

# A Review of Citespace-based Literature Research on Safety Behavior in Construction Industry

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**Abstract:** Purpose: This study aims to effectively reduce the occurrence of safety accidents in the construction industry by focusing on the safety behavior of construction workers. Method: We selected core literature from the Web of Science(WOS) database published between 2014 and 2024 in the field of construction safety behavior. Using Citespace software, we conducted a visual analysis of researchers, collaborating institutions, keywords, and documents. Findings: The findings reveal the following: 1. China leads in the number of research papers published in this field over the past decade. 2. There are key researchers in the field, but influential, large-scale research teams are scarce. 3. The majority of studies are concentrated in universities. 4. Current research hotspots include themes such as safety climate and safety management practices targeting construction workers. 5. Recent research on construction safety behavior can be divided into three phases, further confirming the research hotspots and trends. Value: The application of Citespace facilitates a comprehensive review of the literature on construction safety behavior from multiple perspectives, revealing new research angles and issues, thereby providing a basis for industry development and policy formulation. However, this study remains at the surface level of analyzing existing literature and does not delve deeply into critical issues or theoretical assumptions; future research will explore these areas further. Innovation: The innovative aspects of this study include the use of Citespace software for a comprehensive visual analysis of the literature, which reveals new research angles and trends not previously identified. This approach provides a unique perspective on the evolution of research topics and collaboration patterns within the field of construction safety behavior. Furthermore, the identification of specific research hotspots, such as safety climate and safety management practices, contributes to a deeper understanding of the factors influencing construction workers' safety behavior.

**Keywords:** Citespace, Visual analytics, Safety climate, Construction worker safety behavior, Occupational safety.

## 1. Introduction

The construction industry is a foundational sector and a crucial component of national economic production, closely linked to the development of the economy and the improvement of people's living standards (Global Data, Construction Intelligence Center, 2023). However, it is considered one of the most hazardous industries, with accident and fatality rates consistently exceeding those of other sectors (Shohet et al., 2018). The substantial investment in construction projects and the large workforce involved mean that the consequences of safety incidents are particularly severe and significant (Osei-Asibey et al., 2023).

The occurrence of accidents in the construction industry is influenced by a multitude of factors. In the early stages of research, scholars analyzed accidents based on their types, concluding that the primary contributing factors were lax management of worker behavior, harsh working environments, deficient protective equipment, inadequate enforcement of safety regulations, and weak safety culture among workers (Jasni, et al., 2019), encompassing human, physical, organizational, and managerial aspects. As technological advancements progressed, the focus of research shifted from tangible factors such as working conditions and safety technologies to more intangible factors like safety leadership (SL), safety climate (SC), and safety behavior (SB) (Huang, 2023).

Significant progress has been made in the analysis of the causes of construction accidents, with various analytical methods and models proposed. For instance, based on

accident classification, different theories and models have been developed, such as the Swiss Cheese Model, the Human Disaster Theory, and the System Accident Model (Yang and Haugen, 2018). Zhang et al. (2019) utilized data from the Occupational Safety and Health Administration (OSHA) to categorize accident causes and proposed five baseline models. While these theories highlight the primary mechanisms through which risk factors lead to accidents, they do not fully explore the underlying causes and interrelationships. Statistical evidence suggests that up to 80% of construction site accidents are attributable to unsafe worker behavior (Gupta, 2021). Therefore, eliminating unsafe worker behavior is essential for further reducing the incidence of accidents. Further theoretical innovation and refinement are needed. However, there is a lack of systematic review and synthesis of research findings in this area.

Analyzing construction worker safety behavior-related literature using Citespace can help researchers better understand the state and trends of research in this area, addressing this gap. Through bibliometric and visualization analyses, key publications, core authors, significant concepts, and research foci can be identified, providing empirical support for theory development. Moreover, such analyses facilitate the identification of connections and discrepancies between studies, promoting theoretical integration and advancement. Practically, Citespace analysis offers scientific grounding for construction safety management. By examining the factors mentioned in the literature, managers can develop more effective safety policies and measures, enhancing site safety. Additionally, Citespace analysis

outcomes can serve as educational resources, helping workers comprehend the importance of safe behavior and fostering self-protection awareness.

## 2. Materials and Methods

### 2.1. Materials

The Web of Science (WOS) is a well-established, comprehensive, multi-disciplinary citation indexing database recognized internationally for its authority and extensive collection of scholarly literature. This database includes a wide range of influential core academic journals across various research fields. To determine the current state and emerging trends in the field of construction safety behavior, we conducted a comprehensive review of existing literature to explore the significance and development of construction safety behavior.

We searched the WOS Core Collection using the query ‘Construction “\*” Safety Behaviour’ in the topic field, limiting the search to articles published between 2014 and 2024. This initial search yielded 4,368 records. After filtering the document type to "Article," selecting "English" as the language, and specifying "Construction & Building Technology" as the research area, we further refined the dataset by excluding articles with titles that did not closely align with our research objectives. This process resulted in a final sample of 2,176 articles for analysis. As shown in Table 1.

**Table 1.** Data screening process and results

Database type	Retrieval stage	Search terms/conditions	Number of searches
WOS Core Collection	Initial stage	Topics: Construction *Safety Behaviour	4368
		Publication Date: 2014-2024	
	Screening Stage	Document Types: Article	2176
		Languages: English	
Research Areas: Construction Building Technology			
Final Results	After the above conditions are filtered		

### 2.2. Methodology

Citespace is a bibliometric software tool developed by Professor Chaomei Chen using Java programming language.

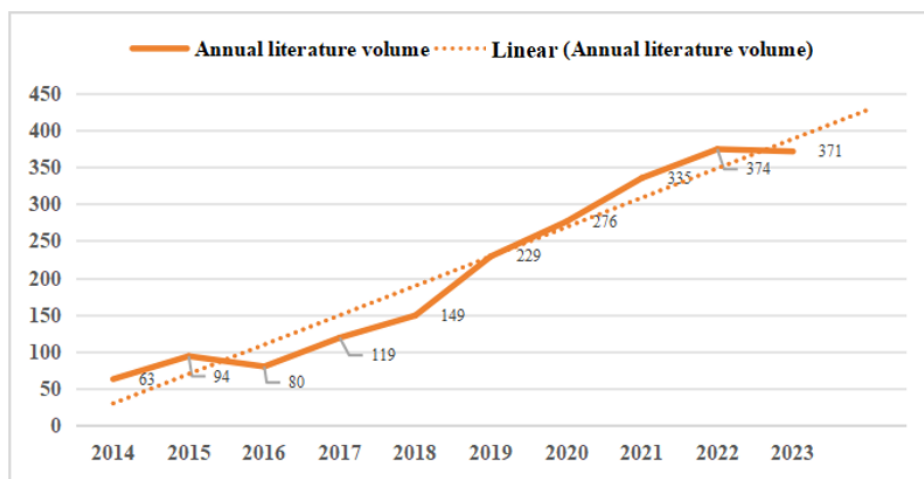
It employs spectral clustering techniques to analyze co-citation networks in scientific literature, thereby enabling the visualization of the evolution and trends within a particular discipline or knowledge domain over time (Chen,2020). By utilizing the WOS database and Citespace software for visual analysis, we mitigate the potential for subjective biases inherent in manual literature reviews. This approach facilitates the illustration of the development process and structural relationships within the field, aligning with the current socio-economic and industrial contexts to inform future research directions.

Numerous scholars have employed Citespace to conduct literature reviews in various domains related to safety behavior. For instance, Malakoutikhah et al. (2022) utilized Citespace software to investigate research trends and hot topics regarding unsafe behaviors, suggesting that future studies could focus on organizational factors. To reduce unsafe behaviors, Cai et al. (2022) conducted a literature review on safety training and applied Citespace to visually analyze the findings, proposing personalized training approaches tailored to individual workers. In the field of traffic safety, Shen et al. (2023) employed Citespace to perform a knowledge mapping study of traffic collision scene reconstruction literature from 2001 to 2021, identifying the top three trending themes and potential research directions involving artificial intelligence technologies such as neural networks and genetic algorithms. These studies demonstrate the effectiveness of Citespace in assisting researchers in identifying and visualizing research trends.

## 3. Analysis of Research Status and Hot Spots

### 3.1. Publication Volume Analysis

As illustrated in Figure 1, the research dynamics in this specific domain have shown a marked upward trend over the past decade. Specifically, since 2018, the output of research has grown at an accelerating rate. Notably, the number of scholarly publications in this field significantly increased, surpassing 300 in 2021, 2022, and 2023. As of the latest update, 86 articles had been indexed in 2024, and based on the current trend, the total number of publications for the year is projected to exceed 400. These data unequivocally demonstrate that construction safety behavior has garnered considerable attention and become a focal point of research in the construction safety domain.



**Figure 1.** Trend of the volume of related research literature in WOS last ten years

Figure 2 presents the number of publications in this field by country from 2014 to 2024. The data reveal that China leads in research on safety behavior in the construction industry. One contributing factor is the rapid growth of the industry and products in this country, making unsafe behaviors and accidents of paramount importance. This is a direct consequence of the expanding scale of production and operations in Chinese construction enterprises and the continuous growth in the total construction output (China Data Statistics Bureau, 2023). There is a critical need for more effective safety management and education strategies in Chinese construction projects to reduce workplace accidents

and injuries. Following China are countries such as the United States, Australia, and the United Kingdom. The large scale of the U.S. construction sector and stringent occupational safety regulations likely contribute to the high level of research activity. Similarly, Australia and the UK, with their mature market economies and strong safety cultures, have also made notable contributions to the study of construction worker safety behavior. Research indicates that there remains a significant disparity in the study of unsafe behaviors between developed and developing countries (Malakoutikhah et al., 2022), a finding that aligns with the publication volume data.

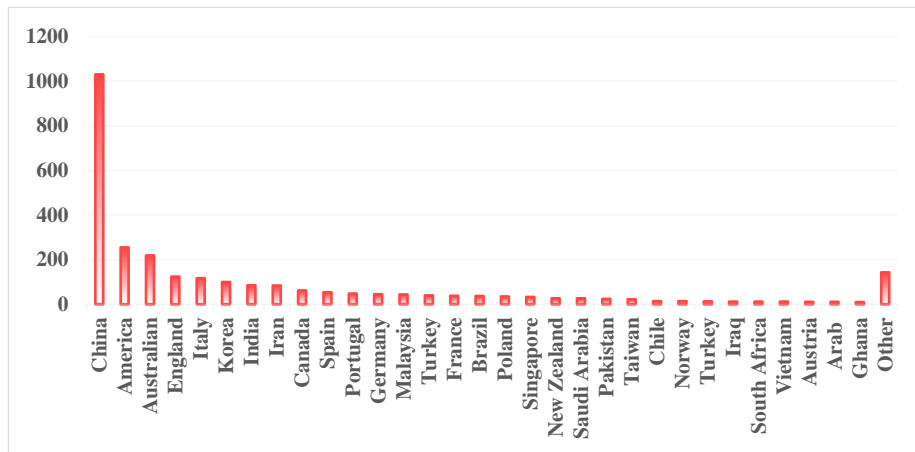


Figure 2. Statistical graph of the amount of relevant literature published in each country during 2014-2024 in WOS

### 3.2. Analysis of Core Researchers

The co-authorship network knowledge graph, constructed through the application of Citespace software (as shown in Figure 3), facilitates the identification of key figures in the field of construction safety behavior research. Over the past ten years, a total of 413 authors have contributed to this

domain. Notably, the most prominent network nodes emerged during the period from 2019 to 2021, with researchers Li, Heng; Fang, Weili; and Goh, Yang Miang demonstrating high centrality. Consequently, these authors merit particular attention. The remaining researchers are largely distributed individually, indicating weak collaborative efforts and a scarcity of influential research teams at scale within this field.

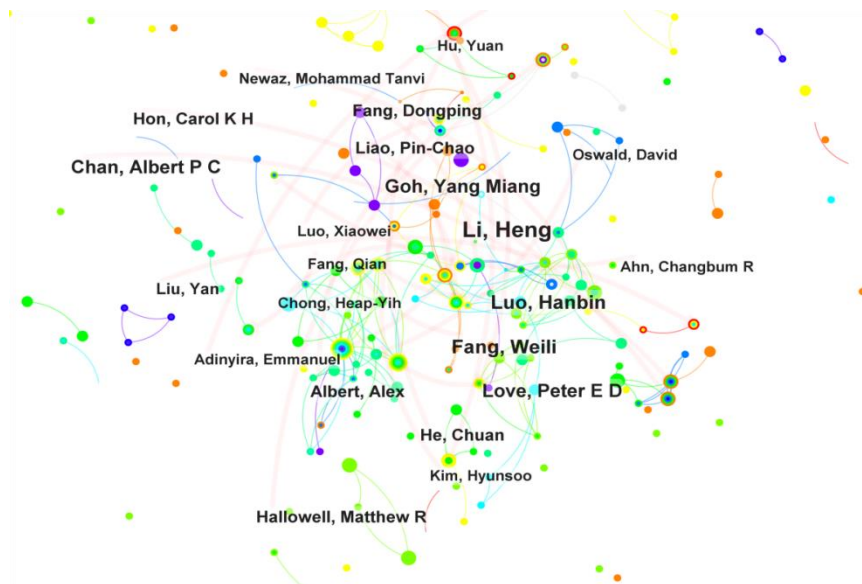


Figure 3. Co-occurrence mapping of researcher collaboration

Table 2 showcases the top ten authors ranked by the number of publications over the past decade. Li, Heng leads the list with the highest publication count, having authored 19 articles since 2015. His work has spanned from the validation of proactive behavior-based safety (PBBS) (Li, Heng et al., 2015) to leveraging modern science and technology to address the safety and health concerns of construction

workers (Shringi et al., 2022; Wang et al., 2023), contributing significantly to the field. In contrast to Li, Heng, Albert, Alex was involved in the field earlier and concluded that effective interventions can enhance workers' hazard recognition capabilities (Albert, Alex et al., 2014). Apart from Li, five other authors have published more than ten papers between 2014 and 2024. These include authors who have focused on

the application of computer vision and deep learning for managing safety in construction notably Luo, Hanbin; Fang, Weili; and Peter E.D. Love (Fang, Weili et al., 2022).

**Table 2.** List of top 10 coresearchers in terms of number of publications

No.	No. of Publications	Year of First Publication	Researcher
1	19	2015	Li, Heng
2	14	2018	Luo, Hanbin
3	13	2018	Fang, Weili
4	12	2016	Chan, Albert
5	12	2018	Peter ED Love
6	11	2018	Goh, Yang Miang
7	9	2014	Albert, Alex
8	9	2019	He, Chuan
9	9	2016	Hon, Carol
10	9	2018	Liao, Pin-Chao

In recent years, scholars have explored various aspects of construction worker safety behavior, including leadership on-site and organizational climate. For instance, Chan et al. (2023) investigated the impact of safety culture on the safety performance of construction workers, revealing that safety culture plays a critical role in enhancing the effectiveness of safety education on performance. Specifically, the study found that the positive impact of safety education is more pronounced in environments where safety culture is robust. This underscores the importance of cultivating a strong safety culture alongside worker education. Moreover, Cong et al. (2023) focused on the influence of workers' unsafe behaviors and leadership practices on safety performance. Through empirical analysis, they demonstrated the facilitative effect of leader-worker communication on informal safety communication. The study emphasized the mediating roles of psychological contract and psychological safety, enriching theoretical knowledge in the area of leadership-worker interactions and providing practical insights for fostering worker interactions conducive to improved safety outcomes on construction sites. Overall, the body of literature on leadership styles and safety climate remains relatively sparse, with a limited number of publications and well-known scholars dedicated to these areas. Therefore, there is a clear need to attract more high-caliber researchers to advance understanding in these important dimensions of construction safety.

### 3.3. Distribution of Core Research Institutions

The identification of core institutions within a research domain facilitates the expeditious location of academic hubs, pivotal for advancing knowledge in specialized fields. Employing Citespace software to analyze 2,176 pertinent documents, we have delineated the leading institutions in terms of publication output, as summarized in Table 3.

**Table 3.** List of top 10 core agencies in terms of number of articles issued

No.	No. of Publications	Year of First Publication	Institution
1	69	2015	Tongji Univ
2	62	2015	Hong Kong Polytech Univ
3	57	2014	Tsinghua Univ
4	45	2015	Huazhong Univ Sci & Technol
5	43	2019	Southwest Jiaotong Univ
6	41	2017	Cent South Univ
7	40	2014	China Univ Min & Technol
8	40	2017	Southeast Univ
9	38	2016	Curtin Univ
10	36	2019	Chongqing Univ

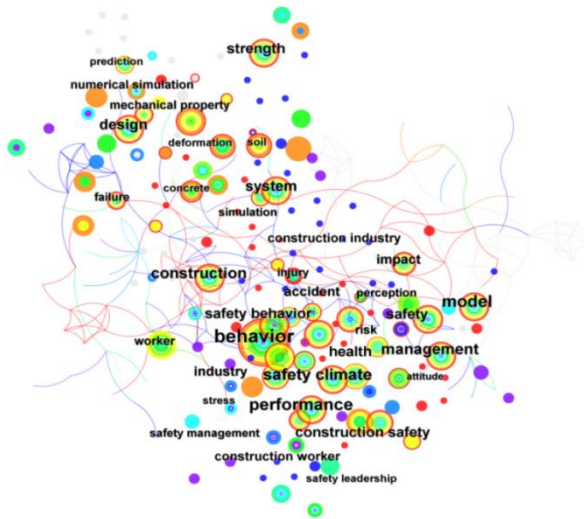
The results indicate that the main research institutions are primarily universities, with Tongji University, Hong Kong Polytechnic University, Tsinghua University, and Huazhong University of Science and Technology standing out as key research centers. However, inter-institutional collaborations are limited, with many institutions conducting independent research. For example, Tongji University has focused on safety management (Wang et al., 2022; Pi & Liu, 2019), while Tsinghua University has emphasized the formation of safety culture (Huang & Fang, 2022; Hao & Zhang, 2020), and Hong Kong Polytechnic University has concentrated on safety climate (Man et al., 2021). This has led to a multidisciplinary research landscape in the construction sector. However, universities serve primarily as theoretical research bases and lack collaboration with industry, hindering the integration of academia, industry, and research. To address this, future efforts should focus on strengthening cooperation among universities and between universities and businesses, fostering a harmonious development of academia, industry, and research. This will facilitate the integration of theory and practice. Furthermore, by combining building information modeling, intelligent technologies, and various psychological experimental methods, we can deepen our understanding of individual psychology and behavior, thereby advancing occupational safety standards in the construction industry.

### 3.4. High-frequency Keyword Analysis

Keyword co-occurrence analysis uncovers research themes within a specific domain over a given time frame. By identifying high-frequency keywords and their interconnections, insights into prevailing research topics and trends can be gained. When two or more keywords appear together across different publications, their relationships and centrality become apparent, reflecting thematic trends and shifts within the field.

#### 3.4.1. High-frequency keyword co-occurrence analysis

Utilizing Citespace software for data analysis, we generated a keyword co-occurrence network map (Figure 4) for the domain of safety behavior in the construction industry. The map displays the connections between keywords, with a network density of 0.020. Notably, the terms "performance," "safety climate," "management," and "model" exhibit particularly strong associations, indicated by their similar node sizes, highlighting the diversity and breadth of research themes in this area.



**Figure 4.** Co-occurrence mapping of high-frequency keywords

To further explore the centrality of these keywords, we analyzed their centralities (Table 4). "Safety climate" ranks highest with a centrality score of 0.34, underscoring its pivotal role. Safety climate is a critical component of occupational safety culture, playing a vital role in accident prevention and the enhancement of safety awareness (Draghici et al., 2022). Chen et al. (2021) reviewed 33 studies and revealed a complex relationship between safety climate and occupational safety behaviors in the construction industry, with 32 studies confirming either direct (78.8%) or indirect (18.2%) links between the two. The mediating role of safety climate between transformational leadership and safety practices has been corroborated by additional research. Shi (2022) found that safety climate effectively moderates the relationship between transformational leadership and safety behaviors, facilitating the development of safe practices in the Chinese oil industry. Zhao et al. (2022) noted that safety leadership positively influences safety climate and safety participation, with transformational leadership having a particularly significant impact. Furthermore, safety climate mediates the relationship between safety leadership and safety participation. Zulkefli et al. (2020) investigated the relationship between safety leadership and safety behaviors among TNB technicians, mediated by safety climate, confirming significant effects among the variables. Chen et al. (2020) employed meta-analysis to examine the relationship between safety leadership and safety behaviors, finding that safety climate partially mediates the relationship between dimensions of transformational leadership and employee safety behaviors, with transformational safety leadership having a more pronounced effect on employee safety behaviors. These findings align with the close association between the keywords "safety leadership" and "safety climate" depicted in Figure 4, confirming the trend of studying safety climate as a mediator.

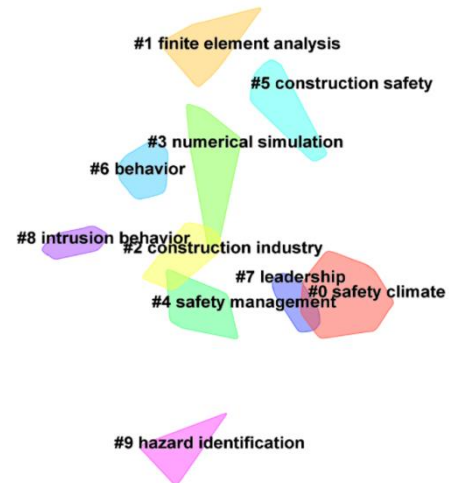
**Table 4.** List of top 10 centrality in keyword co-occurrence

No.	Count	Centralit y	Year of First Publication	Keyword
1	299	0.34	2014	safety climate
2	171	0.22	2014	system
3	145	0.21	2015	construction safety
4	163	0.2	2014	design
5	744	0.19	2014	behavior

### 3.4.2. Keyword clustering analysis

In the keyword clustering map (Figure 5), the Q-value and S-value reflect the structure and effectiveness of temporal clustering. The Q-value of 0.774, which exceeds 0.3, and the S-value of 0.9082, which is greater than 0.5, both fall within acceptable ranges, indicating a high-quality and reliable clustering outcome (Chen et al., 2020). The top 10 cluster keywords are as follows: "safety climate," "finite element analysis," "construction industry," "numerical simulation," "safety management," "construction safety," "behavior," "leadership," "intrusion behavior," and "hazard identification."

Among these, "safety climate" emerges as the leading theme, exhibiting significant overlap with the theme of "leadership." Leadership and safety climate are integral components of occupational safety culture, playing crucial roles in preventing occupational accidents and enhancing safety awareness (Draghici et al., 2022). Themes related to "construction safety" and "behavior" are also prominent. Employee unsafe behaviors are often highlighted as major causes of occupational accidents (Huang et al., 2018). Statistical evidence indicates that up to 80% of construction site accidents can be attributed to worker unsafe behaviors (Gupta, 2021). Therefore, it is imperative to mitigate such unsafe behaviors to improve occupational safety in construction.



**Figure 5.** Keywords clustering map

### 3.5. Citation Co-Occurrence Analysis

Through citation co-occurrence clustering analysis, we quantified the co-occurrence frequency of bibliographic features to measure their interrelationships, thereby revealing the information connections and co-occurrence patterns within the literature. This method not only identifies thematic associations but also delineates research phases, offering a nuanced perspective on the evolution of scholarly discourse.

#### 3.5.1. Citation co-occurrence clustering analysis

The citation co-occurrence clustering map shown in Figure 6 has a Q-value of 0.7095 and an S-value of 0.8787, indicating a high level of reliability in the clustering results. The network consists of 13 clusters, each representing distinct thematic areas. The largest 13 clusters cover a wide range of research themes, with dense inter-node connections (density = 0.014) highlighting the multifaceted nature of the construction safety behavior research domain. A notable feature of the map is the concentration of yellow nodes on the left side, representing current research trends, with a particular emphasis on

"transformational leadership." These nodes are situated within a densely connected network, emphasizing the strong association between transformational leadership style and construction safety behaviors.

Notably, Guo BHW (2016) leads Cluster #0 with 48 citations, followed closely by Ding LY (2018) with 41 citations in Cluster #3 and Li H (2015) with 38 citations in Cluster #0. Other authors with significant citation counts

ranging from 30 to 36 include Man SS (2017) in Cluster #0, Choudhry RM (2014) in Cluster #1, Fang WL (2018) in Cluster #3, Zaira MM (2017) in Cluster #0, Newaz MT (2019) in Cluster #2, Chen YT (2017) in Cluster #0, and He CQ (2020) in Cluster #4. These data strongly support the focal themes of "safety behavior," "construction safety," and "transformational leadership" in academic research.

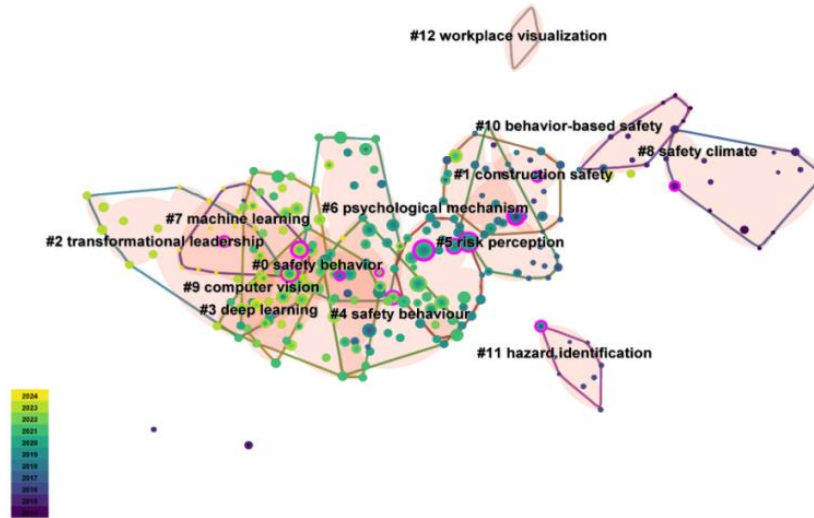


Figure 6. Citation co-occurrence clustering map

### 3.5.2. Literature clustering degree

Literature clustering serves as a pivotal metric for gauging the similarity among documents, providing a means to discern the relationships between them and facilitating thematic categorization. Utilizing Citespace, a powerful bibliometric analysis tool, we generated a clustering map, depicted in Figure 7. This map vividly illustrates the interconnections among 13 clusters, unveiling the network of research associations within the domain of construction safety

behavior. Particularly noteworthy is the relatively sparse connectivity of the cluster centered around "safety climate" with other clusters, suggesting an area ripe for further exploration. This finding underscores the need for future studies to strengthen interdisciplinary integration, particularly the linkage between safety climate and other themes, to substantiate its significance in the realm of construction safety behavior (Huang et al., 2019; Zou et al., 2020).

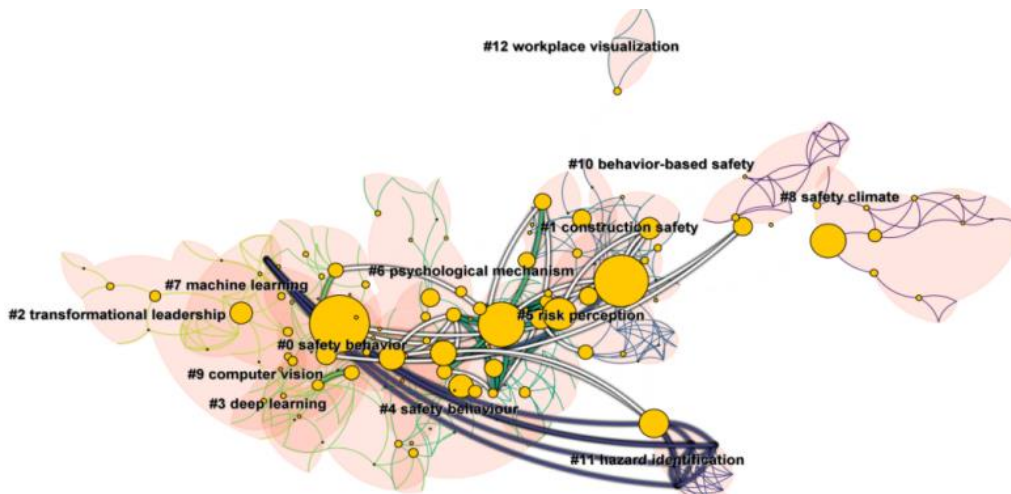
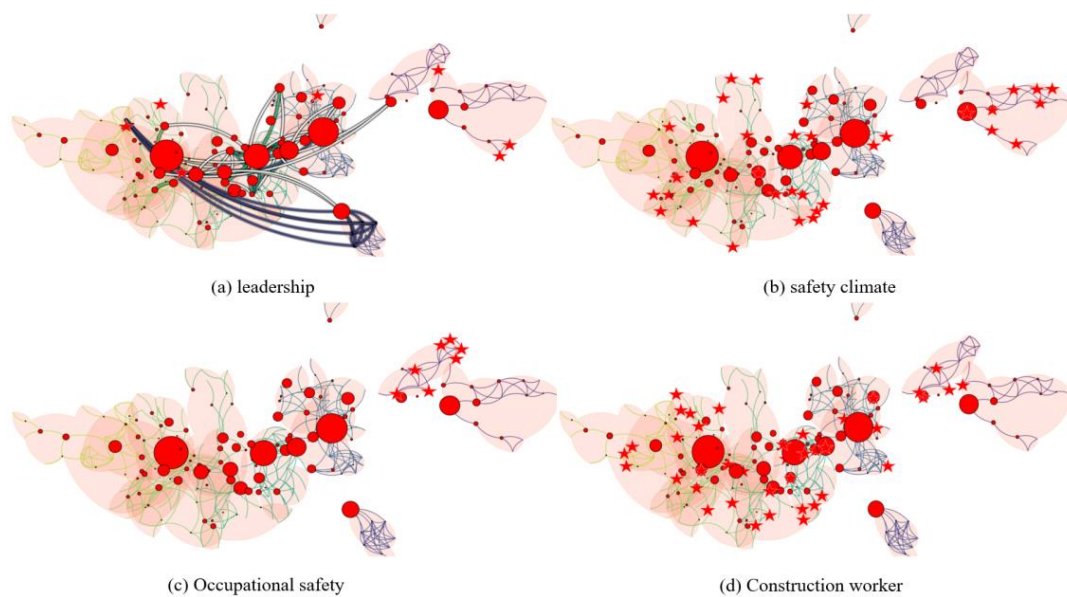


Figure 7. Literature clustering degree map

To further elucidate the interconnections among themes, we conducted targeted searches within the Citespace clustering map, focusing specifically on "leadership," "safety climate," "occupational safety," and "construction workers," as illustrated in Figure 8. The search outcomes, highlighted by red pentagrams, reveal the broad distribution of studies related to safety climate and construction workers, further affirming their central role in research on construction safety behavior. Conversely, the literature pertaining to leadership and occupational safety appears less abundant, indicating

underexplored dimensions within the research domain. The scattered distribution of leadership studies contrasts starkly with the concentrated cluster of occupational behavior studies around the theme of safety climate, pointing towards a promising avenue for future research. This contrast suggests the potential for exploring the interrelationships among leadership, occupational safety, and safety behavior, which could serve as a critical direction for elucidating their complex dynamics (Man et al., 2021; Zulkefli et al., 2020).



**Figure 8.** Distribution of study participants' profiles in the Literature clustering degree map

### 3.5.3. Analysis of citation emergence

Based on the credible citation co-occurrence clustering map (Figure 6), we generated the citation keyword burst chart

(Figure 9). Analyzing the development of research chronologically, it can be divided into three distinct phases.

#### Top 15 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2014 - 2024
Zhang MZ, 2013, AUTOMAT CONSTR, V34, P101, DOI 10.1016/j.autcon.2012.10.019, DOI	2013	9.84	2015	2018	
Shin M, 2014, ACCIDENT ANAL PREV, V68, P95, DOI 10.1016/j.aap.2013.09.019, DOI	2014	8.64	2015	2019	
Fang DP, 2013, SAFETY SCI, V57, P138, DOI 10.1016/j.ssci.2013.02.003, DOI	2013	7.47	2015	2018	
Choudhry RM, 2014, ACCIDENT ANAL PREV, V70, P14, DOI 10.1016/j.aap.2014.03.007, DOI	2014	13.7	2016	2019	
Han S, 2013, AUTOMAT CONSTR, V35, P131, DOI 10.1016/j.autcon.2013.05.001, DOI	2013	6.64	2016	2018	
Hinze J, 2013, SAFETY SCI, V51, P23, DOI 10.1016/j.ssci.2012.05.016, DOI	2013	6.64	2016	2018	
Zhou ZP, 2015, SAFETY SCI, V72, P337, DOI 10.1016/j.ssci.2014.10.006, DOI	2015	6.57	2016	2020	
Li H, 2015, SAFETY SCI, V75, P107, DOI 10.1016/j.ssci.2015.01.013, DOI	2015	11.37	2017	2020	
Fang DP, 2015, J MANAGE ENG, V31, P0, DOI 10.1061/(ASCE)ME.1943-5479.0000355, DOI	2015	8.56	2018	2020	
Seo J, 2015, ADV ENG INFORM, V29, P239, DOI 10.1016/j.aei.2015.02.001, DOI	2015	7.98	2018	2019	
Jiang ZM, 2015, J MANAGE ENG, V31, P0, DOI 10.1061/(ASCE)ME.1943-5479.0000350, DOI	2015	7.11	2018	2020	
Guo BHW, 2016, SAFETY SCI, V84, P1, DOI 10.1016/j.ssci.2015.11.020, DOI	2016	7.01	2018	2021	
Fang WL, 2019, ADV ENG INFORM, V39, P170, DOI 10.1016/j.aei.2018.12.005, DOI	2019	8.52	2022	2024	
He CQ, 2019, J SAFETY RES, V71, P231, DOI 10.1016/j.jsr.2019.09.007, DOI	2019	7.29	2022	2024	
Choi B, 2018, J CONSTR ENG M, V144, P0, DOI 10.1061/(ASCE)CO.1943-7862.0001421, DOI	2018	6.45	2022	2024	

**Figure 9.** Top 15 Keywords with the Strongest Citation Bursts

Phase 1 (2015–2018): During this initial phase, the seminal work by Zhang and Fang (2013) proposing the integration of Behavior-Based Safety (BBS) practices into routine management served as a cornerstone. Extensive research was conducted around this concept, demonstrating that persistent BBS strategies represent a promising approach for achieving continuous safety improvements in the construction industry. Subsequently, scholars explored optimal strategies for managing latent human risk factors, highlighting the differential contributions of personnel at various functional levels within such models. These findings facilitated the design of enhanced BBS interventions, thereby exerting a more enduring impact on employees' safety behaviors (Tong et al., 2018). Additionally, during this period, the theme of safety culture emerged. Numerous studies cited the conceptual framework and definition of safety culture outlined by Fang and Wu (2013). A positive safety culture was found to be crucial for improving safety performance in construction workplaces. Building upon this foundation, Trinh et al. (2018) developed a conceptual model of resilient

safety culture, demonstrating the potential for ultra-safe construction organizations to maintain consistently high safety performance regardless of the complexity and changing conditions of construction projects.

Phase 2 (2019–2021): Despite significant advancements in creating safer construction environments, there remained a lack of understanding regarding how to eliminate unsafe behaviors among construction workers (Shin et al., 2014). In response, the psychological process model of construction workers emerged. This model aided in analyzing the feedback mechanisms between workers' safety attitudes and safety behaviors and their dynamic changes. Yang et al. (2021) proposed the Integrated Model for Construction Worker Unintentional Behaviors (IM-CWUB) to explore the comprehensive interactions between psychological, physiological factors, and unsafe behaviors. Furthermore, researchers demonstrated that influencing employees' psychological safety impacts their growth, learning, contribution, and behavioral performance (Brohi et al., 2021).

Phase 3 (2022–2024): In this most recent phase, based on

the works with the highest number of co-citations, including Fang WL (2019), He CQ (2019), and Choi B (2018), the focus shifted primarily to the safety behaviors of construction workers. Specifically, Fang WL (2019) argued that real-time identification of unsafe behaviors could prevent their recurrence and reduce accident rates. He CQ (2019) analyzed the influence of psychological capital (PsyCap) on employees' mental health and job performance. Choi B (2018) extended the social cognitive processes and their interaction with the environment, which play a critical role in shaping workers' safety behaviors. These themes have laid a solid foundation for current research directions.

Based on the citation burst intensity, it is evident that the work by Choudhry RM et al. (2014) has received the highest attention, with a burst strength of 13.7. The findings from this study indicate that an approach grounded in goal setting, feedback, and effective measurement of safe behaviors, when appropriately implemented by committed management, can significantly enhance safety performance in construction site environments. Furthermore, the second most prominent citation, with a burst strength of 11.37, also underscores the impact of safety management on safe behaviors. Li, H. et al. (2015) argue that proactive guidance toward safe behaviors is effective in preventing construction accidents and improving team safety metrics. This further substantiates the importance of safety management leadership.

#### 4. Research Conclusion

This paper employs Citespace software to conduct a visual analysis of 2,176 documents in the field of construction safety behavior, sourced from the WOS Core Collection database. The conclusions and recommendations are summarized as follows:

##### (1) Quantitative Analysis of Research Publications:

The quantitative analysis of research publications indicates that China has produced the largest number of publications in the past decade, reflecting significant efforts and advancements in construction safety. However, despite these achievements, safety issues persist within the industry, necessitating continued regulatory oversight and heightened safety awareness.

##### (2) Authorship Analysis:

The authorship analysis reveals a limited number of research teams, which may result in a narrow focus and hinder interdisciplinary collaboration, thus constraining the breadth and depth of research. Therefore, core researchers are encouraged to collaborate with scholars from diverse disciplinary backgrounds to broaden their perspectives and foster innovation.

##### (3) Institutional Analysis:

The institutional analysis shows a predominance of universities, which may lead to insufficient research resources for other institutions such as companies and research institutes, thereby impeding the overall advancement of scientific research. Given this, universities should strengthen their collaborations with industries to effectively generate research outputs, in line with the ongoing development of industry-academia integration.

##### (4) Analysis of Research Hotspots:

The analysis of research hotspots through keyword clustering highlights a strong association between "performance," "safety climate," "management," and "model." Among these, "safety climate" exhibits a high centrality, leading to a focus on occupational safety in

construction. Based on the analysis of literature over the past decade, three distinct phases can be identified. Currently, the primary focus is on the safety behaviors of construction workers, with computer simulations, social cognition, and psychological safety being key influencing factors. For future research, leadership in safety management (particularly transformational leadership), occupational safety in the construction sector, safety climate within safety organizations, and the mediating role of safety climate warrant further investigation.

#### Acknowledgements

The authors gratefully acknowledge the financial support from 2024 Anhui Provincial Scientific Research Programme Preparation Project 'Research on the Development of Commercial Concrete Industry Based on Green and Low Carbon Construction--Taking Hefei City as an Example' Project No. 2024AH052548

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