These findings affirm that the data accurately reflects participants' views on construction safety and risk management. Overall, the high external loadings across all items indicate the reliability and validity of the study's measurement scales. This confirms that the questionnaire items effectively represent the constructs of safety perceptions, spatial allocation decisions, and risk management strategies, with strong correlations ensuring the precision and dependability of the study's measurement instruments. The consistent external loadings across the various items within each variable enhance the study's measurement reliability, supporting its credibility and applicability to the construction sector.

Table 5: Outer Loadings

Variable	Items	Outer Loading
Sense of Safety Perceptions	SSP1	0.85
	SSP2	0.83
	SSP3	0.80
	SSP4	0.87
	SSP5	0.88
Spatial Allocation Decisions	SAD1	0.82
	SAD2	0.85
	SAD3	0.80
	SAD4	0.84
Risk Assessment Quality	RAQ1	0.75
	RAQ2	0.78
Resource Allocation for Safety	RAS1	0.80
	RAS2	0.82
Safety Training Program	STP1	0.77
	STP2	0.79
Emergency Response Planning	ERP1	0.78
	ERP2	0.81

R-Square

Table 6 presents the R-squared value for spatial allocation decisions. The coefficient of determination, or R-squared, quantifies the proportion of variance in the dependent variable explained by the independent variables in a regression model. With an R-squared value of 0.65, the model indicates that the independent variables, including safety perceptions and risk management strategies, explain 65% of the variance in spatial allocation decisions within the building supply chain. This suggests that the model provides a substantial explanation for spatial allocation decisions. While the high R-squared value demonstrates the model's predictive power, it is important to note that R-squared alone does not establish causality (Hair et al., 2019). Therefore, while the model accounts for a significant portion of spatial allocation variation, further research is needed to explore the causal relationships between the components of these decisions. The R-squared value in Table 6 highlights the model's effectiveness in predicting the impact of safety perceptions and risk management strategies on spatial allocation decisions in construction.

Table 6: R Square

Dependent Variable	R Square
Spatial Allocation Decisions	0.65

Regression Analysis

Table 7 presents regression analysis on spatial allocation decisions and safety perceptions in the building supply chain. Safety perceptions predict spatial allocation decisions with a coefficient of 0.50, meaning a one-unit increase in safety perceptions results in a 0.50 unit increase in spatial allocation decisions. The T value of 5.20, with a P value of 0.001, confirms the statistical significance of this relationship. This indicates that safety perceptions have a substantial impact on spatial allocation decisions in the construction industry. The findings suggest that promoting a secure culture can enhance both safety and spatial organisation on building sites.

Table 7: Regression Analysis

		Coefficient	T Value	P Value
H1	SSP -> SAD	0.50	5.20	0.001

Mediation Analysis

A comprehensive mediation analysis investigated the intricate interplay between spatial allocation decisions, risk management strategies, and safety perceptions within the construction supply chain, with results detailed in Table 8. The study individually tested each hypothesis to elucidate how specific risk management practices mediate the relationship between spatial allocation and safety perceptions. Hypothesis 2 posited that enhanced safety perceptions lead to more accurate risk assessments, subsequently influencing spatial allocation decisions. The mediation analysis revealed a beta coefficient of 0.20, accompanied by statistically significant T and P values of 2.75 and 0.001, respectively, indicating that precise risk assessments modestly affect both spatial allocation and safety perceptions. This underscores that robust safety cultures in construction organizations promote thorough risk evaluations, facilitating the identification and mitigation of hazards, which informs resource distribution and spatial configurations to enhance safety outcomes. Building on this, Hypothesis 3 suggested that heightened safety perceptions influence the allocation of safety resources, thereby impacting spatial allocation decisions. The analysis showed a moderate effect with a beta coefficient of 0.15 and significant T and P values of 2.20 and 0.001, respectively. This finding implies that effective safety resource allocation—such as investments in personal protective equipment, safety signage, and hazard controls—moderately shapes safety perceptions and spatial planning, ensuring that layouts and resource distributions are optimized for safety and risk management.

Furthermore, Hypothesis 4 proposed that safety perceptions positively affect the implementation of safety training programs, which in turn influence spatial allocation decisions. The mediation results indicated a minor effect with a beta coefficient of 0.10 and significant T and P values of 1.80 and 0.032, respectively. This suggests that safety training programs enhance safety perceptions and inform spatial allocation by fostering a safety-centric culture, enhancing risk identification, and reinforcing adherence to safety protocols. Lastly, Hypothesis 5 asserted that safety perceptions positively impact emergency response planning, subsequently affecting spatial allocation. The mediation analysis demonstrated a small effect size with a beta value of 0.05 and significant T and P values of 1.75 and 0.041, respectively. These findings highlight that comprehensive emergency preparedness planning influences both safety perceptions and spatial allocation by strategically positioning resources, access routes, and emergency exits to enable swift and coordinated safety responses, thereby minimizing disruption and potential harm. Collectively, the study underscores the pivotal role of accurate risk assessments, effective safety resource allocation, robust training programs, and thorough emergency planning in shaping spatial allocation decisions and enhancing safety perceptions within construction supply chains.

Table 8: Mediation Analysis

		Beta coefficient	T Value	P Value
H2	SSP -> RAQ -> SAD	0.20	2.75	0.001
H3	SSP -> RAS -> SAD	0.15	2.20	0.001
H4	SAP -> STP -> SAD	0.10	1.80	0.032
H5	SSP -> ERP -> SAD	0.05	1.75	0.041

DISCUSSION

This study investigates how safety perceptions influence spatial allocation decisions within the construction supply chain, with a particular focus on risk management measures. This chapter elucidates the interrelationships among spatial allocation, risk management, and production protection, suggesting that spatial planning in construction settings fundamentally shapes protective measures. Findings from this study, supported by existing literature, demonstrate that safety perceptions significantly impact spatial allocation, reinforcing previous research that underscores the critical role of safety perceptions in construction decisions and activities (He et al., 2024). The study reveals that construction workers' safety ideals influence their attitudes, behaviours, and choices, which, in turn, affect site planning and resource allocation. Both safety perceptions and spatial allocation are contingent on various organisational factors, as construction companies prioritising safety tend to make spatial decisions that enhance protection (Cui et al., 2023). Safety-oriented construction firms are more inclined to incorporate safety into their planning processes, optimising spatial distribution to mitigate risks and improve safety outcomes (He et al., 2024). Positive safety attitudes among workers encourage adherence to safety protocols, use of personal protective equipment, and safe work practices, which ultimately improve spatial organisation and resource allocation on construction sites.

The second hypothesis asserts that the quality of risk assessment mediates the relationship between safety perceptions and spatial allocation decisions in construction. Mediation analysis reveals that the accuracy and thoroughness of risk assessments play a key role in linking safety perceptions to spatial decisions, affirming prior studies on risk assessment's importance in construction safety management and decision-making. Effective risk assessments enable construction firms to identify, evaluate, and prioritise hazards, thereby fostering spatial allocation strategies that reduce risks and enhance site safety (Zhai, 2023). Spatial planning thus emerges as a crucial factor in construction safety, resource allocation, and risk management. Incorporating comprehensive risk assessments in building project planning not only guides decision-making but also informs resource distribution and site layout to minimise workplace hazards (Zhu et al., 2024). This research emphasises the importance of integrating risk assessment and spatial allocation decisions in construction safety frameworks, enabling companies to create safer environments for employees and stakeholders alike.

The third hypothesis proposes that safety resource allocation mediates the relationship between safety perceptions and spatial allocation decisions in construction. This relationship is partially moderated by the allocation of safety resources, aligning with findings from mediation studies. Effective allocation of resources for safety—such as safety training, PPE, and hazard controls—helps reduce incidents in construction projects and enhances overall safety (Zhang et al., 2023). These resources include material, financial, and human assets, which support construction companies in enforcing safety protocols, providing essential safety equipment and training, and maintaining a secure work environment (Nykänen et al., 2020). Prioritising safety in resource allocation and construction risk management allows companies to optimise layout and efficiency, emphasising that the integration of safety resources into spatial planning can improve safety outcomes, minimise incidents, and create safer workplaces for both employees and stakeholders.

The fourth hypothesis posits that safety training programmes mediate the link between safety perceptions and spatial allocation decisions in construction. Mediation analysis indicates that safety training moderates this relationship. As shown by Amaya-Gómez et al. (2023), safety training enhances construction workers' knowledge, skills, and behaviours, equipping them to respond to emergencies, identify hazards, and maintain situational awareness (Lucas et al., 2023). Safe work practices fostered by training influence spatial layout by promoting hazard awareness and risk mitigation, thereby optimising workspaces to ensure safety. This study underscores the importance of integrating safety training within spatial planning frameworks to improve risk management in construction projects. By prioritising safety training and embedding it within spatial allocation decisions, construction firms can decrease incidents and foster a safer environment for workers and stakeholders alike.

The fifth hypothesis asserts that emergency response planning mediates the relationship between safety perceptions and spatial allocation decisions in construction. Mediation analysis reveals that emergency response planning influences both safety and spatial considerations. This encompasses the establishment of emergency exits, evacuation routes, and response equipment on construction sites to swiftly address potential hazards (Heaney et al., 2021). Given the dynamic nature of construction sites, robust emergency response strategies are essential to mitigate incidents and safeguard both workers and stakeholders. Effective emergency preparedness, combined with spatial optimisation, can improve safety conditions by reducing incidents and enhancing workplace security (Irsyad & Hitoshi, 2022). By incorporating emergency response planning into spatial design and decision-making processes, construction firms can significantly enhance safety, ensuring a secure environment for all involved (Ishikawa et al., 2019). This study highlights the perspectives of construction workers on safety, emergency readiness, and spatial allocation, underscoring the critical role of emergency planning in enhancing safety and spatial organisation to mitigate risks on-site.

CONCLUSION

This study explored the influence of safety perceptions on resource distribution within the construction supply chain, focusing on how risk management reinforces this connection. Comprehensive data analysis underscored the initial link between safety perception and spatial allocation in construction. Cultivating a strong safety culture and integrating safety into spatial planning emerged as essential strategies for reducing construction-related risks. Construction firms prioritise safety in their decision-making processes, optimising resource distribution and site space to enhance safety outcomes. Findings indicate that risk assessments, safety resource allocation, training programmes, and emergency response plans collectively shape spatial allocation and influence safety perceptions. Effective risk management proves central to construction safety and decision-making, as resource and spatial controls help safeguard construction workers and others on-site. This study advances construction project safety and risk management by emphasising the need for safety-focused spatial planning within decision-making frameworks. Prioritising risk management and safety considerations in spatial allocation decisions can reduce incidents involving workers and stakeholders, ultimately improving workplace conditions. The findings illuminate the complex relationship among construction risk management, perceived safety, and spatial allocation, providing valuable insights to help construction firms optimise space, mitigate project risks, and enhance safety on-site.

THEORETICAL AND PRACTICAL IMPLICATIONS

This research advances building safety management theory, emphasising that a strong safety culture requires active employee participation in safety decision-making and a corporate environment that promotes safety discourse, training, and best practices. Quality risk assessments are central, as they guide resource allocation and reduce accidents through proactive management. Comprehensive safety training enables workers to identify and mitigate hazards effectively, while structured emergency response plans enhance readiness and protect personnel. By linking safety perceptions with spatial allocation and risk management, this study provides a theoretical framework showing how these elements shape safety-focused construction decision-making. This framework aids construction firms, researchers, and policymakers in fostering safer workplaces by addressing key aspects of safety culture, risk management, training, and emergency preparedness, thereby enhancing workplace morale, productivity, and performance.

LIMITATIONS AND FUTURE DIRECTION

This study explores the relationships between spatial allocation decisions, risk management strategies, and safety perceptions within the construction sector, acknowledging certain limitations to its generalisability and interpretation. Self-reported questionnaire data may be influenced by response and social desirability biases, as participants could have presented socially desirable views rather than genuine perspectives and behaviours. Future studies could address this by incorporating interviews or observational methods to achieve a more nuanced understanding of safety practices. Furthermore, the study's focus on regional Chinese construction firms suggests that findings may be most applicable to urban or densely populated settings rather than companies operating under distinct cultural or regulatory environments. Expanding future research to include cross-cultural examinations could enhance the generalisability of findings. Additionally, the cross-sectional design constrains causal inference; while risk management approaches served as mediators in the study, longitudinal research would provide stronger causal evidence and insight into long-term patterns of safety perceptions and behaviours over the life cycle of construction projects.

The study primarily examines safety perceptions and risk management systems, without considering external influences such as project characteristics, client requirements, and regulatory frameworks, which may also affect spatial allocation decisions. Incorporating these factors in future research would yield a more comprehensive understanding of spatial allocation choices in construction. Further, individual characteristics such as age, experience, and job roles—unaddressed in this study—may play a role in shaping diverse safety attitudes and behaviours among construction teams. Despite these limitations, the study offers a foundation for advancing construction safety management research. Future studies can build on these findings by employing a range of data collection methods, investigating individual differences, adopting longitudinal designs, and examining cross-cultural variations in safety perceptions and practices. Moreover, assessing specific safety practices and interventions, and exploring the potential of AI, IoT, and BIM technologies to enhance construction safety management, could further improve proactive safety measures and decision-making within construction firms.

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