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Article

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Article

Building Safer Workplaces: Unveiling the Impact of Safety Leadership Styles in the Construction Industry

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Abstract: This study investigates the most effective leadership style for enhancing safety performance in the construction industry. Through a scientometric analysis of 114 research papers and a meta-analysis of 13 studies involving 7220 participants, it uncovers a growing body of research on safety leadership in construction and identifies safety-specific transformational leadership as the most impactful style for improving safety outcomes. The research highlights the increasing importance of safety leadership in the construction sector and reveals a trend towards safety-specific transformational leadership as the preferred approach. This leadership style emphasizes empowering and motivating employees to prioritize safety through shared values, vision, and goals. The study also emphasizes the need for enhanced collaboration among researchers and institutions, and advocates for the inclusion of studies from developing countries to ensure a comprehensive understanding of safety leadership practices globally. Additionally, the findings align with the Sustainable Development Goals 3, 8, and 11, underscoring the significance of fostering safe and secure working environments and promoting sustainable urbanization. This research serves as a valuable resource for construction industry stakeholders seeking to implement effective safety leadership strategies, and it lays the groundwork for further exploration in this critical area.

Keywords: safety leadership; safety performance; safety climate; construction industry; transformational leadership; leadership styles



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1. Introduction

The global construction industry (CI) is renowned for its elevated risk profile (Soundarya Priya et al. 2023), with a substantial number of annual incidents and injuries documented (Luo et al. 2022; Yuan et al. 2022). Factors such as the intricate nature of construction work (Winge et al. 2019; Yuvaraj et al. 2023), the presence of non-standard (Soundarya Priya et al. 2024) and temporary tasks (Mohammadi et al. 2018), diverse technology (Kang et al. 2020), and susceptibility to macroeconomic changes all contribute to the challenges in managing occupational safety (Liang and Zhang 2019; Senthamizh Sankar et al. 2022a). This results in an escalation of accidents and injuries, leading to substantial personal, societal, and economic implications (Guo et al. 2016). From 2016 onwards, the CI in the United States has witnessed over 1000 fatal accidents each year, making it the country's most hazardous industry (Jalil Al-Bayati et al. 2023; Bureau of Labor Statistics 2020). Similarly, China's construction industry has the highest rate of occupational injuries worldwide (Fang et al. 2023; Loosemore and Malouf 2019). In India, the CI, which employs 31 million individuals and is the largest employer in the country (Soundarya Priya and Anandh 2024), has a significantly higher mortality rate compared to the other sectors (Senthamizh Sankar et al. 2022b; Sankar et al. 2024). These statistics underscore the need for enhanced safety protocols in the CI. The current research endeavors are concentrated on improving safety performance (SP) in the CI, with particular attention to areas such as safety programs, safety leadership, safety climate, and safety performance measurement.

Research has confirmed a significant connection between leadership and health and safety results (Al-Bayati 2021; Senthamizh Sankar and Anandh 2024). Leadership is a complex process that includes the selection, training, equipping, and influencing of followers to accomplish organizational goals (Gogo and Musonda 2022; McCabe et al. 2008; Armandi et al. 2003; Winston and Patterson 2006). Safety leadership (SL), especially in high-risk industries like construction, is a practice that promotes safety procedures through leaders who prioritize and exemplify health and safety behaviors (Magalhães et al. 2022; Zhu et al. 2005; Li et al. 2021; Lingard et al. 2019). SL involves dynamic interactions between leaders and followers, considering both organizational and individual factors, with the goal of achieving safety objectives (Daniel 2015; Magalhães et al. 2022; Zhu et al. 2005). Grill and Nielsen (2019) discovered that construction managers can positively impact workers' safety performance through ongoing planning, coordination, monitoring, and the proactive correction of deviations. However, prioritizing deadlines and cost reduction can adversely affect SP (Grill and Nielsen 2019; Cooper 2010). The association between workers' perceived safety responsibilities and their SP is more robust when their perception of SL is elevated (Anandh et al. 2020; Grill and Nielsen 2019). The correlation between SL and occupational safety performance is influenced by the interaction among construction stakeholders, such as project owners, main contractors, and subcontractors (Oswald and Lingard 2019; Wu et al. 2016). Supervisors have the authority to ensure compliance with safety protocols and promote safety policies at construction sites, effectively communicating the organization's commitment to safety (Deepak and Mahesh 2019). The effectiveness of leadership in managing unexpected events in the construction industry relies on the presence of a favorable safety culture, which has an impact on safety performance outcomes (Skeepers and Mbohwa 2015). The cumulative results of prior research indicate that SL exerts a direct and favorable influence on SP.

Leaders can display a variety of attitudes and behaviors, collectively referred to as leadership styles (LSs) (Anderson and Sun 2017). Numerous LS have been recognized, including transformational, transactional, and empowering leadership (Hillen et al. 2017; Hoffmeister et al. 2014; Khasanah et al. 2019; Martínez-Córcoles et al. 2012; McFadden et al. 2009; Rahmawati et al. 2018). Clarke's (2013) meta-analysis revealed that both transformational and active transactional leadership styles have a positive impact on "safety behaviours" i.e., "safety performance", with the perceived safety climate serving as a mediator. Specifically, transformational leadership was associated with safety participation, while active transactional leadership was linked to both safety participation and compliance (Clarke 2013). Multiple LS have been analysed as influential factors on safety climate (SC) and SP in diverse contexts and organisations, with most indicating a favourable impact on an organization's safety culture and SP. (Hillen et al. 2017; Khasanah et al. 2019). However, a thorough exploration of the various safety leadership styles (SLSs) within the CI and their potential influence on SC and SP is still needed. The CI, due to its project-oriented nature, high risk, and the temporary and dynamic composition of teams, necessitates a unique approach to leadership (Ellis 2022; Conchie et al. 2013). Leadership in construction not only involves task management but also safety assurance given the high-risk nature of the work (Leadership in the Construction Industry 2008). In addition, leaders in the CI must possess a forward-thinking mind-set, fostering a distinct company vision that influences every level of the organisation (Liu et al. 2021). They also need to advocate for inclusivity, acknowledging that diverse teams and perspectives are beneficial to a construction business (Jitwasinkul and Hadikusumo 2011). Therefore, while leadership principles can be generally applied across industries, their application and impact can significantly vary depending on the context. In the CI, leadership goes beyond traditional team management to areas such as safety management and the promotion of an inclusive and visionary culture.

Understanding the present state of research on "safety leadership in the construction industry (SLCI)" and identifying the areas of deficiency and potential avenues for future research is of utmost importance. This can help address challenges, capitalize on SL

opportunities in the CI, and enhance its sustainability and effectiveness. However, there is a lack of a comprehensive and structured analysis of the current literature on SLCI. The review would offer a brief overview of the current trends, patterns, themes, authors, journals, countries, institutions, and research networks associated with this topic. This will be accomplished by performing a scientometric analysis of the research articles published on SLCI. It is essential to conduct this research to bridge the gap between the industry's current state and the urgent need for SL and SP. Prior studies have investigated different SLs as a factor affecting SP in different environments. Remarkably, all the different styles of leadership have had a positive influence on the SP of the construction personnel, with the exception of one style, namely laissez-faire leadership (Khasanah et al. 2019; Hillen et al. 2017). However, research on the most effective LS for achieving a positive SP, whether in a particular situation or in general, has not been conducted (Grinerud et al. 2021). This study aims to identify the most effective LS for enhancing and ensuring a positive SP among the employees in the CI. The authors used a meta-analysis methodology to examine the mentioned question. Moreover, meta-analysis can offer insights into industry-specific differences in how leadership affects improving SP. The study employed the following research questions:

- (1) Which articles, authors, and institutions have the greatest impact on the field of safety leadership in the construction industry?
- (2) Which journal has the highest level of productivity in the field of safety leadership in the construction industry?
- (3) Which countries and regions have conducted the highest amount of research on safety leadership within the field of the construction industry?
- (4) What are the primary themes and concepts related to safety leadership in the construction industry?
- (5) How can we measure the overall influence of the different leadership styles on safety performance?
- (6) What is the most influential leadership style for improving safety performance?

This study makes significant contributions to the existing body of knowledge by providing a comprehensive overview of SL research in the CI through scientometric analysis and quantitatively assessing the impact of different LSs on SP through meta-analysis. The identification of safety-specific transformational leadership as the most influential style and the practical implications for CI stakeholders further enhance the study's contribution. This research represents a pioneering effort by being one of the first to combine scientometric analysis and meta-analysis to comprehensively investigate the impact of various LSs, including the under-explored safety-specific transformational leadership, on SP in the CI. Furthermore, the authors provide a comprehensive amalgamation of LSs and their impact on SP. The research findings can help leaders and managers implement the most suitable LS to guarantee the organization's safety and security. The authors then present the methodology, analysis, discussion, limitations, future directions, and conclusion in the subsequent sections.

2. Navigating the Landscape of Safety Leadership in Construction

The subject of SLCI is multifaceted, involving different styles and factors that contribute to accidents. Accidents can be caused by factors such as autocratic behavior, inadequate communication, ambiguous directives, and perceived incompetence (Andriessen 1978). Leaders have a vital role in fostering a safety culture within an organization by serving as examples and promoting safe work practices. Additionally, they ensure that workers are aware of and willingly accept their safety obligations. Leaders have the responsibility of creating thorough safety policies and fostering a strong safety culture (Chinda and Mohamed 2008). Supervisors and foremen in construction sites are commonly regarded as authoritative figures who symbolize the company's leadership (Dingsdag et al. 2008). The leader–member exchange (LMX) theory posits that cultivating positive relationships between leaders and followers can foster follower behavior that is congruent with the

leader's objectives and principles (Hofmann and Morgeson 1999). Comprehending these LSs is crucial for establishing a secure work environment, as outlined in Table 1.

Table 1. Diverse safety leadership styles in construction.

Safety Leadership Styles	Explanation	Authors
Safety-specific Transformational Leadership	This approach encourages the adoption of safety-conscious actions, cultivating a collective comprehension among employees, and instilling the drive, expertise, and self-confidence necessary to accomplish safety objectives without solely depending on the established protocols.	(Cheung et al. 2021, 2022; Cheung and Zhang 2020; Conchie 2013; Conchie and Donald 2009; Rafique et al. 2021; Xia et al. 2021)
Transformational Leadership	Transformational leaders motivate and encourage their followers to surpass their own personal interests, deal with individual issues, and collaborate towards shared objectives, while also ensuring that the followers' values are in line with the organization's goals (Clarke 2013).	(Bahn 2013; Grill et al. 2017, 2019; Kim and Jung 2019; Oswald et al. 2022; Shen et al. 2017; Sunindijo and Zou 2013; Wu et al. 2022; Hoffmeister et al. 2014)
Transactional Leadership	Transactional leaders possess a comprehension of employees' needs and employ a system of exchanging rewards to motivate them. They establish specific goals, closely monitor performance, and offer constructive feedback to facilitate improvement (Bass 1985).	(Zuo et al. 2019; Grill et al. 2017; Hoffmeister et al. 2014; Oswald et al. 2022)
Laissez-faire Leadership	Laissez-faire leaders grant their team members freedom and autonomy, promoting self-motivation and decision making, while providing minimal supervision and direction.	(Grill et al. 2017)
Rule-oriented Leadership	Rule-oriented leaders place a high emphasis on maintaining order, consistency, and predictability. They prioritize the use of rules to ensure that tasks are carried out correctly and efficiently.	(Grill et al. 2017)
Participative Leadership	Participative leadership entails leaders actively engaging team members in the process of decision making, appreciating their contributions, and recognizing the benefits of collaborative efforts for achieving superior results.	(Grill et al. 2017)
Temporal Leadership	Task-oriented behaviors encompass activities such as scheduling, synchronizing, and allocating resources. They also involve promoting progress, resolving conflicts, and fostering collaboration within a team (Mohammed and Nadkarni 2011). These behaviors have the potential to influence how employees perform their assigned tasks in situations where time is limited.	(Zheng et al. 2022)

3. Methodology

Scientometrics, a branch of informatics, is characterized as “the application of quantitative methods to the study of science as an informational process” (Chen et al. 2014). This field involves the numerical examination of patterns in the scientific literature to chart the structure of knowledge and forecast upcoming trends in a given research area. The main approaches employed are performance analysis and science mapping (Bota-Avram 2023; Donthu et al. 2021). Performance analysis evaluates the actions of scientific entities, such as authors, institutions, countries, and journals, by closely examining their publications, citations, and collaborations (Kastrin and Hristovski 2021). In contrast, science mapping focuses on the relationships between different elements of research (Bota-Avram 2023;

Donthu et al. 2021) with the goal of identifying research areas and emerging patterns (van Raan 2014). Meta-analysis is a retrospective procedure that combines multiple similar studies to update and merge evidence related to specific research questions (Higgins et al. 2011). By integrating the quantitative results of separate studies, a more accurate outcome is obtained by utilizing larger sample sizes (Faragher et al. 2005). This study adhered to the meta-analysis reporting standards outlined by Appelbaum et al. (2018) and followed the PRISMA (Page et al. 2021) guidelines for reporting meta-analysis (Liberati et al. 2009). The methodology included collecting pertinent papers from online sources and examining them with a suitable scientometric tool. The following sections will provide more details about this procedure.

3.1. Selection Criteria

This review examines the impact of SLS on SP outcomes in organizations, selecting publications based on specific criteria. The literature surveyed spans from 1978 to 2023, providing a contemporary comprehension of SL and its diverse styles. The study includes English literature from various international regions, encompassing a range of social orientations and cultural viewpoints. The emphasis is on articles from peer-reviewed journals. However, certain types of publications and topics were omitted. These exclusions comprise reviews, conference papers, dissertations, non-English studies, research on SL in governmental or non-profit organizations, and papers unrelated to construction safety leadership. These exclusions were made to maintain the focus of the study on the empirical research directly related to the impact of SLS on SP within the CI, ensuring a homogenous and relevant dataset for analysis.

3.2. Search Strategy and Data

Step 1: Identifying Papers

The paper retrieval process involved a methodical examination of scholarly journals using appropriate keywords within a specific time period. A thorough review of the pertinent literature in the Scopus database was performed twice, in November 2022 and April 2023, to steer the research review. Scopus was selected due to its broad coverage, outperforming other databases like Web of Science and Google Scholar (Hosseini et al. 2018). The search query incorporated “safety leadership” and terms associated with the CI. No supplementary keywords were employed to maximize the volume of articles retrieved. A comprehensive desktop search was conducted to identify the pertinent articles on SLCI. The complete search code was as follows:

(TITLE-ABS-KEY (safety AND leadership) AND ALL (“Construction Industry” OR “Construction Sector” OR “Construction Projects” OR “Construction Sites” OR “Construction Organizations”)) AND (LIMIT-TO (SRCTYPE, “j”)) AND (LIMIT-TO (PUBSTAGE, “final”)) AND (LIMIT-TO (DOCTYPE, “ar”)) AND (LIMIT-TO (LANGUAGE, “English”))

The initial search conducted in the Scopus database resulted in the identification of 570 academic papers. The detailed search strategy is illustrated in Table 2. The search for publications was limited to the timeframe spanning from 1 January 1978 to 4 April 2023, resulting in a total of 364 scholarly articles. Figure 1 presents a flowchart illustrating the different stages of the PRISMA search process.

Step 2: Screening Publications

During this phase, additional vetting criteria were utilized to evaluate the papers obtained from the database, with the exception of the publication year. To ensure the study’s objectives and scope were met, an extra filtering process was used to remove publications that did not align with them (Mok et al. 2015). After conducting the preliminary search and retrieval process, a total of 364 scholarly articles were generated. The papers were subjected to a rigorous screening process that utilized specific criteria to determine SLS and eliminate any duplicate articles. This process yielded a total of 139 scholarly articles. These studies were further assessed for relevance, quality, and influence within the research

community. Twenty-five papers were excluded due to their irrelevance to the study. The study comprises 114 papers examining various SLSs impacting SP outcomes in the CI.

Table 2. Search strategy in the SCOPUS database.

Step	Criteria
1	(safety AND leadership) AND ("Construction Industry" OR "Construction Sector" OR "Construction Projects" OR "Construction Sites" OR "Construction Organizations")
2	Results retrieved from scratch to present, i.e., 1978–2023
3	Included all the subject areas such as engineering, social sciences, business, multidisciplinary, management and accounting, economics, finance, and arts and humanities
4	Limited to journal articles, excluding conference papers, textbooks, proceedings, articles in press, and reviews
5	Included all the countries that contributed towards publication
6	From Step 5, limit to the English language only

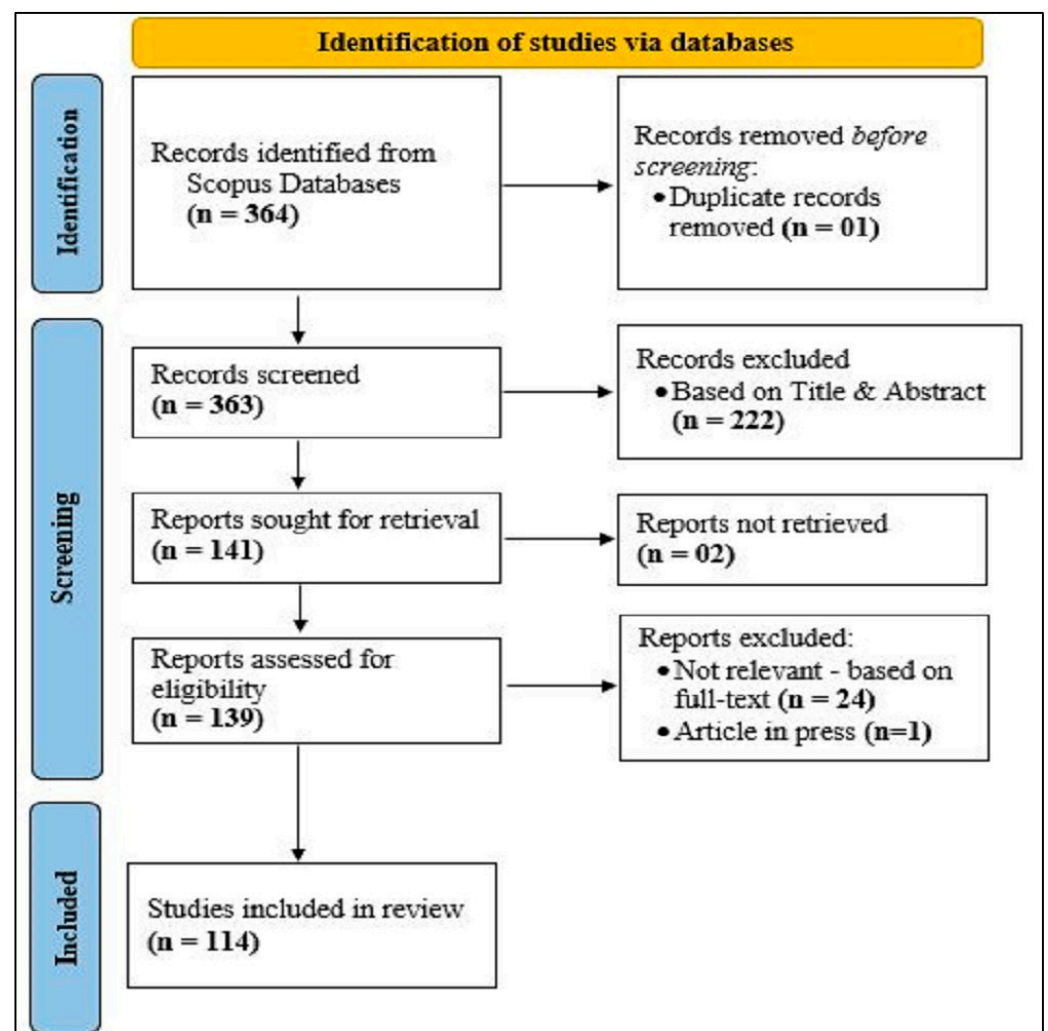


Figure 1. PRISMA flowchart of the systematic review process. (Source: Authors).

Step 3: Including Papers

This study entailed an in-depth analysis of 114 chosen publications to identify different SLS. The results are presented according to variables such as annual publications, country, research methodology, publications per document source, and other significant findings

from the analysis. Data extraction was performed using Microsoft Excel version 2013, and the final phase of the analysis was devoted to recording the findings.

3.3. Analytic Procedure

The choice of data analytic tool depends on the specific type of analysis (Dervis 2019; Farooq 2022). This study utilized Biblioshiny, a web interface for Bibliometrix, an R package specifically developed for scientometric and co-citation analysis. Bibliometrix has the ability to simultaneously analyze and map bibliographic data (Dervis 2019), while Biblioshiny simplifies the process of importing, converting, filtering, analyzing, and generating plots from the data (Farooq 2022). This study utilized the meta-analysis tool (Suurmond et al. 2017), a simplified Excel tool (Kim et al. 2019; Luoma et al. 2020; Turk and Waller 2020; Zhao et al. 2021). Additionally, jamovi version 2.3 was also used. Although there is no universally agreed-upon standard for the minimum number of studies needed for a meta-analysis, it is recommended that a minimum of two studies be included (Borenstein et al. 2021; Ryan 2016; Valentine et al. 2010). This study employed a meta-analysis approach, incorporating 13 studies with a combined sample size of 7220, to determine the consensus effect size of SLS on SP in the CI.

4. Analysis

4.1. Analysis of Performance

Performance analysis is a technique that involves a thorough examination and assessment of the influence of scholarly research components on a particular academic discipline. Descriptive analysis is often used in literature reviews to show the effectiveness of research elements like authors, countries, institutions, and sources.

4.1.1. Publication Growth

Figure 2 illustrates the trend in publication expansion from 1978 to 2023. There were 114 articles published during this period, showing an annual growth rate of 2.53%. The document's average age is 6.04, suggesting that it pertains to a relatively recent and actively pursued research field. The temporal distribution of the articles exhibits a notable upsurge in the quantity of publications from 2008 to 2023, with a total of 113 articles published during this interval, in contrast to a solitary article from 1978 to 2007. This shift represents a fluid and evolving research environment in recent years. The years with the highest number of publications are 2019, 2021, and 2022, each having a total of 15 articles. Conversely, the period from 1979 to 2007 has no articles, making it the lowest in terms of publication count. The literature on SL was analyzed through citation analysis, revealing that the article with the highest number of citations was authored by Kines et al. (2010). This article examined how enhancing leader-based on-site verbal safety communication affects safety levels and SC at construction sites. The article garnered 242 citations, indicating its substantial relevance and influence in the field. Kapp (2012), the second most cited, examined the impact of first-line supervisors' leadership practices on the safety compliance and safety participation of their subordinates. This article garnered 144 citations, indicating its role in enhancing the comprehension of the importance of SLCI.

Table 3 displays the compilation of the ten articles with the highest number of citations. The results indicate a significant rise in the quantity of research papers focused on SLCI during the last ten years. The most influential papers have focused on the correlation between SLS and the SP of construction professionals.

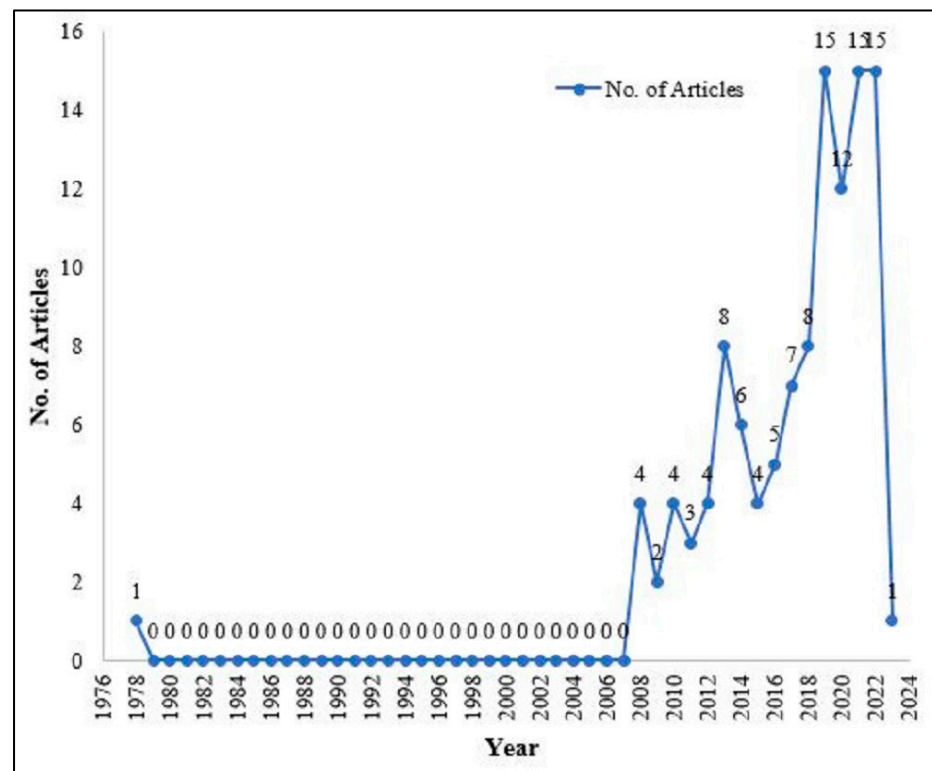


Figure 2. Publication growth trend. (Source: Authors).

Table 3. Most cited articles.

S. No.	Article	Total Citations
1	KINES P, 2010, <i>J SAF RES</i> (Kines et al. 2010)	242
2	KAPP EA, 2012, <i>SAF SCI</i> (Kapp 2012)	144
3	HOFFMEISTER K, 2014, <i>SAF SCI</i> (Hoffmeister et al. 2014)	125
4	WANBERG J, 2013, <i>J CONSTR ENG MANAGE</i> (Wanberg et al. 2013)	122
5	CONCHIE SM, 2013, <i>J OCCUP HEALTH PSYCHOL</i> (Conchie 2013)	115
6	CONCHIE SM, 2009, <i>J OCCUP HEALTH PSYCHOL</i> (Conchie and Donald 2009)	113
7	CHINDA T, 2008, <i>ENG CONSTR ARCHIT MANAGE</i> (Chinda and Mohamed 2008)	108
8	ANDRIESEN JH, 1978, <i>J OCCUP ACCIDENTS</i> (Andriessen 1978)	102
9	WU C, 2016, <i>INT J PROJ MANAGE</i> (Wu et al. 2016)	100
10	CONCHIE SM, 2013, <i>SAF SCI</i> (Conchie et al. 2013)	92

4.1.2. Most Productive Authors

There were 302 authors who collaborated to create 114 papers on SLCI. Figure 3 illustrates the top 10 individuals who have made significant contributions to the research field. Rita Peihua Zhang was the most prolific author, having published seven works, while Dongping Fang followed closely with six publications. Chunlin Wu and Helen Lingard each had five publications in this field. The authors have significantly contributed to the field through their research on topics like safety leadership, safety culture, safety climate, and construction safety management. Their research clarifies the relationship between various SLSs and the SP of employees in the industry by analyzing an underlying mechanism.

Figure 4 displays the temporal evolution of the output of the top ten authors. The node's size is proportional to the quantity of articles, and the node's color indicates the total number of citations received by those articles. When applying Lotka's law to the analysis of author publications in the literature on SLCI, an inverse relationship is observed between the number of publications and the number of authors contributing to them (Kumar et al. 1998). Lotka's law reveals that 245 authors, accounting for 81.1% of the total, made a

solitary contribution, while 36 authors, representing 11.9%, made two contributions. This suggests an imbalanced productivity pattern, indicating that numerous researchers may not regularly participate in SL studies.

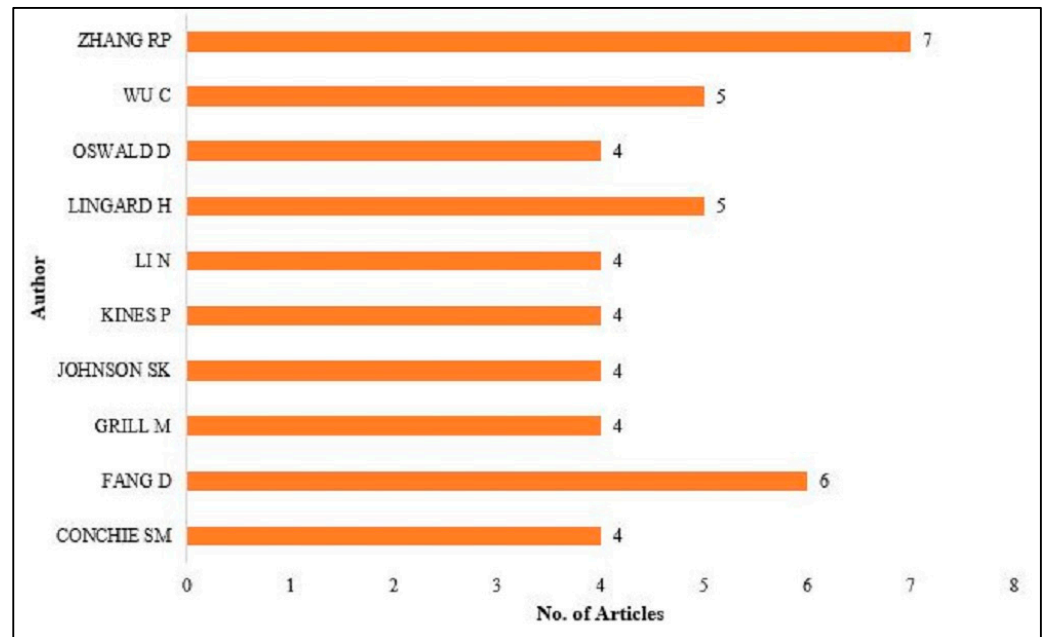


Figure 3. Most productive authors. (Source: Authors).

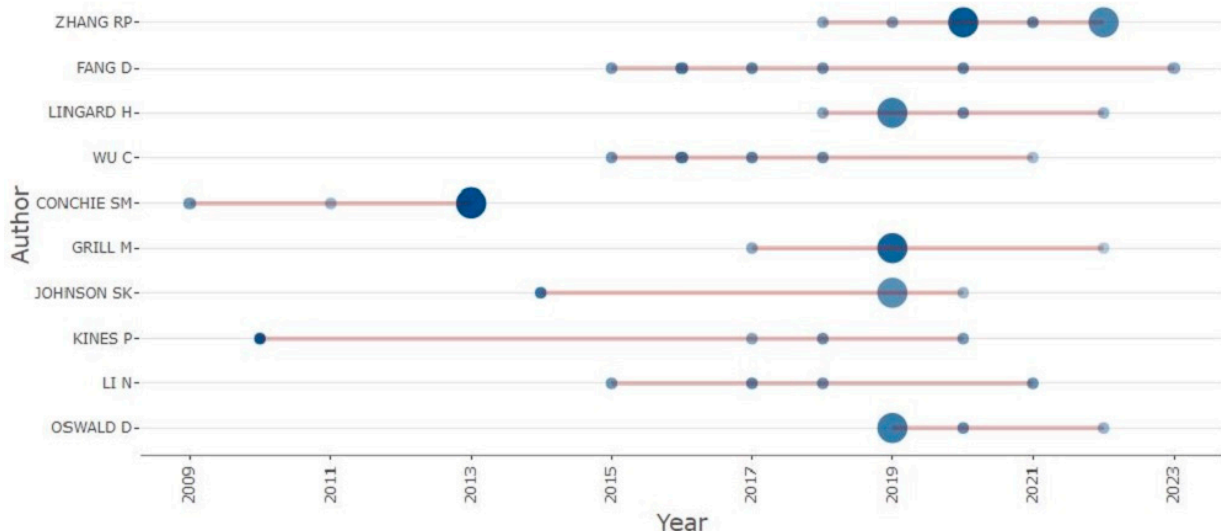


Figure 4. Author's production overtime. (Source: Authors).

4.1.3. Most Relevant Sources

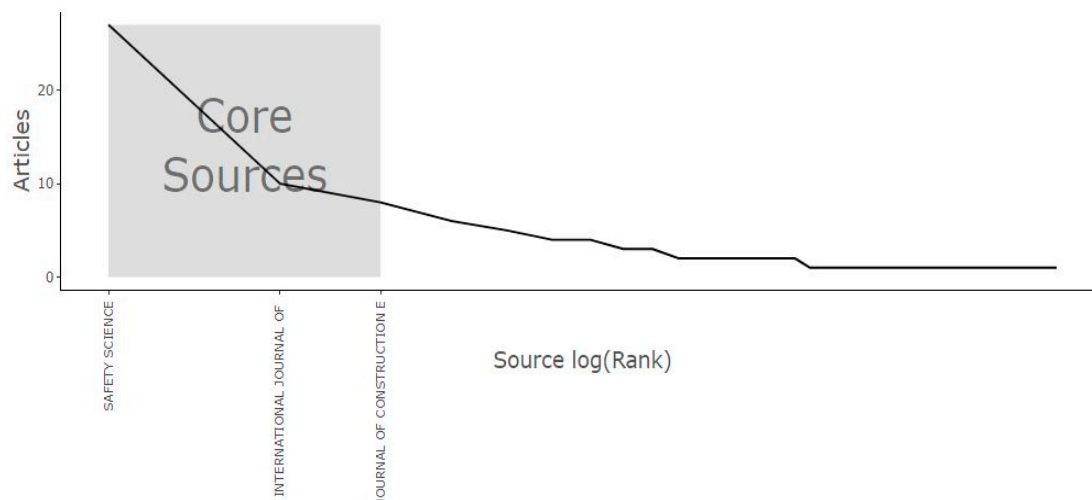
The research literature on SLCI has been distributed among 46 separate sources. Table 4 presents the ten primary sources that have the greatest number of publications in this field. The field of *Safety Science* demonstrated the highest level of productivity, yielding 27 publications. It was closely followed by the *International Journal of Environmental Research and Public Health*, which produced 10 publications, and the *Journal of Construction Engineering and Management*, which produced eight publications. The *Journal of Safety Research* contributed six publications, while *Construction and Architectural Management* contributed five publications. These sources cover the primary platforms and disciplines related to SLCI.

Table 4. Most relevant sources on the concept of SLCI.

S. No.	Source	No. of Articles
1	<i>SAFETY SCIENCE</i>	27
2	<i>INTERNATIONAL JOURNAL OF ENVIRONMENTAL RESEARCH AND PUBLIC HEALTH</i>	10
3	<i>JOURNAL OF CONSTRUCTION ENGINEERING AND MANAGEMENT</i>	8
4	<i>JOURNAL OF SAFETY RESEARCH</i>	6
5	<i>ENGINEERING, CONSTRUCTION AND ARCHITECTURAL MANAGEMENT</i>	5
6	<i>CONSTRUCTION MANAGEMENT AND ECONOMICS</i>	4
7	<i>JOURNAL OF MANAGEMENT IN ENGINEERING</i>	4
8	<i>INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT</i>	3
9	<i>SUSTAINABILITY (SWITZERLAND)</i>	3
10	<i>ACCIDENT ANALYSIS AND PREVENTION</i>	2

4.1.4. Source Dynamics Using Bradford's Law

The study utilized Bradford's law of scattering to identify the primary sources of the literature on SLCI. This scientometric technique demonstrates the distribution of journal articles across different sources within a particular research field (Desai et al. 2018). Bradford's law classifies sources into different zones based on the quantity of articles they possess. The study categorized the sources into three zones: Zone I with three sources totaling 45 articles, Zone II with 10 sources totaling 33 articles, and Zone III with 33 sources totaling 36 articles. Figure 5 displays the three primary sources in Zone I, which are *Safety Science*, *International Journal of Environmental Research and Public Health*, and *Journal of Construction Engineering and Management*. These sources represent the most influential and relevant platforms for sharing research on SLCI.

**Figure 5.** Bradford's law on core sources. (Source: Authors).

4.1.5. Most Productive Countries

An examination was directed to determine the geographic distribution of publications on SLCI using the scientific output of different countries as the basis. Table 5 displays the top 10 countries that have generated the highest number of publications in this particular field. China ranked first on the list with 27 publications, while the USA came in second with 15 publications. Australia followed closely with 14 publications, and the UK had 10 publications. These four countries collectively represented more than 55% of the overall publications. Malaysia and Sweden were ranked fifth and sixth, respectively, with 5 and 4 publications, respectively.

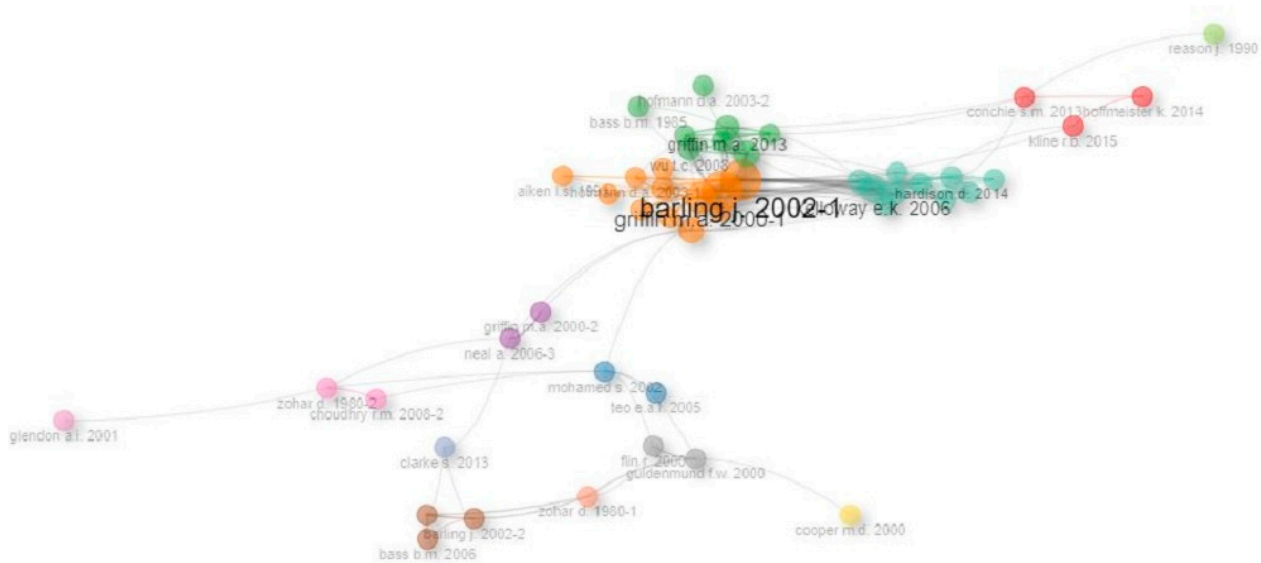


Figure 8. Co-citation analysis of documents. (Source: Authors).

4.2.3. Clustering by Coupling

Coupling-based clustering is a scientometric technique that groups authors or sources together by analyzing common references (Aria and Cuccurullo 2017), offering valuable insights into their connections and influence within a particular field. Figure 9 demonstrates the utilization of scientometric coupling analysis, which relies on sources that have shared references. The findings revealed a distinct cluster consisting of seven sources that share references, suggesting a significant thematic correlation among these sources. The sources in this cluster have a total link strength value of around 2783, indicating their strong interconnections and central importance in the discourse of this particular field or topic. Furthermore, the presence of 21 links indicates that these sources hold considerable sway over the network, potentially shaping the trajectory and emphasis of research in this field.



Figure 9. Clustering by coupling based on sources. (Source: Authors).

The analysis additionally identified four separate clusters of authors within the research field, as depicted in Figure 10. Each cluster exhibits common references that suggest thematic similarity. Cluster 1, which occurs six times, is distinguished by the cooperation

of the authors Kines P, McCabe B, Mohamed S, Musonda I, Sunindijo R Y, and Zou P. This indicates a strong network of papers co-authored by these individuals, with substantial connections. Cluster 2, with a frequency of five, comprises the authors Goldenhar L M, Grill M, Johnson S K, Nielsen K, and Schwatka N V, suggesting a cohort of authors whose contributions have had a significant influence. Cluster 3, which also has a frequency of five, includes the authors Cheung C M, Conchie S M, Lingard H, Oswald D, and Zhang R P, suggesting a network of interconnected researchers. Cluster 4, which has a frequency of four, comprises the authors Fang D, Li N, Wu C, and Xia N, suggesting a noteworthy collaboration among these four authors. The findings of the bibliographic coupling analysis demonstrate the differing levels of collaboration among the distinct clusters of authors. This offers valuable insights into the dynamics of author relationships within the specific context of SLCI.

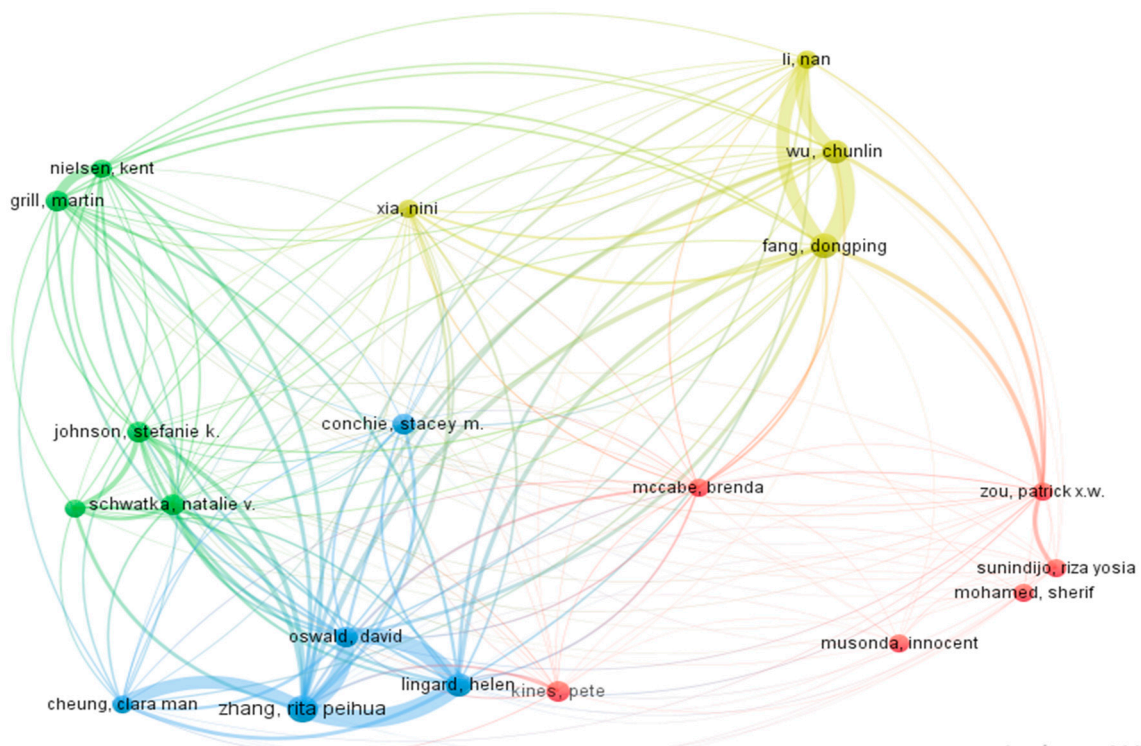


Figure 10. Clustering by coupling based on authors. (Source: Authors).

4.2.4. Collaboration Network

Figure 11 displays the collaboration network of authors, which consists of fourteen distinct clusters. The primary cluster comprises ten authors, whereas there are seven clusters that consist of only two authors each. Notable academics who have worked together with more than two collaborators include Dongping Fang from Tsinghua University, Rita Peihua Zhang from RMIT University, and Stefanie K. Johnson from the University of Colorado Boulder.

Figure 12 illustrates the seven clusters that represent the collaboration network among the participating institutions. Prominent collaborators with multiple institutions include the University of Colorado, Colorado State University, Queensland University of Technology, Southeast University, and the University of Hong Kong. Moreover, a more substantial connection between the Queensland University of Technology and the Southeast University indicates a greater quantity of shared publications, suggesting a strong and productive collaborative partnership.

Figure 13 illustrates the collaboration network among countries, which can be divided into three distinct clusters. The initial cluster depicts the cooperative alliances among China, the USA, Australia, and the UK. The second cluster consists of Sweden, Denmark, Israel,

4.3. Meta-Analysis

Meta-analysis is a technique that synthesizes data from various empirical studies to establish a common effect size between independent and dependent variables (Hak et al. 2016; Kitchenham and Charters 2007; Suurmond et al. 2017). It can be applied in various contexts and situations (Blom et al. 2021; Hunter and Schmidt 2004) by adhering to the guidelines specified in the PRISMA (Page et al. 2021) statement.

4.3.1. Overall Impact of Leadership Style on Safety Performance

The researchers estimated the aggregate effect size of all the SLS that influence SP in order to reveal the overall impact of SLS on SP. The authors employed the meta-analytic approach (Suurmond et al. 2017) and elucidated the findings in accordance with prior research (Hak et al. 2016; Hunter and Schmidt 2004). The meta-analysis results are presented in Table 6. The analysis revealed a combined effect size of $r = 0.39$, indicating a strong impact of SLS on SP. The significance level value, $p = 0.001$, which is less than 0.05, further supports this finding. Additionally, the positive association between SLS and SP is confirmed by the correlation coefficient of $r = 0.39$, with a 95% confidence interval of [0.15, 0.63].

Table 6. Meta-analysis results: random-effects model.

Independent Variable	Dependent Variable	No. of Studies	No. of Samples	Effect Size (r)	p-Value	CI [LL, UL]	Z-Value
Safety Leadership Styles	Safety Performance	13	7220	0.39	0.001	[0.15, 0.63]	3.19

The authors utilized a forest plot to visually present the results of a meta-analysis that integrated data from various studies. The magnitude of the effect was plotted on the X-axis and the number of studies on the Y-axis. Confidence intervals to the right of zero represented statistically significant positive effects, while those to the left indicated negative impacts. The size of the bullets indicates the importance of each study, and the diamond at the bottom row represents the combined effect size. Refer to Figure 14 to view the forest plot diagram.

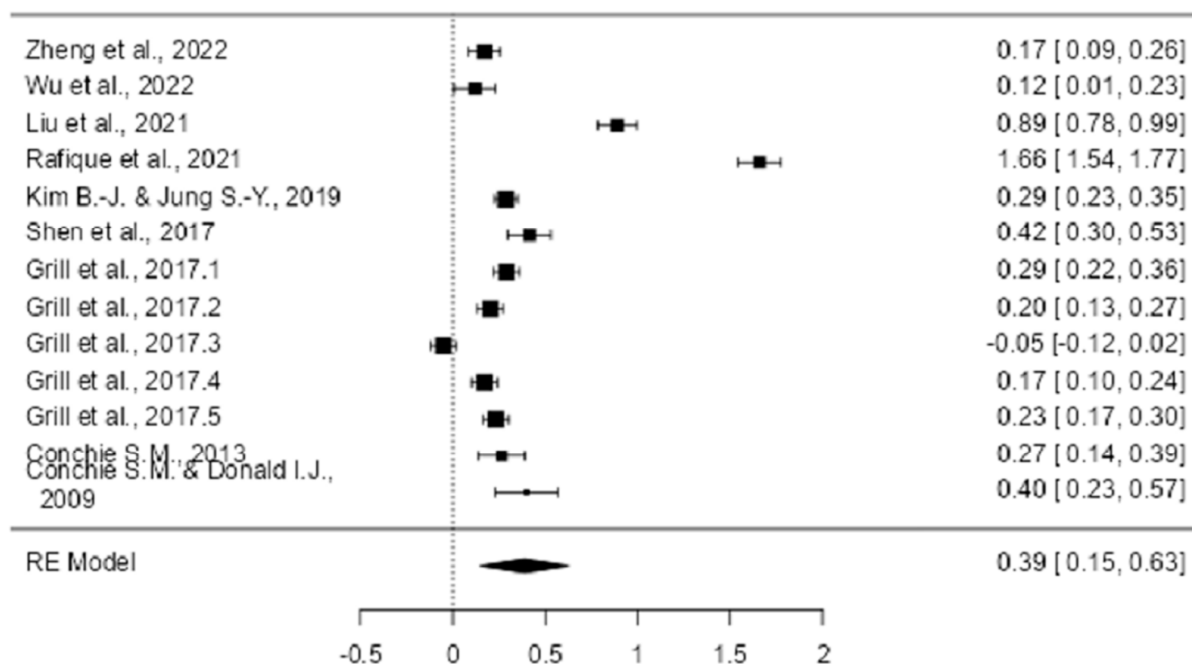


Figure 14. Forest plot. (Source: Authors).

Furthermore, the researchers calculate the I^2 value to evaluate the level of heterogeneity in the sample (Hak et al. 2016). Heterogeneity levels are classified as low when I^2 is less than 25%, medium when I^2 ranges from 26% to 50%, and high when I^2 exceeds 75%. Furthermore, the I^2 statistic stands at 99.03%, suggesting that the studies in this meta-analysis are not representative of the same population.

4.3.2. Most Influential Leadership Style Enhancing Safety Performance

The SLS with the greatest influence in the CI was discovered. The authors compared the effect size of various LSs and organized them in descending order. The process of comparing and organizing the different LSs is derived from the research conducted by Nasim et al. (2022), which utilized meta-analysis to examine LS in a broad context (Nasim et al. 2022). The meta-analysis utilized multiple studies to calculate the combined effect size of a specific SLS. Safety-specific transformational leadership is the most influential LS for enhancing the SP of construction company personnel. Kindly refer to Table 7 for supplementary information.

Table 7. Most influential leadership style in descending order.

Leadership Styles	Correlation Value	Hierarchy
Safety-specific transformational leadership	0.65	1
Transformational leadership	0.27	2
Participative leadership	0.23	3
Transactional leadership	0.20	4
Rule-oriented leadership	0.17	5
Temporal leadership	0.17	5
Laissez-faire leadership	−0.05	6

5. Discussion

The scientometric analysis of 114 research papers from the Scopus database offers a comprehensive overview of the evolving research landscape on SLS within the CI. The study indicates a surge in research interest in this area, with the number of articles increasing tenfold from 10 in the first decade (2000–2010) to 103 in the second (2011–2023). This growth is mirrored by a rise in the number of contributing authors to 302, who collectively produced these 114 articles. Among these, eight were single-authored. The most prolific contributors to this field, namely Rita Peihua Zhang (7), Dongping Fang (6), Chunlin Wu (5), and Helen Lingard (5), have particularly focused on the impact of SLS on construction personnel. As per Lotka’s law, the majority (81.1%) of the authors have contributed to just one document, suggesting sporadic or occasional engagement in SL research. The 114 documents were sourced from 46 different publications, underscoring the breadth of SL research in the CI. Bradford’s law points to three primary sources—*Safety Science*, *International Journal of Environmental Research and Public Health*, and *Journal of Construction Engineering and Management*—which together account for 39.5% (45) of the total articles, indicating their pivotal role in advancing this field of study.

Key contributions to the SL literature include the works by Kines et al. (2010), Kapp (2012), and Hoffmeister et al. (2014). Kines et al. (2010) examine the effect of leader-led safety communication at construction sites on safety levels and SC, shedding light on the complexities of promoting safety measures and fostering a safety-oriented environment (Kines et al. 2010). Kapp (2012), meanwhile, explores the impact of first-line supervisors’ leadership practices on employee safety compliance and participation, addressing concerns around SP and communication (Kapp 2012). In terms of institutional contribution, Tsinghua University (11 articles), Queensland University of Technology (10 articles), National Research Centre for the Working Environment (8 articles), University of Gothenburg (8 articles), and Universiti Teknologi Mara (7 articles) lead the way. Geographically, the top contributors are China, USA, Australia, UK, and Malaysia, collectively responsible for 71 of the total articles on this subject.

The keyword analysis of the research papers indicates that the terms “leadership” and “construction industry” are the most commonly utilized, with 105 and 64 occurrences, respectively. These terms account for 10% and 6% of the top 50 keywords. Additional noteworthy terms encompass safety, human, occupational health, safety climate, safety leadership, and safety performance. These findings indicate that SL research in the CI primarily centers around the topics of leadership, safety climate, and safety performance. The co-occurrence network of keywords revealed two distinct clusters, which indicate the specific thematic areas of focus in the research. The initial cluster, with a focus on “leadership”, encompasses keywords such as humans, transformational leadership, employee, organizational culture, supervisory personnel, and motivation. This cluster focuses on thoroughly examining the influence of different LSs in the CI. The second cluster, which pertains to “construction safety”, includes keywords such as safety leadership, safety climate, safety performance, safety management, safety culture, and accident prevention. This cluster emphasizes the research’s concentration on the safety elements of leadership, specifically SC and SP within the CI. The authors have identified a distinct group of seven sources that are highly interconnected and influential. This cluster has the potential to guide future research in this field. Furthermore, the analysis revealed the presence of four separate groups of authors, each exhibiting different degrees of collaboration, centrality, and influence. These insights provide a clearer understanding of the intricacies of author relationships within the context of SLCI.

The inquiry into author collaboration in the domain of SLCI unveiled fourteen distinct clusters, with the most substantial one comprising five authors. Dongping Fang, Rita Peihua Zhang, and Stefanie K. Johnson have made noteworthy contributions to this research field. Regarding institutional collaboration, a total of seven clusters were identified. The University of Colorado, Colorado State University, Queensland University of Technology, Southeast University, and the University of Hong Kong were identified as the most prolific contributors. At the national level, three separate clusters were identified, with China and Australia emerging as the top countries in terms of active collaboration. Surprisingly, even though there is a strong emphasis on SLCI, there has not yet been a well-developed and extensive network of collaboration among authors and institutions. Initial SLCI research has caused researchers to be spread across different disciplines and regions, leading to the formation of smaller, specialized groups. Institutional factors such as competition for funding and policies that do not encourage collaboration also play a role in this phenomenon. The limited connections offer possibilities for future collaborations and idea exchange, which could improve research and practical application. The findings emphasize the worldwide worry regarding SLCI and the significance of cooperative research in enhancing our comprehension of this crucial issue.

Further, this study utilized a meta-analysis methodology to investigate the relationship between the different SLSs and SP. The results suggest a positive correlation between all the LSs except for one. The style of safety-specific transformational leadership was found to have the greatest impact on improving an organization’s safety performance. Leadership theories, such as the leader–member exchange theory proposed by Hofmann and Morgeson (1999), suggest that cultivating positive relationships between leaders and followers can promote behaviors that are in line with the leaders’ objectives and principles (Hofmann and Morgeson 1999). Safety-specific transformational leaders demonstrate behaviors that foster a collective comprehension of safety goals among employees and cultivate the essential drive, expertise, and self-assurance to successfully accomplish these goals. This concept refers to a leader who inspires and encourages employees by embracing a vision centered on safety and actively collaborating with them to achieve it, instead of solely depending on formal measures such as the established protocols.

The findings of this study emphasize the critical role of SLCI. The identification of safety-specific transformational leadership as the most influential style for improving SP has significant implications for various stakeholders. In the context of the CI’s unique challenges, safety-specific transformational leaders can play a pivotal role in fostering a

proactive safety culture, empowering workers to take ownership of safety, and promoting a shared commitment to safety goals. Construction managers and supervisors can benefit from adopting and implementing safety-specific transformational leadership behaviors, such as articulating a clear safety vision, providing individualized support, and fostering a collaborative SC (Sankar et al. 2023). Construction companies should prioritize the development of training programs and policies that cultivate safety-specific transformational leadership skills among their leaders. Furthermore, policymakers can play a crucial role in encouraging the adoption of effective SL practices through regulations and incentives.

The presence of positive emotional interactions between leaders and employees results in an increased acceptance of leaders' initiatives, including compliance with organizational policies, procedures, rules, and safety regulations. Therefore, when employees are led by safety-specific transformational leaders, they are anticipated to demonstrate safer behaviors (Cheung et al. 2021; Xia et al. 2021). Thus, safety-focused transformational leaders cultivate a transparent and liberated atmosphere that strengthens the organizational safety culture and climate. A recent study by Al-Bayati et al. (2024) suggested a significant role of frontline supervisors in mediating the influence of safety leadership on the safety performance of field workers (Al-Bayati et al. 2024). In addition, organizations that have a robust safety culture and climate can expect employees to exhibit minimal risky and accident-prone behavior (Frazier et al. 2013), resulting in a decrease in accidents and an enhancement of SP. By promoting SL, the CI can make significant strides towards achieving the Sustainable Development Goals related to decent work, economic growth, and sustainable communities.

6. Research Gap and Future Directions

This study illuminates the most commonly examined SLS in the CI, such as transformational, safety-specific transformational, transactional, and participative leadership. A significant portion of the literature concentrates on workplace safety in CI (Sampson et al. 2014; Wu et al. 2017; Bahn 2013; Conchie 2013), the role of SC (He et al. 2021; Lingard et al. 2009; Cheung et al. 2022; Rafique et al. 2021), the influence of safety indicators on employee safety behavior (Martin and Lewis 2014; Zhang et al. 2016; Cooper 2010; Grill et al. 2017; Hoffmeister et al. 2014; Zheng et al. 2022), and the correlation between SL and SP (Oswald et al. 2022; Sampson et al. 2014; Sunindijo and Zou 2013) among construction professionals. However, other aspects of SLS, such as laissez-faire, temporal, rule-oriented, and emerging LS, have not been thoroughly investigated. Future studies could explore these under-researched LS, assessing their impact on SP in the CI and their contribution to a safer workplace. The comparative analyses of the traditional and emerging SLSs could also be beneficial.

The existing literature focuses on examining the correlation between SLS and safety culture, supervisor's commitment to safety, workplace health and safety, and employee safety behavior. However, further research is necessary to explore the impact of SLS on additional outcomes such as employee turnover, absenteeism, performance, creativity, organizational commitment, and job satisfaction. Future research should also investigate the underlying mechanisms and moderators that elucidate how SLS impacts these outcomes and SP outcomes. How do SL and its styles affect the safety motivation, safety attitudes, safety behavior, and well-being of employees in CI? What is the role of SC, safety culture, trust, and safety voice in moderating the impact of SL and its styles on SP outcomes, specifically on employee safety performance?

Research on SLS in the CI is predominantly carried out in developed nations such as the USA, UK, and Australia, with fewer studies originating from developing countries like India, Singapore, and Malaysia. This emphasizes the necessity for thorough research that examines SLS across various regions and contexts, taking into account historical, political, economic, social, and cultural factors. The study concentrated on quantitatively analyzing the published literature on SLCI without assessing the quality of the articles.

Future research should utilize qualitative analysis methods such as content analysis to gain a more thorough understanding of SLS in the CI.

The meta-analysis performed in this study is correlational, which may limit the ability to establish causality. The prevalence of cross-sectional studies relying on self-reported measures and the limited number of longitudinal studies may further limit the research's ability to be widely applicable and relevant. The study encompassed all studies, irrespective of their research level, which could limit our findings. For instance, the impact of SL on SP may be powerful within a particular section or unit, but it may not have the same level of strength at the organizational level. Although the meta-analysis in the study has its limitations, it provides opportunities for future research on SL and SP. The study found that safety-specific transformational leadership had the greatest impact on enhancing SP in the CI. Future research should investigate the underlying mechanism by which safety-specific transformational leadership improves SP outcomes in construction organizations and on construction sites.

7. Conclusions

Research in recent times has increasingly focused on SLCI. By employing scientometric and meta-analysis techniques in the Scopus database, this study has provided insights into the progression, patterns, and deficiencies within this field of research. There has been a steady increase in research on SLCI, with a notable surge in the past decade. The identified areas of emphasis include safety culture, safety climate, safety performance, and LS such as transformational and transactional leadership. The study also identifies the most prolific contributors in this field. Nevertheless, it underscores the necessity for a more robust collaborative network among researchers and institutions and advocates for further investigation into alternative SLS, including laissez-faire, rule-oriented, safety-specific transactional, temporal, and other emerging styles. Most of the research has been carried out in developed nations, highlighting the necessity for additional studies from other swiftly expanding regions. The results of this study can provide valuable guidance to researchers, policymakers, and industry professionals in comprehending the current body of literature and pinpointing potential areas for future research. Stakeholders can utilize it to identify impactful works and delve into specific SLS within the CI.

This study makes a significant contribution to the existing body of knowledge on safety-specific transformational leadership by establishing it as a crucial factor in improving SP in the CI. The text offers a theoretical explanation, using the leader–member exchange perspective, for the positive relationship between safety-specific transformational leadership and SP. Nevertheless, it also emphasizes the limited number of research studies on safety-specific transformational leadership in the CI. This prompts scholars to further investigate this subject and examine its intricacies in other high-risk industries such as oil and gas, mining, and aviation. The study proposes that leaders can employ diverse styles to achieve their safety and organizational objectives, as there is no one style that is universally efficacious. The statement highlights the significance of safety-focused transformational leadership in improving SP in the CI. It suggests that this type of leadership should be encouraged and advanced within the management hierarchy. Implementing this could not only enhance the overall safety atmosphere but also enhance safety outcomes, potentially resulting in significant monetary savings for the company.

The findings of this study not only contribute to the academic understanding of SL but also resonate with the broader goals of sustainable development. By promoting effective SL practices, particularly safety-specific transformational leadership, the CI can make significant strides towards achieving SDG 3 (Good Health and Well-being) through the reduction in workplace accidents and injuries, fostering a culture of well-being on construction sites. Furthermore, enhanced SP contributes to SDG 8 (Decent Work and Economic Growth) by increasing productivity, reducing absenteeism and turnover, and improving overall worker morale and job satisfaction. Finally, a focus on SL aligns with SDG 11 (Sustainable Cities and Communities) by ensuring that construction projects are

executed responsibly, minimizing risks to workers and the surrounding communities, and contributing to the development of resilient infrastructure.

Nevertheless, the study acknowledges specific limitations. The reliance on a single database (Scopus) for literature retrieval might have inadvertently excluded relevant studies indexed in the other databases. Additionally, the focus on quantitative analysis, while offering valuable statistical insights, might have limited a deeper understanding of the complexities of SL. Furthermore, the majority of the included studies originated from developed countries, potentially limiting the generalizability of findings to other contexts. The meta-analysis conducted in this study, while robust, is subject to inherent limitations such as publication bias and heterogeneity. Finally, the cross-sectional nature of many included studies and the reliance on self-reported measures might limit the generalizability and applicability of the findings.

This study is an inaugural attempt to quantify the correlation between SL and SP specifically in the CI using a meta-analysis. The objective was to identify the SLS that have an impact on SP in the CI and improve our understanding of their relationship. The examination of data from 13 studies involving a total of 7220 participants revealed the existence of seven distinct styles of SL. Among these styles, safety-specific transformational leadership, transformational leadership, participative leadership, and transactional leadership were found to have the most notable influence on the SP of construction personnel. This meta-analysis serves as an initial step in establishing a standardized SLS that impacts SP in the CI. It also provides a framework for future research in this field.

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