

ARTICLE

An Integrated Framework for Behavioural Safety Improvement Strategies in the Construction Industry: A Systematic Review

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ABSTRACT

Despite the importance of behavioural safety (BS) in construction, there are few comprehensive frameworks that define measures for improvement. This work fills the gap via a systematic analysis, offering direction for future research and practical improvements to BS performance. A comprehensive database search encompassing literature published between January 1997 and September 2022 was carried out across EBSCOhost, Emerald Insight, Google Scholar, JSTOR, PubMed, SAGE, SCIRP, Scopus, Taylor & Francis, and Wiley-Blackwell. Key phrases including "construction workers", "risk perception", "safety behaviour", "safety compliance", "safety participation", "safety citizenship behaviours" "construction industry" and other related terms were used for the search. The initial 2,427 records were trimmed to 2,267 after language and title keyword filters were applied. After excluding 2,156 records based on title, abstract, and content analysis, 111 relevant papers were chosen for further review. The selected papers underwent a thorough screening procedure that included title, abstract and full-text analyses and 41 were finally chosen on the basis of their results, conclusions, or recommendations explicitly included BS improvement techniques. QSR NVivo 10 software was used to examine and code the chosen articles. Five levels—organisational, management, leadership, workgroup, and individual—as well as related sub-themes were used to comprehensively classify improvement techniques. An integrated six-level framework was established, incorporating an external component that includes regulatory, economic, and sociological impacts based on these results. This framework clearly connects external and internal factors, enhances the theoretical comprehension of behavioural safety, and offers a practical framework for academics, regulators, and industry professionals aiming to enhance safety outcomes in the construction industry.

Keywords: Behavioural safety improvement strategies; external factors; organisational factors; management factors; leadership factors; workgroups factors; individual factors; systematic review; framework; construction industry.

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1. Introduction

Despite continued efforts to reduce the number of accidents, the construction industry continues to be seen as an exceptionally dangerous sector^[1], with an elevated rate of workplace mishaps^[2]. Accidents in the construction business culminate in large, both direct and indirect, expenses for employers and society, according to Haupt and Pillay^[3]. Despite worldwide advances, workplace injuries and deaths in the construction industry remain common and devastating^[4, 5], yet there remains much that can be done to improve construction safety^[6]. Generally, safety management systems must be established with the goal of improving BS performance, particularly at the end user, the worker, where most failures occur^[5].

Choudhry^[7], citing Cooper (1994), describes “behavioural safety” as the systematic application of psychological studies on human behaviour to the subject of safety. Cooper^[8] and^[9] have both referred to behaviour-based safety (BBS) as a behavioural safety process and BS. Several writers have called it BBS, including^[7],^[10], and others. A variety of safety interventions have employed this strategy for modifying behaviours on front-line workers’ safety behaviour (SB)^[11]. According to Cooper^[8], the BS process, which calls for concerted activities, reduces occurrences caused by risky or unsafe behaviours.

According to Zhang et al.^[12], citing Blackmon and Gramopadhye (1995), workers’ risky behaviour generates more than 80% of workplace occurrences. Unsafe behaviours, according to^[13], are risky or harmful actions that violate safety laws and can result in accidents. Prior behavioural investigations revealed that violations of safety regulations and procedures are common among construction workers^[14].

Given the aforementioned, it is argued that any deliberate effort to foster good H&S behaviour in the construction sector is referred to in this review as BS improvement strategies. This might involve H&S management techniques, safety climate and culture, safety compliance (SC) and participation (SP), safety citizenship behaviours (SCB), safety motivation and commitment, safety communication,

safety knowledge, and safety education and training techniques including related terms.

Hinze et al. (2013), as cited in^[15], describe SB as “safety-related acts performed by employees within an organisation.” This behaviour is an important predictor of safety performance. According to^[16], analysing safety-related behaviours is a highly efficient method for forecasting workplace safety. Organisational norms, legislative frameworks, ethos, work environment, and cultural traits were identified as the top individual human environment elements impacting construction workers’ health and safety behaviour. When public policy components were considered together, they had the largest effect. These findings underline the importance of the work environment in affecting employee behaviour^[17].

Distal context-related elements such as leadership and safety climate and proximal person differences such as safety awareness and motivation^[18], as well as multiple factors like colleague connections and management team initiatives, influence workers’ safety-related behaviours^[12]. According to Turner et al. (2012), cited in^[19], workers will widen their vision to include safety (i.e., safety citizenship) in fulfilment of an obligation or loyalty to their superiors. Workers’ safety attitudes are favourably connected with safety leadership^[20]. Workers on construction sites will almost certainly communicate with management teams, and these interactions may have an important effect on how they perceive safety and how they act as a result^[21].

Recent systematic reviews in the construction sector have focused on improving Health and Safety (H&S) performance. Studies such as^[22] on safety barrier identification and classification,^[23] on safety leading indicators, and^[24] on the link between safety culture, climate, and performance all give useful insights. Furthermore,^[25] investigate variables influencing construction workers’ risky behaviours, whereas^[26] evaluate safety strategies for accident prevention. These studies cover key areas of construction safety, such as obstacles, indications, culture, interventions, and worker behaviour. Nevertheless, none of these studies thoroughly

examined the range of strategies for improving behavioural safety (BS), which are essential to proactive safety management in the construction sector. These techniques include external and internal factors. While ^[27] investigated behavioural safety in Qatari megaprojects and ^[28] introduced a framework categorising 16 elements into organisational, safety climate, and individual dimensions, their geographic and contextual breadth is constrained, underscoring the importance of an exhaustive evaluation of programmes and systems that improve BS outcomes worldwide.

This study is unique because it takes a detailed and organised approach that goes beyond prior assessments of BS in construction. First, it does a bibliographic analysis to investigate the sources of published publications as well as their publication dates, following the history, trends, and patterns in BS research in the construction sector. Second, it synthesises the methodological techniques used in previous research, highlighting both best practices and shortcomings to present a more complete view of how BS has been examined. Third, the study delves deeper into the behavioural improvement drivers by identifying and assessing the important elements impacting BS management and performance. Finally, it presents a comprehensive theoretical framework that incorporates a variety of evidence-based methodologies and practices designed to improve BS management in the construction sector. This research fills a significant gap in the literature by offering a comprehensive view on enhancing safety behaviour in construction contexts. It provides a workable implementation roadmap, filling a crucial gap in academic research and industrial practice, thus significantly contributing to the construction BS literature.

Against this backdrop the study is guided by the following objectives:

- To conduct a bibliographic analysis of the selected articles on behavioural safety in construction.
- To identify and synthesise the methodological approaches previously employed in BS related

research.

- To examine the key factors influencing behavioural safety improvement within the construction industry.
- To develop an integrated theoretical framework aimed at enhancing behavioural safety management in the construction industry.

2. Research Methodology

2.1 Literature search

The study employed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram guidelines ^[33] such as identification, screening, eligibility, and inclusion to arrive at the final selection of the included articles (Figure 1). Articles published in English and contained in their titles, either one or a combination of the following keywords: “safety behaviour”, or “unsafe behaviour”, or “risk perception”, or “safety violation”, or “safety compliance”, or “safety participation”, or “safety citizenship behaviour”, or “safety climate”, or “safety culture”, “construction workers”, “construction industry”, and “leadership”, were used to search from the stated databases. Before screening the publications obtained for the systematic review, duplicate records, reviews, systematic reviews, and meta-analyses were eliminated, since the review focused on research providing empirical data. The screening procedure also entailed the exclusion of conference papers, theses, and other unpublished or non-peer-reviewed materials, as these may lack a stringent peer-review process (Butler & Visser, 2006, as cited in ^[29, 30, 31], Chai & Wen, 2005, as cited in ^[32]). The authors utilised the double screening (two-fold screening) technique ^[33] to ensure that all records were checked twice and only human decisions were used for the evaluation. Authors independently examined titles and abstracts to determine article eligibility, and any disputes were resolved through discussion and consensus in both situations ^[33]. The procedure for gathering materials included title analysis, abstract analysis, and content analysis. The analysis

of the included articles was conducted through a qualitative strategy (Whittemore, 2005, cited in [34]. Using content analysis, the required data was coded into themes and sub-themes, with the use of QSR Nvivo 10 software, by noticing patterns and themes, clustering, counting, and noting similarities and relationships [35]. The decision on the improvement strategies and the probable factors was based on the authors' consensus after independently reviewing thoroughly the articles by considering those that contained sentences that suggested improvement strategies for H&S management and improvement in the construction industry and discussing them. Again, similar strategies were employed to extract the probable factors that influence BH&S management and performance. These were coded into themes and sub themes. Descriptive analysis was used to present

the results in the form of texts, tables and figures.

3. Results

3.1 Literature search

A search through 10 databases yielded 2427 records for the identification process. Most of the articles were drawn from the Taylor and Francis database (630), followed by Google Scholar (392), then Scopus (369), with the least drawn from EBSCO Host (13) (Figure 2). The last search dates from the databases were: EBSCO Host (25/2/22), Emerald Insight (14/4/22), Google Scholar (11/3/22), JSTOR (6/3/22), PubMed (8/4/22), Sage (1/4/22), Scirp (2/4/22), Scopus (13/4/22), Taylor and Francis (18/3/22) and Wiley and Blackwell (31/3/22).

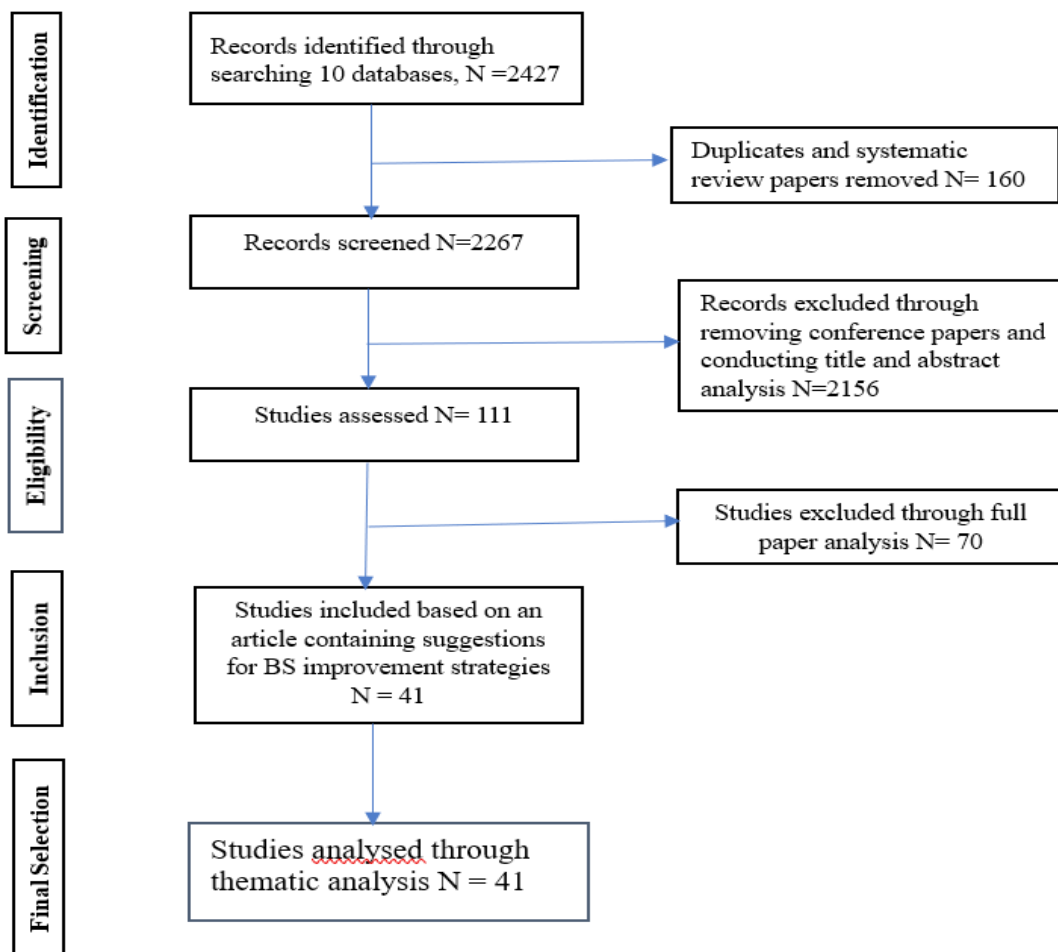


Figure 1: PRISMA study screening flow chart

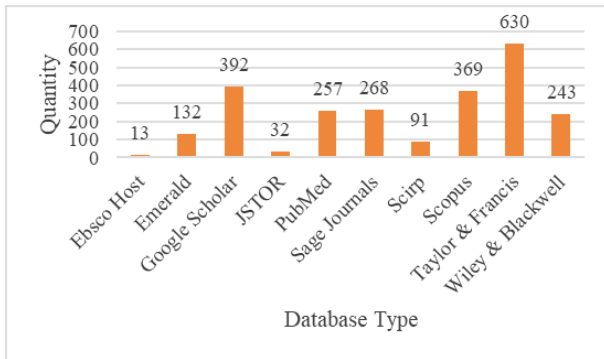


Figure 2: Statistics on the result of the electronic databases searched

Prior to the primary screening process, 160 publications were excluded, of which 77 were duplicates and 83 were reviews, systematic reviews, or meta-analyses, as the focus was on empirical research. 2,267 records were then looked at, removing conference papers, theses, and other unpublished works, since they might not have been properly reviewed by experts (Butler & Visser, 2006, as cited in [29], [30,31], Chai & Wen, 2005, as cited in [32]).

The screening process included many stages: title analysis, abstract analysis, and complete content analysis. The first stage, title analysis, determined if the titles were consistent with the study objectives and topic area. This was followed by abstract analysis, which comprised a thorough review of each study’s goal, methods, and main findings. Finally, a content analysis was performed to guarantee relevancy and rigour. After this procedure, 2,156 records were removed, resulting in a more focused

collection of articles for future study. Resultantly, 111 studies were accessed for eligibility, out of which 70 records were removed after conducting full paper analysis. In all, 41 articles were included for the analysis (Figure 1). These were papers that contained suggestions for improvement strategies aimed at enhancing holistic BS performance in the construction industry.

The study used thematic analysis to categorise articles into various categories, such as country of study, journal types, yearly publications, and methodological approaches. Thematic analysis was used to extract improvement strategies and code them into themes and sub-themes using QSR Nvivo 10 software. Factors influencing BS were coded into organisational, management, leadership, workgroup, and individual factors, and the results were descriptively analysed and presented in texts, tables and figures.

3.2 Analysis of sources of published articles and years of publications

3.2.1 Bibliographic analysis of the journal papers included

The results present the country of study and number of papers obtained (Figure 3), types of journals, quantity, and impact factor (Table 1), and the yearly publications of the reviewed papers (Table 2).

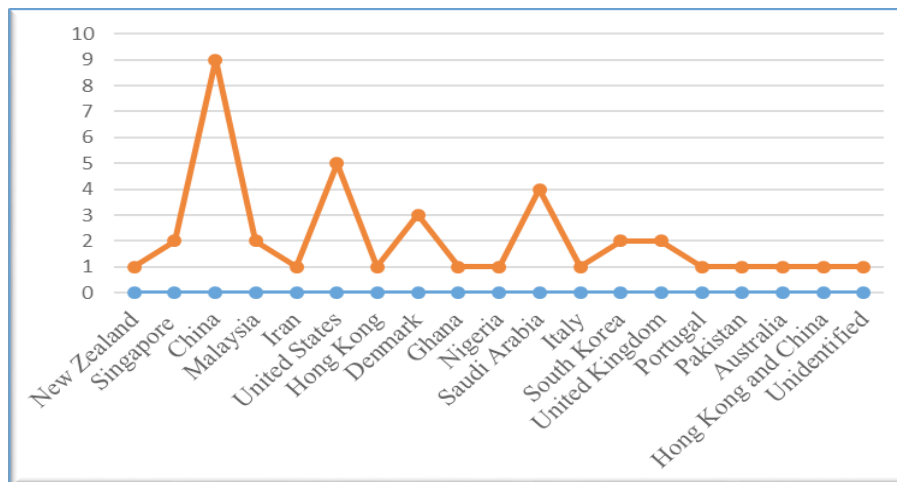


Figure 3: Statistics on the country of study and number of papers obtained

The 41 reviewed articles came from studies conducted in 19 countries, with China (9; 22.5%) having the most publications, followed by the US (5; 12.5%), Saudi Arabia (4; 10%), Denmark (3; 7.5%), South Korea (2; 5%), Malaysia (2; 5%), Singapore (2; 5%), and the United Kingdom (2; 5%). Most (57.9%) of the countries had only one publication each. This includes Iran, Hong Kong, Ghana, Nigeria, and others (Figure 3). This conclusion contradicts the findings of [22], [24], and [25], all of which found the United States to be the most prolific publishing country, rather than China. Other studies, such as [32], Osei-Kyei and Chan (2015), as cited in [32], and [36], have used sample sizes of 56, 38, and 27, respectively, for their reviews concerning safety in the construction industry, and this justifies the sufficiency of this study's sample size of 41 papers.

The quantity of the peer reviewed papers came from the International Journal of Environmental Research and Public Health 7 (17.07%), followed by Construction Management and Economics 6 (14.63%), Safety Science 5 (12.20%), International

Journal of Occupational Safety and Ergonomics 4 (9.76%), Engineering Construction and Architectural Management 2 (4.88%), Journal of Construction Engineering and Management 2 (4.88%), and Open Journal of Safety Science and Technology 2 (4.88%). The rest, such as Accident Analysis and Prevention, the Journal of Management in Engineering, Applied Ergonomics, Buildings, and many others, had one each, forming close to 70% of the total (Table 1). This also contradicts the findings of [30], who found that the Journal of Construction and Management had the most publications, followed by Safety Science.

In Table 2, most of the papers were published between 2017 and 2022, with 2021 having the highest frequency, meaning that researchers have stepped up their publications over the last 6 years. The impact factors of the journals ranged between 0.692 and 6.537, with the Journal of Management in Engineering recording the highest (6.537), while the Journal of Asian Architecture and Building Engineering recorded the lowest impact factor (0.692) (Table 1).

Table 1: Types of journals, quantity and impact factor

No	Peered reviewed journals	Quantity	Impact Factor
1	Accident Analysis and Prevention	1	4.993
2	Journal of Management in Engineering	2	6.537
3	Applied Ergonomics	1	3.94
4	Buildings	1	3.6
5	Journal of Risk Research	1	5.346
6	Construction Management and Economics	6	3.796
7	Engineering Construction and Architectural Management	2	3.531
8	Frontiers in Public Health	1	3.018
9	Information	1	0.78
10	International Journal of Construction Management	1	3.097
11	International Journal of Environmental Research and Public Health	7	4.54
12	International Journal of Occupational Safety and Ergonomics	4	2.141
13	Journal of Asian Architecture and Building Engineering	1	0.692
14	Journal of Construction Engineering and Management	2	3.951
15	Journal of Safety Research	1	3.487
16	Open Journal of Business and Management	1	1.00
17	Open Journal of Safety Science and Technology	2	0.74
18	PLOS ONE	1	3.24
19	Safety Science	5	4.877
	Total	41	

Table 2: Yearly publications of the reviewed papers

No	Year of Publications	Quantity	Percentage	No.	Year of Publications	Quantity	Percentage
1	1998	1	2.2%	9	2016	1	2.2%
2	2005	1	2.2%	10	2017	4	10%
3	2009	1	2.2%	11	2018	5	12.5%
4	2010	1	2.2%	12	2019	2	5%
5	2011	1	2.2%	13	2020	5	12.5%
6	2013	1	2.2%	14	2021	8	20%
7	2014	1	2.2%	15	2022	7	17.5%
8	2015	2	2.2%	16			

3.3 Research methodological approaches

Using QSR NVIVO 10 software, the study conducted the qualitative content analysis procedure by categorising the findings into themes and subthemes.

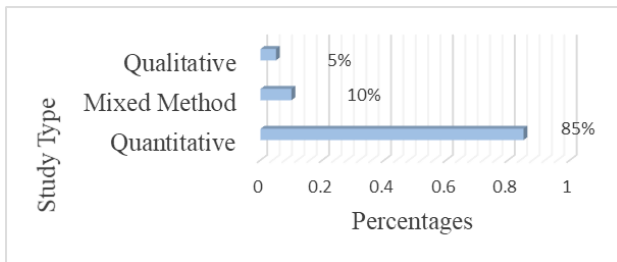


Figure 4: Methodological approaches used by the various articles

The study revealed that most (85%) of the varied articles used quantitative techniques, which include [37], [38], [39], [40], [41], [42], [43], [44], [45], [46], [47], [48], and [49]. [5], [50], [15], [51], [52], and many others also used that. [53], [54], [7], and others used the mixed method-related studies, which formed 10% of the total, whereas the qualitative methods comprised only 5% of the total and consisted of [55] and [56] (Figure 4).

3.5 Factors influencing BS in the construction industry

Multi-level factors such as organisational systems, management practices, leadership styles, team dynamics, and individual characteristics shape BS improvement in the construction industry, influencing safety attitudes, behaviours, and outcomes on site. The following display the outcomes of the review based on the foregoing

themes.

3.5.1 Organisational factors

Table 3 displays five organisational safety themes, as well as associated aspects. Safety culture and climate is an important issue that determines safety behaviour and norms inside an organisation. Safety climate [49, 57, 58, 59, 60, 50], positive safety culture [56], safety priority [37], social support [37], attachment and psychological ownership [58], and cultural and organisational contexts [42] are all factors that contribute to this theme. These components affect the organisational values, attitudes, and circumstances that influence safety results. Safety Systems and Resources refer to institutional systems and physical resources in place to assure compliance and safety preparedness. This subject includes elements such as PPE programmes [5], safety equipment maintenance and availability [5], safety permits and workplace safety inspections [5]. These systems are critical for ensuring a safe work environment and avoiding accidents. H&S policy and planning entail the creation and execution of policies and task structures to encourage safety and well-being. This subject is influenced by regulations that promote a healthy workplace [58], the practicality of safety standards [61], equipment design [52], and a better sequencing of work activities [61]. Training and knowledge enhancement programmes use organised learning to increase awareness, skills, and a safety mentality. This subject includes variables such as effective H&S training programmes [53], as well as enhancing knowledge, improving workshop atmosphere, and altering staff attitudes [46]. These

programmes are critical for providing employees with the information and skills they need to complete their responsibilities safely. Organisational pressure and workload are the stresses and expectations imposed on employees that might influence their

safety behaviour. This topic is influenced by production pressure [42] and work pressure [37]. These demands can cause increased stress, weariness, and a lack of adherence to safety measures, jeopardising safety outcomes.

Table 3: Organisational-Level Safety Themes

Theme	Related Factors	Citations	Theme Summary
1. Safety Culture and Climate	- Safety climate	[49, 57, 58, 59, 60, 50]	Organisational values, beliefs, and environments that influence safety behaviour and norms.
	- Positive safety culture	[56]	
	- Priority of safety	[37],	
	- Social support	[37],	
	- Attachment, psychological ownership	[58],	
2. Safety Systems and Resources	- Cultural and organisational contexts	[42]	Institutional systems and physical resources in place to ensure compliance and safety readiness.
	- PPE programmes		
	- Safety equipment maintenance and availability	[5]	
	- Safety permits		
3. H&S Policy and Planning	- Workplace safety inspections		Development and implementation of policies and task structuring that promote safety and well-being.
	- Policies for promoting a healthy workplace	[58]	
	- Practicality of safety rules	[61]	
	- Equipment design	[52],	
4. Training and Knowledge Enhancement	- Better sequence of work activities	[61]	Programmes aimed at increasing awareness, skill, and safety mindset through structured learning.
	- Strong H&S training programmes	[53]	
	- Increasing knowledge, improving workshop climate, and changing employee attitudes	[46]	
5. Organisational Pressure and Workload	- Production pressure	[42]	
	- Work pressure	[37]	

3.5.2 Management factors

Table 4 summarises six management-level safety themes, including associated factors. Leadership and commitment are an important subject that shows leadership’s role in promoting safety ideals, influencing the atmosphere, and developing effective connections. Management commitment [62], safety leadership [39, 59], leader-member exchange [25], supervisor-worker relationships [63, 64], supervisory management conditions [14], and safety climate [25]. Supervision and oversight relate to the level of managerial control and execution of safety requirements. This theme includes elements like close and strict supervision [65, 48], direct supervision [61], the strictness and frequency of management feedback [66], workplace safety inspections [5], and safety risk tolerance [59]. Safety training and capacity building are key tactics of management

for increasing worker safety knowledge and capabilities. Safety training programmes [46, 66, 53], theoretical and practical training programmes [66], industry training courses and standards [52], worker safety and health training [65, 61], regular training in hazard perception and risk comprehension and safety and voice ergonomics training [48]. Communication and knowledge sharing relate to the exchange and quality of information among teams and management groups. This theme includes elements like safety communication [37], frequent communication [61], dense communication networks and frequent supervisor-worker communication [63], safety knowledge sharing [67], safety climate and social-network safety communication patterns [60], and social safety capital [54]. Feedback, motivation, and accountability are management techniques that incentivise safe behaviour and prohibit infractions. This is influenced by factors such as goal-setting

and feedback [7], awarding safety role models [61], and enforcing penalties [65]. Worker autonomy and perceived control refer to an employee’s sense

of control over their job activities, decisions, and surroundings. This theme is assessed using job control ratings [19].

Table 4: Management-Level Safety Themes

Theme	Related Factors	Citations	Theme Summary
1. Leadership and Commitment	- Management commitment	[62]	Reflects leadership's role in establishing safety values, shaping climate, and building effective relationships.
	- Safety leadership	[39, 59]	
	- Leader-member exchange	[25]	
	- Supervisor-worker relationships	[63, 64]	
	- Management conditions at supervisory level	[14]	
	- Safety climate	[25]	
2. Supervision and Oversight	- Close and strict supervision	[65, 48]	Degree of managerial oversight and enforcement of safety standards.
	- Direct supervision	[61]	
	- Strictness and frequency of management feedback	[64]	
	- Workplace safety inspections	[5]	
	- Safety risk tolerance	[59]	
	- Safety training programmes	[46, 66, 53]	
3. Safety Training and Capacity Building	- Theoretical and practical training programmes	[66]	Training as a core managerial strategy for improving worker safety awareness and competencies.
	- Industry training courses and standards		
	- H&S training of workers	[52]	
	- Regular training in hazard perception and risk comprehension	[65, 61]	
	- Increasing knowledge, improving workshop climate through training	[48]	
	- Safety and voice ergonomics training		
4. Communication and Knowledge Sharing	- Safety communication	[61]	The flow and richness of information within teams and across management levels.
	- Frequent communication	[63]	
	- Dense communication networks and frequent supervisor-worker communication	[63]	
	- Safety knowledge sharing		
	- Safety climate and social-network safety communication patterns	[67]	
	- Social safety capital	[60] [54]	
5. Feedback, Motivation, and Accountability	- Goal-setting and feedback	[7]	Managerial practices to incentivise safe behaviour and discourage violations.
	- Rewarding safety role models	[61]	
	- Imposing fines	[65]	
6. Worker Autonomy and Perceived Control	- Job control scores	[19]	Employee’s perception having control over their work tasks, decisions, and environment.

3.5.3 Leadership factors

Table 5 covers five leadership-level safety themes, as well as associated indicators and citations. Leadership Styles and Approaches examines several leadership styles and how they affect safety culture and employee behaviour. This topic is influenced by transformational leadership [59], supportive leadership [42, 56], safety-specific leadership [39], effective leadership and attitudes, and safety

leadership) [39]. Leader-follower relationships refer to the quality of leader-follower relationships and how they affect worker commitment to safety. This theme includes aspects such as leader-member exchange (LMX) [44, 68] and workers’ sense of commitment to leaders [59]. Role modelling and impact refer to the impact of visible role models and reinforcement mechanisms on safe behaviour. This topic is influenced by an emphasis on the

demonstrative impact of team leaders and technical specialists ^[47], as well as awarding safety role models ^[61]. Leadership in risk management refers to leaders' responsibilities for discovering, analysing, and managing project safety hazards. This theme includes aspects like project managers' logical

attitude to risk ^[55] and foremen's involvement in risk perception and risk-taking ^[55]. Active supervision and training include ongoing, proactive safety engagement and training from supervisors to employees. This theme is monitored by supervisors who provide continuing safety training ^[42].

Table 5: Leadership-Level Safety Themes

Theme	Related Factors	Citations	Theme Summary
1. Leadership Styles and Approaches	<ul style="list-style-type: none"> - Transformational leadership - Supportive leadership - Safety-specific leadership - Effective leadership and attitudes - Safety leadership 	<p>[59]</p> <p>[42, 56]</p> <p>[39]</p>	Describes distinct leadership styles and how they influence safety culture and employee behaviour.
2. Leader-Follower Relationships	<ul style="list-style-type: none"> - Leader-member exchange (LMX) - Workers felt obligation to leaders 	<p>[44, 68]</p> <p>[59]</p>	Quality of leader-follower relationships and their effect on worker commitment to safety.
3. Role Modeling and Influence	<ul style="list-style-type: none"> - Focusing on demonstration effect of team leaders and technical specialists - Demonstration effect of team leaders and technical specialists - Rewarding safety role models 	<p>[47]</p> <p>[61]</p>	Influence of visible role models and reinforcement mechanisms that guide safe behaviour.
4. Leadership in Risk Management	<ul style="list-style-type: none"> - Project managers' rational approach to risk - Foremen's role in risk perception and risk-taking 	<p>[55]</p>	Leaders' role in identifying, evaluating, and managing safety risks on projects.
5. Active Supervision and Instruction	<ul style="list-style-type: none"> - Supervisors providing on-going safety instruction 	<p>[42]</p>	Continuous, proactive safety engagement and instruction from supervisors to workers

3.5.4 Workgroup factors

Table 6 provides four workgroup-level safety themes, as well as related variables. Group Norms and Social Influence explains how a team's shared ideas and social pressure shape individual safety behaviour. Factors contributing to this subject include social influence ^[41], workgroup norms ^[38, 40], guaranteeing safety as a valued group standard, social identity within a group ^[41], and social consequences on employees. Communication and knowledge sharing are terms used to describe the transmission of information that improves collective safety awareness and responsive behaviour. This theme includes safety communication ^[63, 37], dense communication networks ^[63], peer-to-peer exchange ^[25], safety knowledge sharing ^[67], and the free exchange of safety information among workers ^[60]. Team Dynamics and Support refers to the level of interpersonal support, collaboration, and mutual monitoring within teams. This topic is influenced by factors such as collaboration and cooperation ^[42],

social support ^[42, 56], a supportive atmosphere for coworkers and workers warning each other about harmful activities ^[42, 61]. Localised safety climate is the impression of safety priority and behaviour within certain teams. This theme is measured using the workgroup safety climate ^[50], and guarantees that safety is seen as a fundamental group standard, hence increasing collective accountability.

3.5.5 Individual factors

Table 7 provides seven safety themes at the individual level, along with relevant elements. Psychological capital and traits refer to intrinsic psychological qualities that influence safety behaviour, resilience, and well-being. This theme is influenced by factors such as high levels of psychological capital (PsyCap) ^[69, 44], self-efficacy ^[43], hope, optimism and resilience) ^[15]. Motivation and engagement are motivations and rewards that encourage people to adopt and sustain safe behaviours. This subject includes elements such

as safety motivation ^[43, 42, 39, 57], autonomous safety motivation ^[54], work engagement ^[67], job satisfaction ^[67], and safety participation ^[67]. Knowledge, competence, and skills include cognitive and experiential knowledge, as well as the ability to recognise and respond to risks. This theme is influenced by safety knowledge ^[69, 42, 51, 39, 44], hazard recognition skill development ^[60], job competence ^[70], comprehension of safety signs ^[48], attitude change through training ^[46], knowledge sharing ^[67], and the need for educational and instructional materials ^[52]. Communication competence is an individual's capacity to communicate efficiently and obtain safety-related information. This topic includes elements, including an elevated degree

of communication competence ^[69, 44] and a high level of psychological capital and communication competence ^[44]. Personal preferences and behavioural patterns influence how people engage with danger and others. This theme is influenced by several factors, including proactivity, prosociality ^[25], safety response ^[50], workers' intuitive attitude to risk and risk perception and risk-taking ^[55], Cognitive and physical load relate to cognitive or emotional pressures that might impair attentiveness and decision-making ability. This theme is influenced by mental and physical strain ^[14], as well as occupational stress ^[25]. Demographics and personal background include individual variables, including education level and age structure ^[44].

Table 6: Workgroup-Level Safety Themes

Theme	Related Factors	Citations	Theme Summary
1. Group Norms and Social Influence	- Social influence	[41]	How shared beliefs and peer pressure within a team guide individual safety behaviour.
	- Workgroup norms	[38, 40]	
	- Ensuring safety as a valued group norm	[41]	
	- Social identity within a group		
2. Communication and Knowledge Sharing	- Social effects on employees		Information exchange that promotes collective safety understanding and responsive behaviour.
	- Safety communication	[63, 37]	
	- Dense communication networks	[63]	
	- Peer-peer exchange	[25]	
	- Safety knowledge sharing	[67]	
3. Team Dynamics and Support	- Free exchange of safety information among workers	[60]	The quality of interpersonal support, cooperation, and mutual monitoring within teams.
	- Teamwork and cooperation		
	- Social support	[42]	
	- Co-worker's supportive environment	[42, 56]	
4. Localised Safety Climate	- Workers cautioning each other against unsafe actions	[42, 61]	The perception of safety priority and behaviour within specific teams
	- Workgroup safety climate	[50]	

Table 7: Individual-Level Safety Themes

Theme	Related Factors	Citations	Theme Summary
1. Psychological Capital and Traits	- High level of psychological capital (PsyCap)	[69, 44]	Internal psychological strengths that contribute to safety behaviour, resilience, and well-being.
	- Self-efficacy		
	- Hope	[43]	
	- Optimism	[15]	
2. Motivation and Engagement	- Resilience		Drives and incentives for individuals to adopt and maintain safe behaviours.
	- Safety motivation	[43, 42, 39, 57]	
	- Autonomous safety motivation	[54]	
	- Work engagement	[67]	
	- Job satisfaction	[67]	
	- Safety participation	[70]	

Table 7 continued

Theme	Related Factors	Citations	Theme Summary
3. Knowledge, Competence, and Skills	- (Rich) Safety knowledge	[69, 42, 51, 39, 44]	Cognitive and experiential knowledge and capacity to recognise and respond to hazards.
	- Hazard recognition skill development	[60]	
	- Job competence	[70]	
	- Comprehension of safety signs	[48]	
	- Changing attitude through training	[46]	
	- Knowledge sharing	[67]	
4. Communication Competence	- Need for educational and instructional materials	[52]	Individual's ability to effectively express and receive safety-related information.
	- High level of communication competence	[69, 44]	
5. Behaviour and Social Orientation	- High level of psychological capital and communication competence	[44]	Personal tendencies and behavioural patterns affecting interaction with risk and others.
	- Proactivity	[25]	
	- Prosociality	[50]	
6. Cognitive and Physical Load	- Safety response	[55]	Cognitive or emotional burdens that can reduce alertness and decision-making accuracy.
	- Worker's intuitive approach to risk, risk perception and risk-taking	[14]	
7. Demographics and Personal Background	- Mental and physical load	[25]	
	- Work stress	[44]	
	- Education level		
	- Age structure		

3.5 Framework

The framework for improving behavioural safety (BS) in the construction industry (**Figure 5**) defines a multi-level model that encompasses the many aspects affecting safety performance. It consists of six interrelated levels—external, organisational, management, leadership, team, and individual—each aligned with distinct stakeholders and systems influencing safety behaviour. At the core of the paradigm are behavioural safety enhancement strategies, which demonstrate that advancement arises not from single acts but from the synergistic and interactive impact of several levels.

At the external level, legislative requirements, industry standards, economic situations, environmental constraints, societal expectations, and technical breakthroughs provide the comprehensive backdrop for construction safety measures. The broad influences mentioned earlier affect the organisational level (**Table 3**), where safety culture, systems, policies, resource allocation, training provision, and workload demands establish the internal foundations for safety performance. The management level operationalises these principles via leadership commitment, supervision, training,

capacity development, communication, feedback mechanisms, responsibility sharing, and worker autonomy, ensuring that organisational purpose is reflected in site-level practices.

The leadership level (**Table 5**) emphasises the behavioural and relational aspects of safety; leadership style, leader-member interchange, role modelling, and proactive engagement in risk management directly influence worker attitudes and safety climates. These factors, in turn, affect the team level (**Table 6**), which encompasses workgroup dynamics, communication, cooperation, shared norms, and the development of localised safety cultures that either bolster or detract from behavioural results. At the individual level (**Table 7**), safety conduct is influenced by personal traits such as psychological capital, motivation, competence, communication skills, behaviour, cognitive and physical loads, and demographic variables. These criteria ultimately determine whether workers engage in safe or harmful actions on-site.

Despite their individual presentation, the six layers exhibit extensive interconnection. The arrows in **Figure 5** illustrate direct, indirect, and reciprocal linkages, indicating that actions at one level resonate

across others. New legislation requirements (external level) may transform corporate policies, impact management oversight, modify leadership strategies, change team norms, and ultimately direct individual conduct. In contrast, bottom-up processes—such as employee feedback, team learning, or site-level reporting—can enhance management practices, fortify organisational cultures, and perhaps catalyse policy improvements.

This systemic viewpoint underscores that BS improvement is both iterative and multidirectional. Consequently, effective interventions must concurrently address structural, managerial, social, and individual elements. The paradigm has practical application value, since each level may be associated with quantifiable indicators (e.g., safety climate surveys, leadership evaluations, training

audits, performance records), facilitating both academic assessment and industrial benchmarking. Significantly, it incorporates cultural and contextual variations, making it suitable for many building situations, including resource-limited or international project contexts.

In conclusion, the framework (Figure 5) and its accompanying breakdown (Tables 3–7) provide a thorough, evidence-based guide for comprehending and enhancing behavioural safety in construction. By consolidating external systems, organisational frameworks, management methodologies, leadership behaviours, team dynamics, and personal characteristics into a unified model, it elucidates both the origins of safety impacts and the mechanisms via which enduring enhancements might be realised.

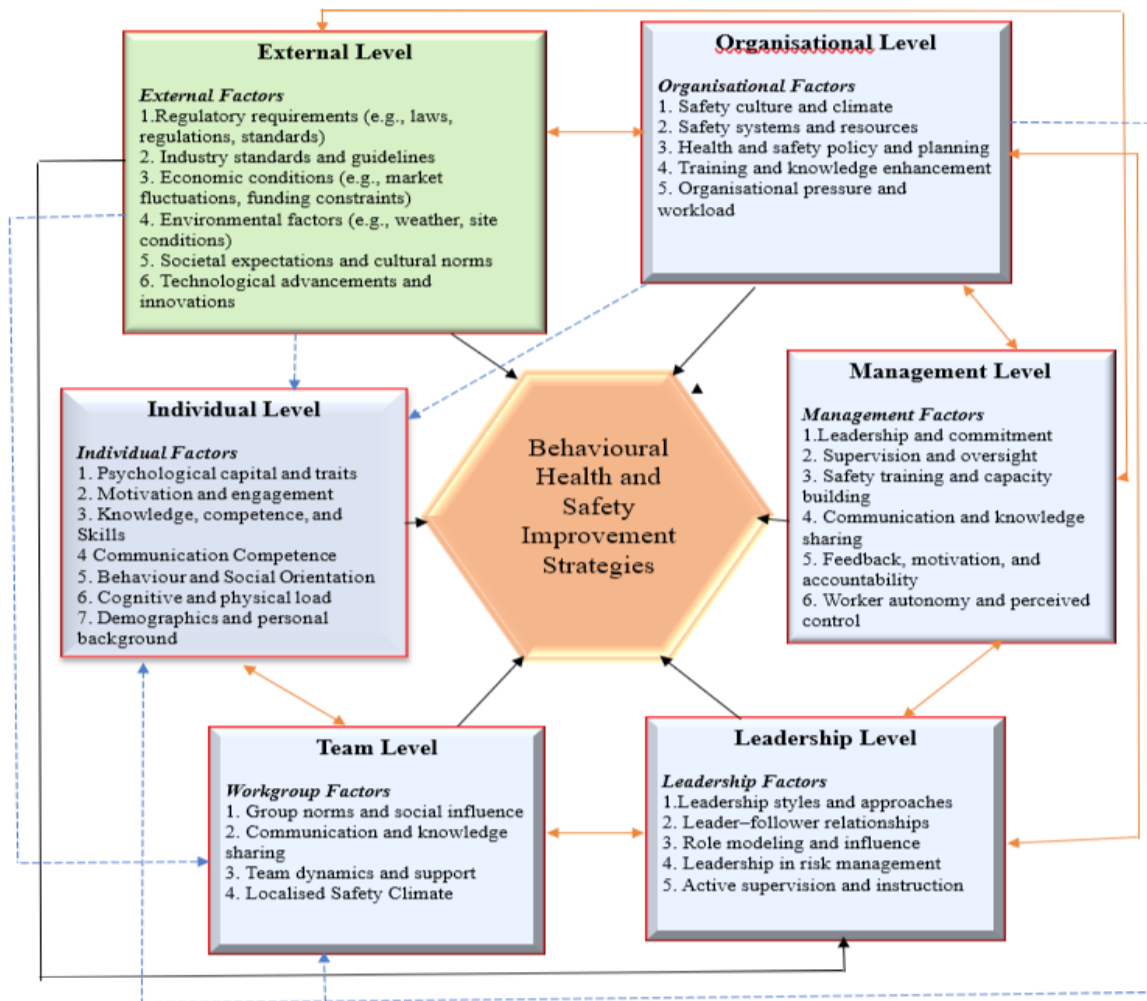


Figure 5: An Integrated framework for behavioural safety improvement strategies for the construction industry

4. Discussion

The framework includes a variety of elements at the external, organisational, management, leadership, team, and individual levels that have a substantial influence on workers' BS in construction (Figure 5). The framework's external level consists of numerous variables. Regulatory standards are critical, with frameworks such as ISO 14001:2015^[71], ISO 45001^[72], and OSHA's Safety and Health Management System offering instructions for increasing worker safety^[73]. Industry standards, such as ISO 45001^[72], provide a systematic approach to risk management and continuous improvement^[73]. Economic conditions exert a significant influence, especially on small and medium-sized enterprises (SMEs), which frequently suffer with insufficient financial resources^[74]. Economic incentives, such as tax rebates and insurance discounts, can help to promote H&S systems^[75]. Environmental elements such as noise and heat stress are crucial to construction safety, and focused interventions such as real-time monitoring can assist in reducing these hazards^[76, 77, 78]. Societal expectations and cultural norms influence the construction industry's attitude to safety, with firms prioritising worker safety and aiming for a zero-harm culture. Committed leadership, openness, and accountability are critical in cultivating a safety-first mentality. Nonetheless, cultural differences and linguistic difficulties might be obstacles. Companies must demonstrate that their activities align with society's norms, beliefs, and values^[79]. Subsequently, technical improvements such as Building Information Modelling (BIM), internet of things (IoT), artificial intelligence (AI), and virtual reality (VR) can dramatically improve risk awareness, prevention, and training^[80, 81]. Nevertheless, the industry continues to face resistance to long-term usage^[82]. By addressing these external factors, construction industry may create successful strategies for improving BS and promoting sustainability.

The organisational factors which encompass safety culture and climate, safety systems and resources, H&S policy and planning, training and

knowledge enhancement, and organisational pressure and workload, each with associated factors found in this study, emphasise their importance in promoting a safe work environment. Organisational elements were considered in^[81]'s review. This included company income, company reputation, company cost, company size, client control, involvement of subcontractors, number of subcontractors, and number of employees or crew size. Organisational variables also included safety management, policy design, safety audit, safety culture, commitment, approach, and safety perception, the implementation strategy, safety compliance, information management, structure and responsibilities, stakeholders' management, resource management, and quality economics^[84]. This study's findings are consistent with the findings of^[83] and^[84], which confirm the importance of organisational structure, resources, and strategic management in promoting a safe construction environment.

This study highlights the importance of managerial influence, oversight, communication, training, and motivational strategies in shaping safety behaviours and outcomes in the construction industry. Hu et al.^[85] assert that it is critical for the organisation's top management team to show that they care about safety. When combined with supervisory support, a safety-supportive organisational environment will encourage people to value the role that safety rules and procedures play in their safety performance and, as a result, be more likely to comply with them. This study's findings complement^[85], who said that strong leadership commitment and supervisory support are critical in creating a safety-supportive atmosphere that fosters adherence to safety standards and improves safety performance.

This study's finding emphasises how important leadership style, relationship between leaders and followers, role modelling, risk management, and proactive supervision are, in fostering a culture of safety and encouraging safe practices in construction environments. Scholars have found that transactional leadership styles^[86], inclusive

leadership that promotes employees' taking-charge behaviour^[87], and^[88] blend of both transformational and transactional leadership styles are helpful in this respect. By demonstrating the beneficial effects of several leadership philosophies, such as transactional, transformational, and inclusive approaches, on promoting safety culture and improving BS management in construction environments, these findings validate and enhance previous research.

This study confirms that group norms, communication, team support, and localised safety climate significantly influence individual safety behaviour and collective commitment in construction teams. The results of this study are supported by^[89], who also noted that individual safety violations are strongly impacted by group safety norms, highlighting the crucial role that teams play in influencing BS in construction environments.

This study's identification of psychological capital and traits, motivation and engagement, knowledge, competence and skills, communication competence and social orientation, behaviour, cognitive and physical load, demography, and personal background, indicates the importance of personal attributes, cognitive capacity, and behavioural tendencies in BS performance. Meng et al.^[91] identified individual factors influencing construction workers' dangerous behaviours as psychological factors, personality characteristics, subjective attitude consciousness, risk perception, and language and cultural obstacles. Khosravi et al.'s^[36] and^[90] studies also found society, organisational, work group, site condition, individual factors, contractor, supervision, and project management factors as influencers of unsafe behaviours on construction sites. This study adds depth by thoroughly classifying individual-level safety factors and supports previous research by^[63],^[36], and^[90], highlighting the complex impact of personal psychological and behavioural factors on construction safety.

5. Study Implications

The integrated framework illustrates that behavioural safety in construction is influenced by

interrelated external, organisational, managerial, leadership, team, and individual elements, emphasising the need for a systems-orientated rather than a worker-focused approach. This theoretically frames behavioural safety as a resultant consequence of multilevel interactions, enhancing previous models by including organisational environments, leadership impacts, and contextual factors. It connects global knowledge with local realities, providing a transferable but context-specific framework for enhancing safety research and practice.

From a policy perspective, enhancing regulatory frameworks is essential for compliance with international standards such as ISO 14001:2015, ISO 45001:2018, and ILO Convention No. 155 on Occupational Safety and Health. Integrating principles from the U.S. Occupational Safety and Health Administration (OSHA), specifically 29 CFR Part 1926 concerning construction safety, improves compliance and accountability, while adherence to the World Health Organisation's (WHO) Global Plan of Action on Workers' Health fosters comprehensive worker well-being. Policymakers may expedite the adoption of behavioural safety (BS) by providing incentives like tax savings and insurance discounts while instituting comprehensive BS rules to promote safer and more sustainable building practices.

In practice, leadership commitment is vital to building a safety-first culture. Senior management must exhibit tangible commitment to safety via participative measures that enhance worker involvement. Ongoing training and professional development are essential, while digital advancements like BIM, IoT, AI, and VR provide innovative methods for hazard prediction, risk management, and immersive safety instruction. At the organisational level, complete safety management systems—encompassing policy, audits, cultural evaluations, and resource distributions—guarantee sufficient assistance.

Ultimately, considering individual psychological characteristics, risk perceptions, and social norms facilitates customised responses. These measures together reduce accidents, strengthen positive safety

cultures, and enhance sustainability in construction.

6. Conclusion

This analysis examined the deficiency of integrated frameworks for enhancing BS throughout the construction sector. Employing the PRISMA technique, 41 pieces of research were synthesised, uncovering essential determinants of BS across external, organisational, management, leadership, team, and person dimensions. An integrated approach was presented to inform both policy and practice based on these observations. The framework emphasises the significance of enhancing regulations, providing economic incentives, adopting technology, ensuring leadership commitment, implementing organisational safety measures, and facilitating good communication. Implementing these techniques may assist construction companies and policymakers in decreasing accident rates, enhancing behavioural safety standards, and fostering sustainable industry performance.

6.1 Limitations and future research

Several limitations must be acknowledged. The review was restricted to journal publications, excluding theses, conference papers, and other grey literature that may offer additional insights. Exclusion of non-English studies and reliance on published data also raise the risk of publication bias. Moreover, the findings are context-dependent, limiting their generalisability across diverse national and industrial settings. The proposed framework is untested in practice, and its robustness across organisational, leadership, team, and individual levels has yet to be empirically validated.

Future research should broaden geographical coverage by including under-represented regions and employ qualitative or mixed-methods approaches to generate more profound insights into behavioural safety processes. Extending the framework to other high-risk sectors such as mining, manufacturing, and healthcare could reveal transferable strategies. Crucially, implementing and evaluating the

framework in real projects will be essential to confirm its effectiveness and refine its applicability.

Author Contributions

KBS was in charge of article selection and inclusion, as well as reviewing and analysing the included papers. He also led the conceptualisation and draughting of the text. NAK participated in the article selection process, read the manuscript, and provided general supervision throughout the project. All writers endorsed the final version and are responsible for the integrity of the work.

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Data availability

The data utilised in this study are peer-reviewed publications which were included in the systematic review. All mentioned sources are publicly available and have been properly cited within the paper.

Declaration of interest

The authors declare no competing interest.

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