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Examining Safety Risk Perceptions Across Demographic Groups in High-Rise Residential Building Construction: An Integrated RS Approach

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ABSTRACT

Construction safety has gained a lot of attention, especially in high-rise residential buildings. In this study, an investigation was carried out on the safety risk perceptions among different demographics. 419 participants were involved in this investigation into the safety risk factors, whereby a Kruskal–Wallis test was conducted based on responses categorised by distinct demographic characteristics. To identify and quantify safety risks in high-rise building construction, this study proposes a novel risk assessment method- Risk Severity (RS). The results indicate that insufficient safety knowledge among high-rise builders, inadequate subcontractor safety control, and lack of safety training are the most critical sub-factors influencing construction safety, with RS values of 0.590, 0.588, and 0.587, respectively. At the broader level, high-rise builders with an RS value of 0.572 represent the highest risk category, underscoring the need to prioritise this group. Meanwhile, the Kruskal–Wallis test result reveals strong consensus in safety risk perceptions across distinct job positions and educational backgrounds, but significant variation across different levels of work experience. Extending the psychometric paradigm, the findings demonstrate that work experience plays a significant role in shaping perceived safety risks an aspect that has been underexplored in the existing literature. The findings suggest that the risks linked to high-rise builders represent the most critical threat to overall construction safety.

Keywords: High-rise residential building construction; safety risk factors; Risk Severity(RS); Relative Importance Index (RII); Kruskal-Wallis Test

INTRODUCTION

The construction of residential buildings, particularly high-rise developments, has expanded rapidly in China due to urbanisation, population growth, and large-scale infrastructure development. Despite its economic importance, the construction industry remains one of the most hazardous sectors worldwide, accounting for approximately 30–40% of fatal occupational accidents. In China, construction is the second most dangerous industry after mining.

High-rise residential building construction involves complex operations, multiple stakeholders, and high-risk working environments, making safety management particularly challenging. Previous studies on construction safety have mainly focused on general building projects, organisational safety culture, or frontline workers' unsafe behaviours, with limited attention given to the unique safety characteristics of high-rise residential construction. Furthermore, existing studies rarely examine whether demographic and socio-economic characteristics, such as education level, work experience, and job position, influence individuals' perceptions of construction safety risks. Since differences in risk perception among project participants may lead to communication barriers, inconsistent safety practices, and ineffective risk control measures, understanding these differences is essential for improving safety management and accident prevention in high-rise construction projects.

Therefore, this study aims to examine safety risk perceptions across demographic groups in high-rise residential building construction in Jiangsu, China. Specifically, the study seeks to: (1) identify the primary safety risk factors with the highest perceived risk levels; (2) determine the safety risk subfactors with the highest risk levels; and (3) investigate whether significant differences exist in safety risk perception among individuals with different educational backgrounds, work experience, and job positions. Using a quantitative questionnaire survey and statistical analysis approach, this study contributes to the existing body of knowledge by providing empirical evidence on demographic differences in construction safety risk perception and offering practical insights for targeted safety management, communication, and risk prevention strategies in high-rise residential building projects.

LITERATURE REVIEW

According to the Ministry of Housing and Urban-Rural Development of the People's Republic of China, 588 fatal construction accidents and 642 deaths were reported nationwide in 2023, representing increases of 4.45% and 0.4%, respectively, compared with 2022. Meanwhile, the National Bureau of Statistics of China (2024) reported that Jiangsu Province ranked among the top provinces in residential building construction area and recorded the highest newly started floor area in 2024. Given the scale and complexity of high-rise residential projects in Jiangsu, the province was selected as the focus of this study.

Table 1 depicts the floor area of residential housing in China in 2024. According to the National Bureau of Statistics of China (2024), among 34 provinces and municipalities, Guangdong, Shandong, Jiangsu, Henan, and Zhejiang ranked the top five in terms of residential building floor area under construction in 2024. Specifically, Jiangsu ranked third in construction area, exceeding 500 million square meters; however, its newly started floor area ranked first. Taken together, this study focuses on Jiangsu as the research target.

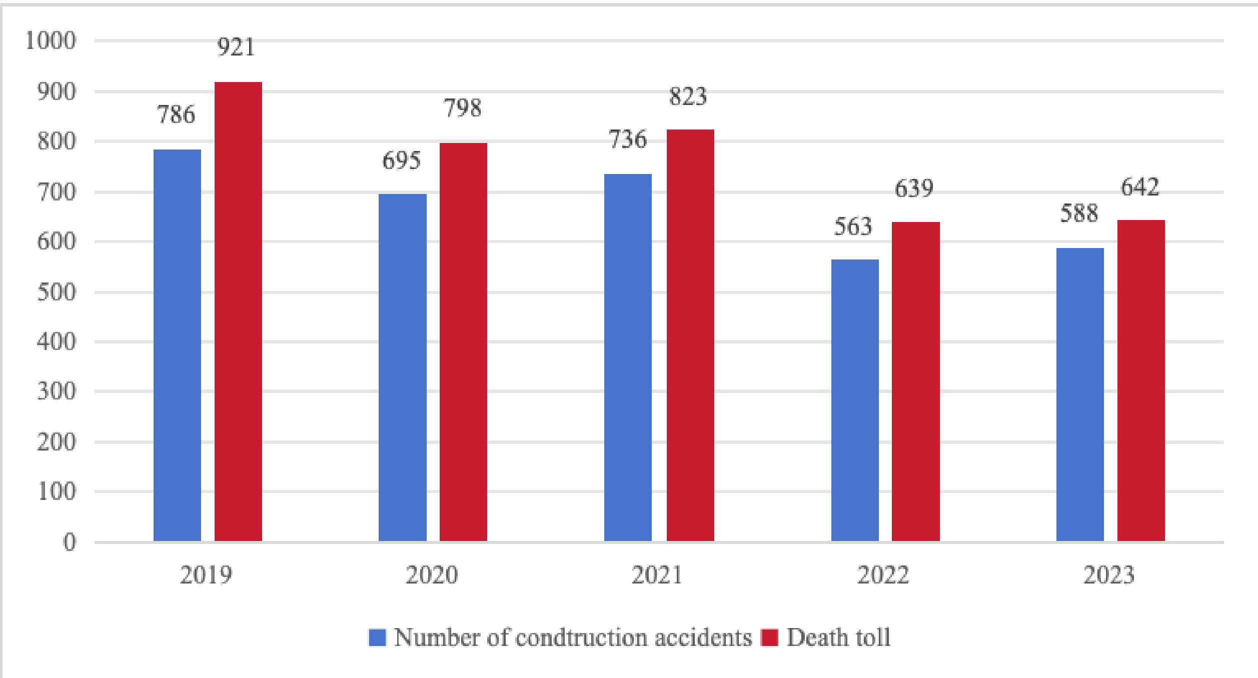

FIGURE 1. The number of construction safety fatal accidents and deaths in China (2019 to 2023)
Source: Ministry of Housing and Urban-Rural Development, PRC

TABLE 1. The floor area of residential buildings in China, 2024 unit: million square meter

Rank	District	The floor area under construction	The newly started floor area	The completed floor area
Total	China	7332.5	738.9	737.4
1	Guang Dong	725.7	52.3	65.6
2	Shan Dong	631	58.2	52.8
3	Jiang Su	500.6	58.7	73.3
4	He Nan	463.1	46.2	34.4
5	Zhe Jiang	460.8	48.9	76.8

Source: National Bureau of Statistics of China

SAFETY RISK FACTORS IN THE HIGH-RISE RESIDENTIAL BUILDING CONSTRUCTION INDUSTRY

Risk factors that impact project construction safety represent common challenges across the global construction industry. For instance, Phoya (2012) employed a mixed-method approach, combining qualitative and quantitative techniques, to examine health and safety risk management on building construction sites in Tanzania. He conducted interviews with experienced site managers and identified 11 types of health and safety hazards commonly present on construction sites: working at heights, falling objects, manual handling, equipment/plant/tools, chemicals, dust, noise, bending and twisting, fire, bullying, and stress. Furthermore, he categorised safety risk mitigation strategies and their implications into four systems: regulatory, organisational, individual, and work environment. Siraj and Fayek (2019) proposed risk grouping methods that provide a broader and more comprehensive categorisation to support both risk identification and subsequent risk management processes. Their findings revealed the top ten health and safety risks in construction, which are (1) Accidents occurring during construction; (2) Inadequate safety measures or unsafe operations; (3) Poor construction safety management; (4) Damage to persons, property, or materials due to ineffective safety and health management; (5) Failure to comply with Health and Safety Executive (HSE) standards or security plans; (6) Ineffective protection of the surrounding environment (such as, adjacent buildings and facilities); (7) Epidemic illness; (8) Strict health and safety regulations; (9) Changes in labor safety laws or regulations, and Fatalities.

Manzoor B (2022) identified and classified approximately sixty-two safety risk factors into ten main categories in Malaysia: (a) safety signs (b) Personal protective equipment (c) Fall from roofs/floor (d) Scaffolding & ladder failure (e) Safety check (f) Transportation & storage (g) work conditions (h) Low knowledge and skill level of worker (i) Personal factors and (j) Overload factors. Each of these main risk categories comprises several sub-factors.

To clarify the scope of existing research on safety risks in high-rise building construction, this study systematically reviewed representative literature. There are significant differences in the number and types of risk factors addressed across these studies.

A portion of the research, such as Xu (2013), Senouci et al. (2015), Awwad et al. (2016), Hatema et al. (2022), and Manzoor et al. (2022), primarily focuses on direct structural and operational hazards (SO), including risks associated with working at height, scaffolding, temporary structures, and mechanical equipment operation. These studies often integrate SO with safety management (SM) aspects, exploring how to control on-site operational risks through managerial measures.

Other studies, including Memon et al. (2013), Khan et al. (2015), Zou and Zhang (2009), Rafique et al. (2022), and Ansari et al. (2022), emphasise Construction Organization - related risks (CO), examining factors such as contractual arrangements, subcontractor management, schedule pressure, and cost and resource coordination. These organisational factors are recognised as important root causes of both SM and SO issues.

Another prominent stream of literature centres on Safety Management (SM), addressing areas such as safety planning, training, supervision, procedural compliance, and safety culture. Studies in this category for example, Luo (2006), Li et al. (2018), Abd Razak et al. (2023), Yew et al. (2023), and Junjia et al. (2023) often link SM with SO or high-rise builder-related risks (HB).

Several studies specifically target risks associated with High-Rise Builders (HB), such as Cheng et al. (2012), Aksorn et al. (2008), and Nurhendi et al. (2022), investigating unique challenges in high-rise building projects, including vertical transportation, falling objects, and evacuation difficulties. These can be viewed as an extension of SO in a specific project context, typically studied in conjunction with SM.

Additionally, research by Ilbahar et al. (2018), Nguyen et al. (2016), and Mohammadi et al. (2018) focuses on Environment Management-related risks (EM), examining the impact of construction on the surrounding environment such as pollution and noise or the influence of natural environmental conditions, like extreme weather, on construction safety. These studies often connect EM with HB-related considerations.

Notably, none of the existing studies systematically incorporates all five risk factors (1–5) proposed in this research into an integrated analytical framework. This selective focus may result in a fragmented understanding of the overall risk landscape. Therefore, to achieve a more comprehensive and systematic understanding of safety risks in high-rise building construction, this study develops an analytical framework that integrates all five risk factor categories, aiming to bridge the limitations of fragmented research and support holistic assessment. The framework synthesises a total of 38 specific safety risk factors, systematically classified into the following five groups: SO (structural and operational safety hazards), CO (construction organisation), SM (safety management), HB (high-rise builders), and EM (environment management) related safety risks. Table 2 presents the detailed composition of these five risk categories along with their supporting references.

To fulfil the third objective, the study proposes the following null hypothesis:

H1. There is no significant difference in the identification of safety risk factors in high-rise building construction among personnel with different educational backgrounds. H2. There is no significant difference in the identification of safety risk factors in high-rise building construction across different working experiences. H3. There is no significant difference in the identification of safety risk factors in high-rise building construction across different job positions.

TABLE 2. Dimensions of the safety risk model and their relevant references

No	Researchers	Safety risk categories				
		Structural and operational safety hazard	Construction Organisation Factors	Safety Management Factors	High-rise Builders Factors	Environment Management Factors
1	Luo D(2006)	√		√	√	√
2	Li Y et al. (2018)	√		√	√	
3	Manzoor B et al.(2022)	√	√	√	√	√
4	Xu R(2013)	√		√	√	√
5	Cheng E et al.(2012)			√	√	
6	Yew et al. (2023)			√	√	√
7	Ministry of Housing and Urban-Rural Development (2011)	√		√		√
8	Memon et al.(2013)		√	√	√	
9	Khan et al.(2015)		√		√	
10	Aksorn et al.(2008)		√	√	√	
11	Awwad R et al.(2016)	√		√	√	
12	Zou, P. X,& Zhang, G.(2009)	√	√	√	√	√
13	Mohammadi, A et al.(2018)		√	√	√	√
14	Ilbahar, E et al.(2018)		√	√	√	√

RESEARCH METHODOLOGY

This section outlines the methodology used to investigate safety risk factors in high-rise buildings within China's construction industry, with a particular focus on data collection procedures, analysis techniques, and the tools applied. As depicted in Figure 2, to achieve research objectives one and two, the Risk Severity (RS) and Relative importance index (RII) method will be used, while for research objective three, this study will employ the Kruskal–Wallis test for hypothesis analysis in the field of high-rise construction safety risk perception, which represents a novel approach.

First, after a comprehensive literature review, a well-structured initial questionnaire was developed. A reliable and valid measurement instrument must undergo content validity and face validity testing. Therefore, six experts were invited to evaluate the content validity of the questionnaire. The results indicated that three items were not relevant to the objectives of measuring construction safety factors in this study and were consequently removed. Additionally, a face validity test was conducted by randomly inviting ten individuals, which led to the revision of several items with unclear wording. Therefore, there remained 35 items for the following pilot study, which was carried out to ensure the clarity and completeness of the questionnaire, as well as the relevance of the identified risks (derived from the literature review) to high-rise construction in China.

This pilot study involved 35 participants, including 5 project managers, 3 site engineers, 7 technical directors, 4 safety officers, 3 safety supervisors, 2 construction workers and 11 other related respondents, from 13 different construction sectors in China. The collected questionnaires must first undergo a reliability test to ensure that the questionnaire measures what it is intended to measure. The result of reliability test indicated that cronbach's alpha of all 35 safety risk factors were above 0.8, excceding the threshold 0.7, demonstrating a well internal consistency. however, based on the descriptive statistics, SO2, labelled "Worker electric shock" recorded the lowest mean score of 2.74, and is similar to the SO1, titled "Workers' lack of knowledge regarding electricity and operation in violation of safety regulations", therefore, SO2 was removed from the final questionnaire. The feedback obtained from the participants was then used to refine and redesign the final questionnaire for main study.

The final questionnaire was structured as follows: The first section of the questionnaire provided an introduction, outlined the objectives, and included a brief conclusion about the questionnaire. The second section contained questions related to the respondents, their work experience, educational background, and job positions. The following two sections were designed to investigate five main categories of safety risk factors in terms of their probability and impact. Respondents were asked to rate the importance of 34 safety risk factors using a five-point Likert scale (1 = very low, 2 = low, 3 = moderate, 4 = high, 5 = very high).

It is a critical step to select an appropriate sample size in the data collection process. One effective way to ensure the generalizability of the results is to use a sufficiently large sample that accurately represents the population. According to reports from Jiangsu Provincial Bureau of Statistics, the total population under study consists of 15436 Construction Enterprises in 2023, which has a large population. Therefore, the sample size can be determined using Equation 1 based on Kotrlik & Higgins (2001):

$$n = \frac{Z^2 p(1-p)}{E^2} = \frac{(1.96)^2(0.5)(1-0.5)}{0.05^2} = 385 \qquad (1)$$

Where:
n = required sample size,
Z = Z-score (1.96 for 95% confidence),
p = estimated proportion of the population (often 0.5 if unknown),
E = margin of error (0.05 for 5%).

Therefore, the sample size for this study was determined to be 385 employees. The questionnaire targeted high-rise building project teams within construction companies, including project managers, safety supervisors, site engineers, construction workers, foremen, and other project-related personnel such as quality and technical control staff.

By verifying the calculation using Krejcie and Morgan's (1970) equation, we arrived at the same sample size of 385 employees. Therefore, our sample size is proven to be sufficient and scientifically valid.

The collected data from the main study were analysed using three nonparametric statistical methods: Reliability testing, RII analysis, and the Kruskal–Wallis test.

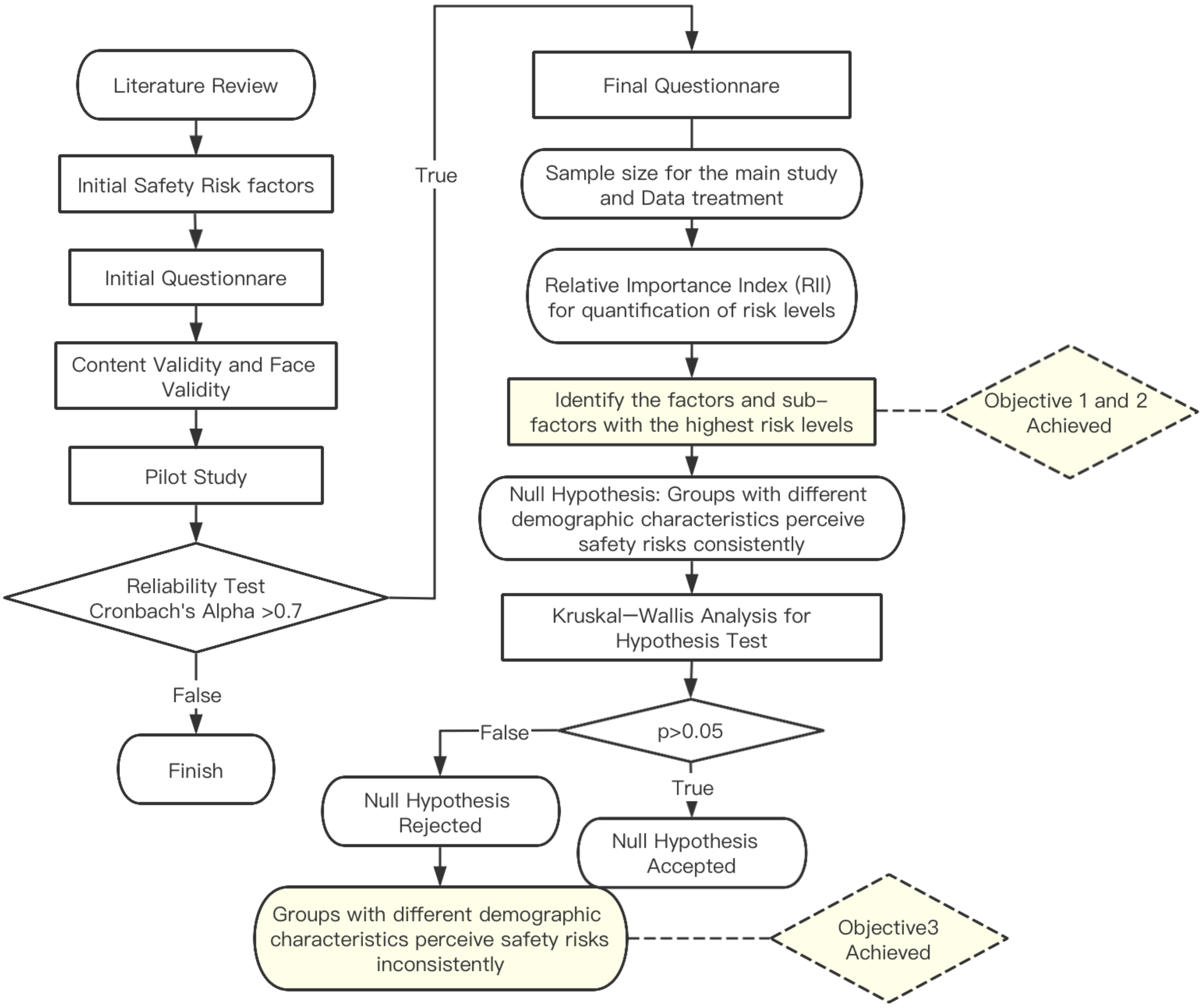

FIGURE 2. Research methodology flowchart

Reliability represents the extent to which measurement results are consistent and stable. The reliability coefficient ranges from 0 to 1, with higher values indicating greater acceptability of the measurement results. Cronbach's alpha is one of the most commonly used indicators of reliability, and a value of 0.7 or higher is generally considered acceptable. Equation of Cronbach's alpha is as follows:

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\Sigma S_i^2}{S^2}\right) \tag{2}$$

Where,
K -The total number of items included in the scale;
S^2-The variance of the total score of the measurement scale;
S_i^2 -The variance of the i-th item;
ΣS_i^2- Sum of variances across all items.

As shown in Table 3, this paper applies the value ranges and reference standards proposed by Zhang M (2009).

TABLE 3. Cronbach's alpha reference standards

Cronbach' s **α** Value range	Reference standard
α ≥0.9	Excellent reliability
0.8 ≤ α < 0.9	Good reliability
0.7 ≤ α < 0.8	Acceptable reliability
0.6 ≤ α < 0.7	Questionable reliability
0.5 ≤ α < 0.6	Poor reliability
α < 0.5	Unacceptable reliability

To synthesise the impact of consequences and the probability of each risk, this study utilises the Relative Importance Index (RII) approach, enabling a systematic quantification of risk severity levels. The RII is determined as a function of the weights assigned to each response, the highest possible weight on the rating scale, and the total number of respondents (Kometa et al.1994). It is computed using Equation 3:

$$\text{RII}=\frac{\sum_{i=1}^{n} W_i}{(\text{N}\times\text{A})}=\frac{5n_5+4n_4+3n_3+2n_2+1n_1}{5N} \quad (3)$$

Where,

W_i, is the weight assigned to each factor by the i-th respondent, rated as 1, 2, 3, 4, and 5 for very low, low, moderate, high, and very high, respectively or very unlikely, unlikely, moderate, likely, and very likely, respectively;

A is the maximum weight (i.e., 5 in this case),

N is the total number of respondents.

As a non-parametric statistical method, the Kruskal–Wallis test was developed by William Kruskal and W. Allen Wallis in 1952, and used to assess whether there are significant differences in the medians among three or more independent groups (Kruskal & Wallis, 1952). It is calculated through Equation 4:

$$H=\left(\frac{12}{N(N+1)}\right)\sum_{i=0}^{k}\frac{R_i^2}{n_i}-3(N+1) \quad (4)$$

Where,
R_i represents the sum of ranks for each group,
k is the number of groups,
n_i is the sample size for group 1, 2, 3, …,
N is the total sample size.
SPSS performs the Kruskal–Wallis test based on the p-value; if $p < 0.05$, it indicates the presence of significant differences among the groups.

RESULTS AND DISCUSSIONS]

The completed questionnaires were collected through an online questionnaire tool, Wenjuanxing. To ensure both the quantity and quality of the survey, 434 questionnaires were administered. Among the 434 distributed questionnaires, a total of 419 were fully completed and deemed valid for analysis. The sample size used in this research is larger and more robust than those in previous studies in the same field.

Table 4 depicts the demographic characteristics of 419 respondents and provides a detailed summary of the demographic characteristics of the respondents. In terms of age, the most respondents were 31-40 years old, accounting for 41.5% of the total number. In the category of working experience, the largest group had 5-10 years of experience in the field of high-rise building, about 26.3% of the total number. As for job positions, the top two most occupied positions were quality controller and construction worker, approximately 20% and 18% of the total number, respectively. The job title category offers valuable insight into the relationship between respondents' positions and their perspectives on the survey topic. Regarding educational background, the majority of respondents held a bachelor's degree, accounting for 52.3% of the total number.

The respondents to the questionnaire represent the majority of high-rise building sector organisations operating in Jiangsu and possess diverse job positions and varying years of experience. Consequently, the results of the analysis hold scientific value, supporting the validity and comprehensiveness of the questionnaire and positioning it as a suitable model. The demographic analysis serves as a fundamental component of the study. The primary objective is to examine the influence of education background, job position, and professional experience on the identification of safety risk factors in high-rise building construction, as well as to assess the degree of variation among participants within the same category and across different groups.

TABLE 4. Analysis of Respondents' Demographics

Demographic characteristic	Frequency	(%)
Age		
30 below	88	21.0
31-40	174	41.5
41-50	98	23.4
51-60	43	10.3
Above 61	16	3.8
Educational background		
Associate's degree or below	134	32.0
Bachelor's degree	219	52.3
Master's degree or above	66	15.8
Working experience		
Less than 5	89	21.2
5-10	110	26.3
10-20	92	22.0
20-30	80	19.1
30 and above	48	11.5
Job Position		
Project Manager	18	4.3
Technical Director	26	6.2
Site Engineer	46	11.0
Safety Supervisor	46	11.0
Safety Officer	56	13.4
Construction worker	75	17.9
Quality controller	83	19.8
Foreman	46	11.0
Others	23	5.5

RESULT OF RELIABILITY TESTING

Reliability testing was conducted before data analysis to ensure the internal consistency of the measurement items, thereby confirming that the collected data were dependable and suitable for subsequent statistical analysis. The questionnaire's reliability was assessed using Cronbach's alpha, yielding a coefficient of 0.962. Table 5 displays that this value is well above the commonly accepted threshold of 0.7 (Nunnally and Bernstein, 1994), indicating excellent internal consistency.

TABLE 5. Cronbach's alpha of Safety Risk Factors in this scale

Dimension	Number of items	Cronbach's Alpha
Total	34	0.962

TABLE 6. Risk Severity of Safety Risk Subfactors in High-Rise Construction Projects

Item No	Code	Safety Risk factors	Risk Impact		Risk Probability		Risk Severity	
			RII	Rank	RII	Rank	RII	Rank
1	SO1	High-rise construction power workers lack knowledge of electricity and operate in violation of regulations	0.727	33	0.714	34	0.519	34
2	SO2	Heavy load on construction machinery leads to overload circuits	0.758	16	0.726	27	0.550	25
3	SO3	Inadequate safety measures during aloft work	0.750	22	0.726	26	0.545	30
4	SO4	Unstable High Temporary Work Platforms	0.761	12	0.763	5	0.581	5
5	SO5	Design errors of Tall Scaffolds/Formwork	0.772	3	0.727	25	0.562	13
6	SO6	Substandard Construction of Tall Scaffolds/Formwork	0.751	21	0.734	21	0.551	24
7	SO7	Use of substandard scaffolding or formwork materials	0.740	30	0.729	24	0.540	31
8	SO8	Overloading of Tall Scaffolds/Formwork	0.746	27	0.720	32	0.537	32
9	SO9	Unskilled tower crane operator	0.759	14	0.737	20	0.559	19
10	SO10	Incorrect installation or disassembling of Special equipment	0.740	31	0.737	18	0.545	29
11	SO11	Collapse of Deep Foundation Pit Due to Improper Excavation and Support	0.758	18	0.721	30	0.546	28
12	SO12	No warning before instability of deep foundation pit	0.759	15	0.722	29	0.548	26
13	CO1	No Safety Production Responsibility System	0.777	1	0.721	31	0.560	17
14	CO2	Compressed Project Duration and Cost by the Client	0.772	4	0.738	15	0.570	9
15	CO3	Shortage of Budget Allocation for Safety	0.762	11	0.738	16	0.563	11
16	CO4	Inadequate safety control of subcontractor for tall buildings	0.772	5	0.762	6	0.588	2
17	SM1	Failure to timely check and correct illegal operations	0.747	26	0.716	33	0.535	33
18	SM2	Failure to conduct daily safety check	0.754	20	0.744	13	0.561	16
19	SM3	Lack of regular safety meetings	0.744	29	0.749	10	0.557	21
20	SM4	Failure to identify the cause, responsible parties, and how it occurred when investigating incidents	0.726	34	0.771	3	0.559	20
21	SM5	No eye-catching and night light warning signs	0.758	19	0.732	23	0.555	22
22	SM6	No On-Site Monitoring System for High-Rise Builders	0.748	25	0.752	9	0.562	12
23	SM7	No identification of potential safety hazards specific to high-rise construction	0.738	32	0.742	14	0.548	27
24	SM8	No Safety Sign Placement Plans of the Tall Building	0.745	28	0.765	4	0.570	8
25	SM9	Poor quality of Height Safety Equipment (PPE) Provided	0.750	23	0.758	7	0.568	10

continue...

...*cont.*

Item No	Code	Safety Risk factors	Risk Impact		Risk Probability		Risk Severity	
			RII	Rank	RII	Rank	RII	Rank
26	HB1	Lack of Personal Safety Awareness	0.749	24	0.737	19	0.552	23
27	HB2	Insufficient safety knowledge of high-rise builders	0.763	10	0.774	1	0.590	1
28	HB3	Lack of safety training of high-rise Builders	0.761	13	0.772	2	0.587	3
29	HB4	Human Error	0.770	7	0.757	8	0.583	4
30	HB5	Alcohol abuse	0.765	9	0.733	22	0.561	15
31	HB6	Not using Height Safety Equipment	0.767	8	0.746	12	0.572	7
32	HB7	Overexertion due to continuous overtime work of High-Rise Builders	0.758	17	0.737	17	0.559	18
33	EM1	Extreme weather conditions at heights	0.774	2	0.726	28	0.562	14
34	EM2	Prolonged exposure to hazardous situation in high-rise construction	0.772	6	0.747	11	0.577	6

RESULT OF SAFETY RISK FACTORS RANKING

Risk Severity (RS) was computed as the product of the probability (P) and impact (I) of each risk, both normalised using the RII method (El-Sayegh et al.2018).

Risk severity = Risk impact × Risk probability, each is calculated using RII Equation 3.3 above, respectively. For example, SO1, RS = 0.727 × 0.714=0.519.

Table 6 has been produced mainly to compare the subfactors among themselves using their relative importance indices. Among subfactors, insufficient safety knowledge of high-rise builders (RS = 0.59), inadequate safety control of subcontractors for tall buildings (RS = 0.588), and lack of safety training for high-rise builders (RS = 0.587) emerged as the Top three most critical subfactors. A closer analysis reveals that all subfactors achieved a score of 0.50 or higher on the relative index scale, suggesting that each exerts a considerable influence on the main factors and, in turn, on the overall safety performance of project construction.

Table 7 illustrates the relationship between the main factors and their corresponding subfactors. The overall RS, and consequently the ranking of the main factors, was derived from the RS of the associated subfactors. For instance, under "Construction organisation", the subfactors CO1, CO2, CO3, and CO4 recorded RS of 0.56, 0.57, 0.563, and 0.588, respectively (Table 7). The average of these values, (0.56 + 0.57 + 0.563 + 0.588) / 4 = 0.570, represents the overall RS of "Construction organisation". Based on the overall RSs calculated in this way, the ranking of the main factors is established, as summarised in Table 7. Specifically, the risk priority levels of the main factors were determined as follows: High-rise builders (RS=0.572), Construction organisation (RS=0.570), Environment management (RS=0.5965), Safety management (RS=0.557), and Structural and operational safety hazards (RS = 0.549). This indicates that High-rise builders related risk factors pose the greatest threat to construction safety and therefore require the highest priority in implementing preventive and control measures. Therefore, it is suggested that decision-makers and safety managers should give top priority to high-rise builders (HB) and allocate safety resources and budgets accordingly, as it represents the highest-ranked risk in both main and sub-risk ranking. The results highlight that prioritising safety training for subcontractors and embedding safety knowledge into onboarding for inexperienced workers can reduce accidents. Therefore, contractors, project managers, and safety supervisors need to strengthen subcontractor management, regulate unsafe behaviours of subcontractors, and simultaneously enhance safety training, expand safety knowledge, and improve safety awareness of high-rise builders.

RESULT OF HYPOTHESIS TESTING-KRUSKAL–WALLIS TEST

The primary data obtained from the questionnaire were analysed by considering the educational background, work experience, and job position of project team members. The Kruskal–Wallis test was applied to examine the three hypotheses. Table 8 and Figure 3 present the results of the analysis, illustrating the identification of safety risk factors in high-rise construction across different demographic categories.

For H1: Educational backgrounds, the Kruskal–Wallis test results revealed that, as displayed in Table 8 and Figure

3, at the 0.05 significance level, notable variations were observed in perception for only 2 out of the 34 identified risk factors by respondents, as highlighted in grey ($p < 0.05$). This suggests that different educational backgrounds in the respondents of Jiangsu generally share a similar view on the safety risk factors affecting construction safety(various educational background categories were examined in the survey, as shown in Table 4).

To examine H2: Work experience, the Kruskal–Wallis test was applied to assess whether perceptions of safety risk factors vary with the project team's work experience. The results indicate a significant difference at the 0.05 significance level, with 19 out of 34 risk factors showing notable variation ($p < 0.05$). This finding implies that differences in years of experience lead to differing views on the safety risk factors influencing construction safety. In other words, the evaluation and identification of risk factors in construction projects tend to vary according to experience level, as many safety risks can be better recognised and assessed through extensive, accumulated work experience. Therefore, future risk management initiatives should actively seek and incorporate the insights of personnel with extensive work experience.

A further test was carried out to examine H3. No significant relationship was found between the identification of construction safety risk factors and participants' job title. Only 1 out of the 34 safety risk factors showed significant differences in perception ($p < 0.05$). This suggests that employees in Jiangsu, regardless of their job position, generally share the same views on the key safety risk factors affecting project safety performance.

The analysis revealed some unexpected results, A plausible explanation is that standardised safety training programs implemented across construction enterprises may have minimised differences in knowledge and awareness between workers with varying educational backgrounds. Similarly, organisational culture in high-rise construction projects often emphasises compliance with unified safety protocols, which may reduce perceptual differences between managerial and non-managerial staff. Consequently, the homogenising effect of training and culture may outweigh the influence of individual demographic attributes such as education or position.

TABLE 7. Risk Severity -Based Relationship Between Main Factors and Subfactors of Safety Risks

Main/Subfactors	Risk Severity of Subfactors	Overall RS for main factors	Overall rank for main factors
Structural and operational safety hazard-SO		0.549	5
SO1	0.519		
SO2	0.55		
SO3	0.545		
SO4	0.581		
SO5	0.562		
SO6	0.551		
SO7	0.54		
SO8	0.537		
SO9	0.559		
SO10	0.545		
SO11	0.546		
SO12	0.548		
Construction organization-CO		0.5703	2
CO1	0.56		
CO2	0.57		
CO3	0.563		
CO4	0.588		
Safety management-SM		0.557	4
SM1	0.535		
SM2	0.561		
SM3	0.557		
SM4	0.559		
SM5	0.555		

continue...

...cont.

SM6	0.562		
SM7	0.548		
SM8	0.57		
SM9	0.568		
High-rise builders-HB		0.572	1
HB1	0.552		
HB2	0.59		
HB3	0.587		
HB4	0.583		
HB5	0.561		
HB6	0.572		
HB7	0.559		
Environment management-EM		0.5695	3
EM1	0.562		
EM2	0.577		

TABLE 8. Kruskal–Wallis Analysis for Perception of Safety Risks Comparison

Safety Risk Groups	Safety Risk Subfactors	p-values of the Kruskal-Wallis test		
		Asymp. Sig. (Education)	Asymp. Sig. (Experience)	Asymp. Sig. (Job position)
Structural and Operational safety hazard	High-rise construction power workers lack knowledge of electricity and operate in violation of regulations	0.880	0.385	0.875
	Heavy load on construction machinery leads to overload circuits	0.769	0.014	0.359
	Inadequate safety measures during aloft work，such as not install guardrails, safety nets, fall protection	0.397	0.001	0.106
	Unstable High Temporary Work Platforms	0.274	0.006	0.167
	Design errors of Tall Scaffolds/Formwork	0.687	0.090	0.143
	Substandard Construction of Tall Scaffolds/ Formwork	0.901	0.020	0.155
	Use of substandard scaffolding or formwork materials	0.942	0.003	0.246
	Overloading of Tall Scaffolds/Formwork	0.885	0.186	0.031
	Unskilled tower crane operator	0.814	0.138	0.132
	Incorrect installation or disassembling of Special equipment such as tower cranes and elevators	0.819	0.000	0.146
	Collapse of Deep Foundation Pit Due to Improper Excavation and Support	0.711	0.000	0.334
	No warning before instability of deep foundation pit	0.786	0.030	0.179
Construction Organisation	No Safety Production Responsibility System	0.127	0.018	0.228
	Compressed Project Duration and Cost by the Client	0.460	0.121	0.742
	Shortage of Budget Allocation for Safety	0.915	0.010	0.803
	Inadequate safety control of subcontractor for tall buildings	0.140	0.091	0.597

continue...

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	Failure to timely check and correct illegal operations	0.037	0.192	0.106
	Failure to conduct daily safety check	0.628	0.046	0.105
	Lack of regular safety meetings	0.956	0.010	0.681
	Failure to identify the cause, responsible parties, and how it occurred when investigating incidents	0.224	0.200	0.689
Safety Management	No eye-catching and night light warning signs	0.644	0.021	0.225
	No On-Site Monitoring System for High-Rise Builders	0.910	0.079	0.418
	No identification of potential safety hazards specific to high-rise construction	0.071	0.068	0.933
	No Safety Sign Placement Plans of the Tall Building	0.701	0.004	0.392
	Poor quality of Height Safety Equipment (PPE) Provided	0.833	0.030	0.489
	Lack of Personal Safety Awareness	0.081	0.181	0.308
	Insufficient safety knowledge of high-rise Builders	0.230	0.092	0.299
High-rise Builders	Lack of safety training of high-rise Builders	0.298	0.068	0.877
	Human Error	0.787	0.015	0.649
	Alcohol abuse	0.551	0.005	0.145
	Not using Height Safety Equipment	0.259	0.211	0.322
	Overexertion due to continuous overtime work of High-Rise Builders	0.823	0.047	0.306
Environment Management	Extreme weather conditions at heights (continuous rainfall, snow, temperature, severe wind)	0.022	0.243	0.714
	Prolonged exposure to hazardous situation in high-rise construction, such as falling from heights, object strikes, scaffold collapses, tower crane collapses, etc	0.069	0.023	0.430

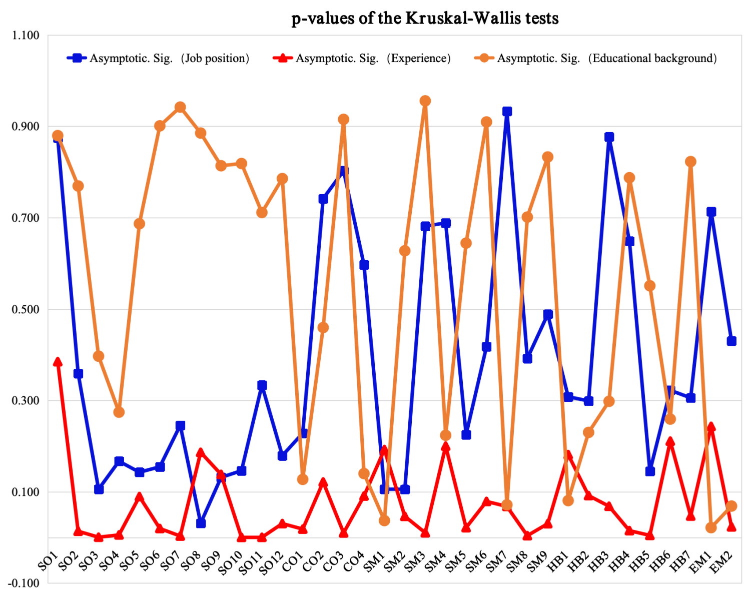

FIGURE 3. P-value of Kruskal-Wallis tests

COMPARISON WITH PREVIOUS STUDIES

The findings of this study are generally consistent with previous research on construction safety risk perception and demographic influences. Similar to the present study, earlier studies have reported that workers' experience significantly affects their ability to recognise and assess construction safety risks, as experienced personnel tend to possess stronger hazard identification skills and greater practical understanding of unsafe conditions developed through long-term site exposure (Choudhry & Fang 2008). Previous studies have also emphasised that unsafe worker behaviour, inadequate safety awareness, and insufficient safety competency are major contributors to construction accidents (Asilian-Mahabadi et al. 2018). In addition, the present findings regarding the critical role of subcontractor safety management are consistent with the study of Dale et al. (2020), which highlighted that weak subcontractor safety management and inconsistent safety practices can negatively affect workers' safety climate and behaviour.

In contrast, the limited differences observed across educational backgrounds and job positions in this study are also supported by previous research, which suggests that standardised safety training, organisational safety culture, and unified safety regulations can reduce perceptual differences among employees from different hierarchical levels (Pandit et al. 2019). Therefore, the present findings reinforce existing evidence that improving worker' safety competency, strengthening subcontractor supervision, and implementing continuous safety training are essential strategies for enhancing safety performance in high-rise residential building projects.

CONCLUSION

This study seeks to identify the main safety risk factors and subfactors that rank highest in overall risk severity level. The findings highlight that insufficient safety knowledge of high-rise builders (HB2), inadequate safety control of subcontractors for tall buildings (CO4), and lack of safety training for high-rise builders (HB3) represent the most critical subfactors affecting construction safety. At the broader level, the analysis of main factors revealed that High-rise builders constitute the highest risk severity level, followed closely by Construction organisation, Environment management, Safety management, and Structural and operational safety hazards. These results indicate that risks associated with high-rise builders pose the most significant threat to construction safety.

The psychometric paradigm emphasises that individuals' perceptions of risk are not entirely rational or objective, but are shaped by various psychological and social factors. Compared with less experienced individuals, those with greater experience demonstrate higher levels of psychological maturity, stronger experiential learning, and more extensive tacit knowledge, which often leads them to underestimate risks. Conversely, less experienced individuals, lacking familiarity and direct exposure to safety incidents, are more likely to overestimate risks by imagining potentially catastrophic outcomes.

The findings of this study hold substantial practical significance for both researchers and stakeholders in the high-rise building construction sector. For safety managers, it is preferable to "overestimate" rather than "underestimate" risks. Accordingly, organisational policies and preventive measures should adopt a conservative orientation, drawing on the higher risk perceptions of less experienced workers to reduce the likelihood of accidents. Another implication derived from the safety risk perception difference explained by psychometric paradigm is that tacit knowledge from practical experience outweighs formal education in shaping safety awareness. This insight calls for experience-driven mentoring programs. However, for academic researchers, reliance should primarily be placed on objective construction safety data such as accident rates, hazard records, and regulatory standards rather than exclusively on the subjective perceptions of any single demographic group.

Combining the results of Objectives 1, 2, and 3, high-rise builders (HB) had the greatest influence on construction safety. Risk perception showed significant differences only among workers with different levels of work experience, while no significant differences were observed across job positions or educational backgrounds. This indicates that work experience is an important factor affecting safety risk perception.

Therefore, based on the conclusions of this study, several practical strategies are proposed for different stakeholders: for contractors, establish mentorship programs that pair new employees with experienced supervisors; for policymakers, set minimum experience thresholds for safety-critical positions; for safety trainers, tailor training programs to account for workforce demographic diversity, and for high-rise builders (HB), it is essential to strengthen safety training, enhance safety awareness and knowledge, and improve safety skills.

LIMITATIONS AND FUTURE RESEARCH

This study was limited to data from Jiangsu Province, China, and did not incorporate international comparisons of construction safety risks. Cross-sectional design limits causal inference. Moreover, it did not explore in depth how work experience shapes safety risk perception specifically, including whether risks are over- or underestimated across groups.

Building on this study, future research could extend the investigation to a broader scope across different countries to explore whether construction safety risks are consistent across regions. Future research may employ longitudinal designs to track evolving perceptions. In addition, more in-depth analyses of how demographic characteristics influence safety risk perception are warranted. Such research could incorporate surveys, experiments, or statistical modelling approaches to systematically capture group differences and integrate them into the analysis.

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DECLARATION OF COMPETING INTEREST

None.

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