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Review

Barriers, Bottlenecks, and Challenges in Implementing Safety I- and Safety II-Enabled Safe Systems of Working in Construction Projects: A Scoping Review

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Abstract: The construction industry has endured high incident rates for many decades. Although multiple safety measures in the form of Safety I- and II-enabled safe systems of working (SSoWs) have been implemented, statistics reveal that a significant prevalence of incidents prevails worldwide. However, there is limited information available about the actual factors that are impeding these SSoWs. This study investigates and evaluates the barriers, bottlenecks and challenges (BB&Cs) that hinder the implementation of Safety I- and II-enabled SSoWs in the construction industry. Using a scoping review methodology, a thorough search of articles documenting the BB&Cs of implementing Safety I- and II-enabled SSoWs was carried out using Google Scholar, Scopus, and Web of Science databases. An initiative model was employed for categorising BB&C to implement Safety I and II, which includes micro- (site), meso- (organisation), and macro (environment)-thematic groupings, as a guiding framework for the mapping and analysis of results. The search yielded 98 articles that discussed the implementation of Safety I and II, with 54 of them specifically related to BB&Cs. Emergent results emphasised how there is scant literature on the BB&Cs of implementation Safety I- and II-enabled SSoWs across site, organisation and environment levels. Extensive global research is necessary to comprehensively understand the obstacles to implementing Safety I and II in practice as a first step towards reducing incidents and accidents on site. Cumulatively, the findings suggest that implementing Safety I- and II-enabled SSoWs should be based on removing BB&Cs and evaluating how they affect safety performance.

Keywords: Safety I; Safety II; safety plan; safety system; barriers

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1. Introduction

Construction activities are integral to a nation's economic health and comprise diverse, inextricably linked and embedded sectors (including the mining, manufacturing and transportation sectors) that are engaged in the creation of infrastructure, buildings, and other physical assets [1]. Furthermore, the government actively engages with this sector as a crucial partner in the construction and maintenance of critical infrastructure projects, such as transportation routes, utility services, and energy networks [2]. However, the sector is simultaneously confronted by omnipresent and substantial health, safety, and welfare risks due to the inherent nature of the work tasks involved. Hinze et al. [3] report that globally, this sector's mortality rate is elevated in comparison to other industries. The construction industry in the United Kingdom (UK) has the greatest fatality rate compared to all other industries [4]. Moreover, the UK has experienced a troubling rise in the number of fatal injuries (increasing from 37 to 45 over five years from 2018/19 to 2022/23 (ibid)). Prioritising safety awareness amongst project personnel is crucial to enhancing their safety awareness and educating them about potential workplace hazards that may result in injuries, illnesses, and fatalities [5].

To augment health and safety, it is crucial to formulate and implement more effective safety strategies [6,7]. In this vein, safety management is often categorised into two distinct paradigms, i.e., Safety I and Safety II [8]. Safety I and II are two perspectives that aim to improve safety management, although they approach it from different perspectives [9]. Safety I is grounded in analysing 'risk' based on failures and past events and has been supplemented by Safety II in recent years [10]. Risk assessments in Safety I seek to determine the likelihood of negative outcomes, which is crucial for planning and managing safety-related risks in construction projects [11]. Safety II emphasises gaining an understanding of successful outcomes and the origins of safety and risk in routine work [12]. Safety II is required to address the growing complexity of socio-technical systems and a lack of improvement in accident rates in specific industries, which hinders the ability to learn from unwanted incidents [13,14]. Safety II, therefore, adopts a more proactive stance, recognising that safety is not merely the absence of accidents but the presence of successful performance [15]. This approach emphasises a deeper understanding of how things go right in everyday operations, learning from successful outcomes (ibid). Combining Safety I and II approaches in a comprehensive safety management system could engender significant benefits for construction organisations, such as accident prevention [12] and the ability to effectively manage unexpected incidents [10]. Moreover, this integration has the latent potential to improve safety performance [15], promote increased worker engagement [16] and produce superior project outcomes [17]. Nevertheless, the actual execution of Safety I- and II-enabled safety systems of working (SSoWs), along with their integrated methodology, is complex and may face various barriers, bottlenecks and challenges (BB&Cs). Hence, it is crucial to determine the role of BB&Cs in implementing Safety I and II strategies and comprehend how the construction sector effectively addresses these challenges. The primary research question for this present study is the following: "What are the significant BB&Cs of implementing Safety I- and II-enabled SSoWs, and how can they be categorised"?

Within the field of construction safety, the terms 'barriers', 'bottlenecks' and 'challenges' are sometimes employed interchangeably [18], thereby obfuscating the crucial differences among them. Nevertheless, each of these concepts has a unique meaning in construction safety and comprehending their disparities is essential for formulating efficient safety strategies. Barriers (whether tangible or intangible) hinder the attainment of a secure working environment [19]. They can range from a deficiency in personal protective equipment (PPE) to a flawed scaffolding structure. Intangible barriers, such as insufficient training or ineffective communication among team members, can also exist. They can be perceived as obstacles that hinder workers from carrying out their tasks safely and effectively. Conversely, a bottleneck refers to a specific point in a process where there is a delay or constraint that obstructs the smooth flow of work or resources [18,20]. A bottleneck can arise due to a shortage of skilled staff or insufficient equipment, resulting in delays in project completion and heightened levels of risk [21]. Identifying bottlenecks necessitates a perceptive attention to detail and a profound comprehension of the project's dynamics. Therefore, to prevent bottlenecks in the project, the flow of information and resources must be mapped to pinpoint specific areas where delays, inefficiencies, or safety problems are likely to occur. However, a challenge encapsulates a more extensive problem (e.g., the workers' unfamiliarity with emerging safety technologies) that necessitates a proactive strategy to overcome it [22,23]. Instead of merely responding to emerging issues, safety managers must adopt a proactive approach by identifying and mitigating potential challenges before they manifest into significant problems [24]. This entails cultivating a culture of transparent communication, wherein employees are encouraged to voice their opinions regarding potential risks and apprehensions [15]. Additionally, it necessitates a dedication to continuous training and education, guaranteeing that every team member has the expertise and understanding essential to negotiate intricate safety situations [25].

In the construction industry, safety implementation faces various BB&Cs at different levels, each contributing to persistent challenges to ensure worker safety. At the micro-level, specific BB&Cs include inadequate safety training and a lack of PPE for workers. These deficiencies directly impact safety practices on construction sites, leading to unsafe acts that are identified as a primary cause of accidents. Unsafe acts, such as neglecting safety protocols or the improper use of equipment, represent significant micro-level challenges that hinder effective safety implementation [26]. Furthermore, the absence of a robust safety climate at the site level can exacerbate these issues, as workers may not feel empowered to prioritise safety without proper support and resources [27]. Moving to the meso-level, organisational BB&Cs play a crucial role in safety management. Poor communication between management and workers can lead to misunderstandings regarding safety protocols, while insufficient safety protocols themselves can create an environment where safety is not prioritised. This lack of effective communication and clear safety procedures can hinder the overall safety culture within construction organisations [28]. Additionally, safety training is a critical meso-level barrier; without comprehensive training programmes, workers may lack the necessary knowledge and skills to perform their tasks safely, further contributing to the risk of accidents [29]. At the macro-level, environmental BB&Cs, such as regulatory challenges and a lack of enforcement of safety laws, significantly affect the construction industry's safety culture. These macro-level issues create a landscape where safety regulations may exist on paper but are not effectively implemented on the ground, leading to what is often referred to as the "last mile" problem. This gap between established safety regulations and their actual implementation results in ongoing safety issues across construction sites [15]. The interplay of micro-, meso-, and macro-level BB&Cs creates a complex environment for safety implementation in construction management.

Premised upon the aforementioned contextual background, this paper examines how BB&Cs impact the use of Safety I and II strategies in the construction industry. where the latter is characterised by complex socio-technical systems [30] involving multiple stakeholders, sub-systems, regulations and procurement methods [31]. A comprehensive literature review is conducted, and the BB&Cs of implementing Safety I- and II-enabled SSoWs are identified. A secondary aim is to categorise the identified BB&Cs into three distinct innovative clusters: micro- (site), meso- (organisation), and macro-clusters (environment). An associated broad objective is to recommend effective strategies that improve the implementation of Safety I- and II-enabled SSoWs in the construction industry. This research contributes to the development of a pragmatic roadmap for identifying, managing, and eliminating the significant BB&Cs to implementing Safety I- and II-enabled SSoWs.

Although Safety I and II are known by some safety experts in the construction industry, discussion on the necessity for combining these principles is necessary. Hence, a brief review of their definitions and the necessity for identifying the BB&Cs that hinder the implementation of Safety I- and II-enabled SSoWs in the construction industry are presented in the current section. The research methodology is described in Section 2, and the findings are illustrated in Section 3. Moreover, the findings and research implications in light of this theory are discussed in Section 4, and finally, conclusions are provided in Section 5.

2. Research Methodology

Using an interpretative philosophical lens and inductive reasoning (cf. [32,33]), a scoping review study was conducted, following the guidance of Arksey and O'Malley [34]. Fink [35] characterises a scoping review as follows: "a systematic, explicit, and comprehensive process for identifying, evaluating, and synthesising the existing body of completed and recorded work produced by researchers, scholars and practitioners". Guidance from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) was also adopted to ensure a comprehensive review and analysis of the extant literature [36,37]. A scoping review protocol was developed based on Peters et al. [38] for the PRISMA-ScR Statement. The protocol included a systematic process for conducting the literature search, including document selection, summarising, and reporting results. Siame et al. [39] employed a similar approach to explore and map the factors influencing the implementation of safety interventions in the fishing industry, and similarly, Safarpour et al. [40] and Hayashi et al. [41] employed the scoping review approach developed by Arksey and O'Malley [34]. These past studies serve to justify the current approach adopted.

2.1. Study Design

A scoping review is a rigorous method that enables the identification, selection, and evaluation of all relevant research in the literature of a certain agreed-upon quality level pertaining to a research question [42]. To conduct this review, an iterative procedure was employed by Zhou et al. [43] and Siame et al. [39], which included aspects relating to data sources and search strategies, screening and selection, data extraction and synthesis and analysis (refer to Figure 1). Indeed, the process of conducting this study involves several steps that ensure a comprehensive and organised approach to the evaluation and categorisation of the literature. Initially, the purpose of the search is defined, which sets the objectives and scope of the literature review. Following this, a search strategy is developed, which outlines a defined plan for searching literature databases to identify pertinent studies. Once the search strategy is in place, the next step is literature selection, which involves applying specific inclusion and exclusion criteria to determine which studies will be retained for the review. The process of pre-selecting publications is the step in which initial filtering occurs to screen studies for relevance before the final selection. After pre-selection, the final selection of studies is made. This definitive choice is based on a thorough evaluation of the pre-selected studies, ensuring that only the most relevant and high-quality papers are included in the review. Subsequently, the classification of publications takes place, where the selected studies are organised into categories based on themes, the type of study and focus area in chronological order. This classification aids in structuring the review and facilitates the easier analysis of the findings. The final step in this process is the analysis of the findings, which involves synthesising and interpreting the data extracted from the selected studies to draw meaningful conclusions. The analysis not only highlights key insights but also identifies gaps in the literature, which can inform future research directions.

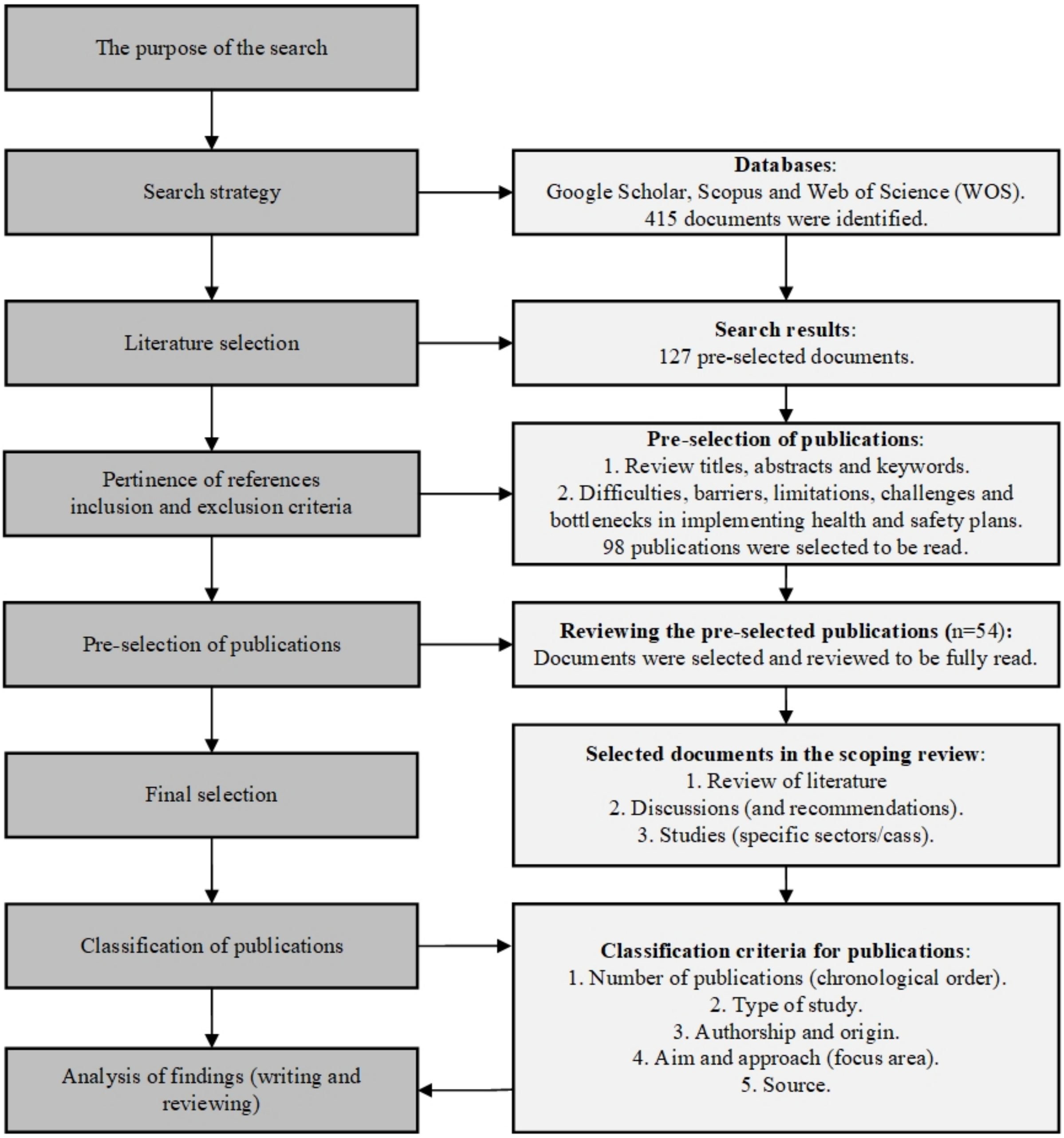

Figure 1. PRISMA diagram describing the flow of decisions when reviewing the literature and categorising its contents [44].

2.2. Literature Search

The time period studied spanned from early 2000 to April 2024 to capture the latest trends in the scientific community. This period was selected for this scoping review due to the interplay of advancements, regulatory changes, cultural shifts, and the evolving understanding of safety frameworks, all of which contribute to the current landscape of safety challenges in the industry. This period has witnessed significant advancements in construction safety practices, making it essential to analyse the evolution of these practices to understand the current BB&Cs. Moreover, the timeframe encompasses various regulatory changes that have directly impacted safety practices within the construction industry. Additionally, the integration of new technologies during this period has transformed safety practices, providing insights into both the advancements made and the challenges that have emerged because of these technological changes. The concepts of Safety I and Safety II are particularly relevant in this context. Indeed, the development of new safety management frameworks based on Safety II and resistance principles during this period were developed and widespread.

The bibliographic search was limited to scientific publications from any country published in English. The inquiry was conducted on three global bibliographic databases, namely, Google Scholar, Scopus and Web of Science (WoS). A comprehensive search was conducted using unrestricted language queries and a full-text search. Keywords were adapted depending on the search type and the web tool utilised in each case. Through Google Scholar searches, various relevant papers were initially examined to determine appropriate keywords. To improve the accuracy of the search, the identified keywords were compared with the keyword Plus terms of highly cited relevant papers in the WoS database [45]. Keyword Plus terms, formed from the titles of cited references, are generally more comprehensive and can encompass a broader range of scientific concepts compared to author keywords, which are typically more specialised and targeted [46]. This broader scope can enhance the comprehensiveness of a literature review by ensuring that relevant but less obvious articles are included. Additionally, it can further refine the search strategy, ensuring that the selected terms are both relevant and comprehensive, thus improving the accuracy and relevance of the extracted literature [47]. User-centred features like keyword comparisons can improve search performance and user satisfaction by helping researchers identify the most relevant articles more efficiently [48]. Finally, personalised search methods that consider the influence and trustworthiness of authors can yield more useful and diverse results, further enriching the literature review [49]. A comprehensive search was conducted in the 'title/abstract/keywords' sections of the referenced databases. During this initial investigation, a total of 24 distinct combinations of keywords were employed across the four databases. The keywords used were 'Safety I', 'Safety II', 'safety plan', 'safe system' and 'health and safety'. This combination of keywords was also replicated by utilising three synonyms for the term 'obstacle', namely 'barriers', 'bottlenecks' and 'challenges'. During the analysis period, a total of 415 publications were identified in the databases and were included in the search strategy. This included 86 publications from WoS, 226 from Scopus, and 103 from Google Scholar.

2.3. Literature Selection

It was unavoidable that replicated publications would emerge due to the potential indexing of the same document in various databases. After eliminating duplicate entries, a total of 127 unique results were obtained. Among these, 93 were categorised as articles, 23 were classified as conference papers and 11 as textbooks. The initial criterion for determining the relevance of these publications involved analysing the title, abstract and keywords to filter out publications that specifically addressed the difficulties, barriers, limitations and challenges that construction companies encounter when implementing safety measures in SSoWs. Furthermore, the 'snowballing' method was utilised to scrutinise the reference lists of eligible documents for any possible novel sources that could be pertinent to the study aims [50] and were not discovered during the initial database search. Nevertheless, the snowballing strategy did not yield any additional articles. After implementing the filtering procedure based on the specified criteria, a total of 98 publications were obtained and then downloaded for review. The complete texts of these particularly significant articles were read to determine the relevance of the documents to the study's aims and objectives. As a second criterion during the final reading, the study types mentioned by Cagno et al. [51] were deemed relevant if they incorporated literature reviews, research articles, discussions, proposals, case studies, or applications in a specific sector that were related to the phenomenon under investigation. Moreover, this study has no geographical focus. Adopting this approach for this study allowed for a broader understanding of safety practices across various contexts. This enhances the generalisability of the findings, making them applicable to a wider range of situations within the construction industry. By including diverse perspectives from different regions, the analysis of safety systems will be enriched, leading to more nuanced insights into effective practices. Moreover, the lack of geographical constraints resulted in an increased sample size, which is crucial for robust data analysis. A larger sample size provides more reliable conclusions, as it reflects a wider array of experiences and practices. Additionally, exploring safety practices without geographical limitations fosters cross-cultural insights. Such insights can inform better safety management strategies by integrating successful practices from different cultural backgrounds. After conducting a thorough examination, a total of forty-eight articles and six conference papers were chosen to review and identify BB&Cs for the implementation of Safety I- and II-enabled SSoWs.

3. Findings

3.1. Safety I: Traditional Safety Approaches in Construction

Organisations can enhance workplace safety and reduce the probability of accidents or incidents by uniformly implementing established rules and practices that apply to all stakeholders [8]. To facilitate risk assessments, the establishment of a clearly defined framework enables safety professionals to execute control measures and interventions, hence reducing potential dangers [52]. Safety professionals and workplace supervisors must oversee and enforce processes to guarantee that workers comply with safety rules [13]. Safety I is primarily concerned with implementing regulations and conducting inspections to guarantee proper adherence and prevent any occurrences of accidents or incidents [8]. Safety I is typified by a reactive approach to events that have already occurred, with a primary focus on investigating accidents and incidents after they have happened [53]. Such a response to occurrences can lead to the development of a culture that is primarily focused on punishment and assigning blame for incidents rather than seeking a deeper understanding of the underlying causes [54]. Another essential attribute of Safety I is its reliance on rules and norms [55]. Organisations adhering to the Safety I approach prioritise the establishment and implementation of regulations and protocols to ensure compliance with rules and limit potential hazards [12]. Although this approach may be successful in mitigating recognised dangers, it tends to be less efficacious in addressing unforeseen risks and dynamic circumstances [56].

Under Safety I, the main duty for ensuring safety is assigned to management and safety specialists [12]. Workers are required to adhere to the regulations established by others and benefit from safety precautions [57]. Employing a top-down methodology may result in BB&Cs concerning employee involvement and a deficiency in the sense of personal accountability for safety measures. Although Safety I has effectively decreased industrial physical injuries and fatalities, it is insufficient in wholly addressing the intricate and dynamic nature of construction work projects [7]. Construction work is distinguished by significant numbers of stakeholders, fluctuating conditions, and evolving hazards [52]. Overreliance on inflexible methods and regulations often hinders an organisation's (or the employees') ability to adapt to shifting demands and developing circumstances [58]. To address these limits, companies are increasingly adopting alternative approaches that prioritise resilience, learning and adaptation [8]. Safety I generally prioritises a reactive approach rather than a proactive approach, and it places greater emphasis on identifying underlying causes rather than considering the impact of human and organisational factors on safety performance [59–61]. Additionally, it prioritises 'accident and mistake avoidance' rather than deriving insights from near-misses and minor failures [62].

3.2. Safety II: The New Paradigm in Construction Safety

Safety II enables organisations to promote learning, collaboration, and flexibility by identifying the factors that contribute to success. Indeed, Safety II emphasises understanding and promoting successful practice. Moreover, the protocols and regulations established by management may not precisely correspond to the actual practices being carried out [63]. Hence, Safety II emphasises the recognition and incorporation of diversity and the importance of flexibility and adaptability of work practices into safety management strategies inside businesses [64]. It acknowledges that strict and precise safety regulations may not always effectively handle urgent and evolving issues [10]. Moreover, it highlights the importance of employing adaptable systems and methods that can accommodate unforeseen circumstances and unexpected occurrences [12]. Worker participation and engagement are key aspects of Safety II (cf. [64]) because workers are not merely passive beneficiaries of safety legislation and processes but rather active agents in shaping safety results [65]. Safety II acknowledges the significance of organisational cultures in relation to safety performance [66]. It highlights the value of cultivating a strong safety culture through ongoing learning, open communication, and trust [67]. Nevertheless, it is important to acknowledge that Safety II is not without its constraints [68]. Implementing Safety II necessitates a substantial investment of time and cost, including an ample number of training sessions and forms of assistance to ensure that staff comprehend and employ this new strategy [57,69]. Another limitation pertains to the challenge of quantifying and evaluating Safety II practices [16]. Conventional safety metrics, such as accident frequency rates and near-miss reports, may not effectively capture and quantify the beneficial impact of Safety II on the overall safety performance [70]. Hence, it is imperative to identify alternative assessment techniques and criteria to accurately measure the efficacy of applying Safety II in a construction setting. By implementing Safety I and II paradigms, businesses in the construction sector can adopt a complete safety management plan that effectively addresses hazards and safeguards the well-being and lives of workers.

3.3. Barriers, Bottlenecks and Challenges of Implementation of Safety I- and II-Enabled SSoWs

The selected publications were utilised to identify and classify the BB&Cs faced in the implementation of Safety I- and II-enabled SSoWs. Table 1 reveals the identification of 55 BB&Cs, which have been categorised into three initiative groups as follows: (1) Micro (site)-BB&Cs—the lack of comprehension and awareness of Safety I And II concepts among construction professionals on site poses a notable obstacle. This encompasses a deficiency in understanding contemporary safety-enhancing technologies and a dearth of adequately trained personnel for safety initiatives [71–73]. Furthermore, the culture and behaviour within the construction industry play a crucial role in hindering safety performance improvement, e.g., a reluctance to embrace change, intense work demands, and a lack of education and experience among workers [74]; (2) Meso (organisation)-BB&Cs—the client's approach to duties might be inadequate, and designers may lack technical competence and interpersonal skills, which hampers the performance of crucial roles in safety management [73]. In addition, there is a deficiency in promoting and providing assistance for the implementation of safety initiatives such as a safe working cycle [71]. Although technology has the potential to enhance safety conditions, there is significant opposition to its consistent utilisation in the industry. This resistance arises from constraints in implementing technology and reluctance to adopt it [75]; (3) macro (environment)-BB&Cs—these BB&Cs are due to insufficient support from the industrial sector and inadequate governmental assistance in implementing innovative approaches and challenges in understanding the legal framework of safety protocols also add complexity to the adoption of Safety I And II [76,77]. Individual BB&Cs within these groupings are accompanied by key citations sourced from the final dataset to substantiate them in each cluster. It is notable that, to successfully implement SSoWs, the BB&Cs must be understood beyond mere severity rankings. The severity of each BB&C can vary significantly across different regions, which complicates the ability to generalise their impact on safety management practices. This variability suggests that a simplistic ranking of barriers based on severity does not adequately capture the complexities involved in safety management, particularly when considering the dual focus of Safety I and Safety II. Moreover, the multifaceted nature of safety issues in construction indicates that barriers perceived as less severe can still have profound implications for implementing SSoW outcomes. Therefore, this highlights the need for a more nuanced understanding of how various barriers interact and influence safety performance rather than relying solely on their severity as a metric. The concept of safety barriers encompasses a range of factors, including behavioural, management, awareness, and cultural barriers, which can all play a role in hindering effective safety measures. Understanding these barriers requires a comprehensive approach that considers not only their severity but also their context and the specific challenges they present in different environments. For example, poor governance and a lack of safety awareness are significant barriers to implementing SSoWs, which can vary in impact depending on the organisational culture and management commitment. Instead, a combination of leading indicators and safety climate measures can provide a more comprehensive view of safety performance, allowing for the better identification and management of critical barriers [27]. A holistic approach that considers the multifaceted nature of safety issues and the specific context of BB&Cs will lead to more effective safety strategies in the construction industry [15].

Table 1. Results from searching the four databases.

Group	Barriers, Bottlenecks, and Challenges	References	2000–2010	2010–2020	Post 2020
Micro (site)	Disorganised labour	[78]	✓		
	Lack of safety engineer/experts on site	[79,80]	✓		✓
	Lack of trained and skilled workers	[81–83]		✓	✓
	Lack of clearly stated occupational SSoWs by contractor	[84]			✓
	Environmental barriers on site (e.g., heavy wind blowing/underground conditions/limited space)	[81,85–87]	✓	✓	✓
	Neglecting safety based on their experiences	[88,89]		✓	
	Assigning more dangerous tasks based on racism and discrimination	[24,73,82,89]		✓	✓
	Lack of technical guidance in performing construction operations	[90]		✓	
	Lack of strictly defined operational procedures	[90]		✓	
	Low levels of awareness of workers about safety laws/standards	[80,81,83,91–94]	✓	✓	✓
	Safety communication barriers	[95,96]		✓	
	Tight project schedules	[97]		✓	
	Obstruction by subcontractors	[97–100]		✓	
	Lack of experience in dealing with emergencies	[73,101]			✓
	Poor safety culture	[97,102,103]		✓	✓
	Inadequate safety measures and materials on site	[84]			✓
	Cultural/language differences among workers	[80,83,104]		✓	✓
	Occupational stressors	[77,105]		✓	✓
	Lack of commitment, motivation, and accountability of workers to implement occupational SSoWs	[24,73,82,106–108]		✓	✓
	Non-conductive work climate (lack of collaboration among workers)	[53,81,102]		✓	✓

Table 1. *Cont.*

Group	Barriers, Bottlenecks, and Challenges	References	2000–2010	2010–2020	Post 2020
Meso (organisation)	Weak implementation of occupational SSoWs	[53,71,97,109–112]	✓	✓	✓
	Increased use of subcontractors	[80]			✓
	High professional fees for safety	[79,81,101]	✓		✓
	Poor accident record keeping and reporting system	[78]	✓		
	Allocating a fixed and special budget for occupational safety	[111]			✓
	The low priority given to safety due to cultural differences in organisations	[78]	✓		
	Inappropriate organisational structure	[53,113]			✓
	Inadequate formal safety training before and during projects	[73,80,81,95,114–120]	✓	✓	✓
	Coordinating issues (lack of regular safety meetings within the project)	[118,121]		✓	✓
	Inefficient safety regulatory committees	[120,122]		✓	✓
	Lack of continuous monitoring and follow-up	[24]		✓	
	Low attention to the contractor's work safety record in awarding the tender	[78,82,120,123]	✓	✓	
	Lack of an integrated team	[124]		✓	
	Poor safety awareness among the firm's leadership	[90]		✓	
	Lack of technological innovation or use to improve safety	[90,122]		✓	✓
	Management culture error	[96,122,125]		✓	✓
	Privacy and data security concerns	[103]			✓
	Lack of standardisation and resistance to change	[81]			✓
	Lack of genuine organisational commitment	[103]			✓
	Problems of poor worker welfare	[83]		✓	
Macro (environment)	Lack of/imperfect safety laws, regulations, and instructions	[93,126]		✓	
	The small size of most construction firms	[78]	✓		
	Lack of support from the government/unsure of government commitment	[81,82,102,127]		✓	✓
	Lack of safety commitment from clients	[82]		✓	
	Lack of H&S legislation in specifying client roles	[92]		✓	
	Improper stereotypes/unsupportive industry norms	[53,104]		✓	✓
	Funding and logistical constraints in safety enforcement institutions	[94,102]		✓	✓
	Contradictory and unclear SSoWs	[78,92,128–130]	✓	✓	✓
	Inadequate instances of sanctions and prosecutions for safety breaches	[94]			✓
	Lack of innovative safety enforcement strategies by enforcement institutions	[94]			✓
	Poor statistics on occupational accidents and diseases	[94]			✓
	Technological limitations	[103]			✓
	Poor safety culture within the construction industry	[103,113]			✓
	Non-inclusion of a third party (public) in SSoW procedures	[78,90,119,131]	✓	✓	✓
	Low attempts to update SSoWs	[120]		✓	

3.4. Chronological Discussion

3.4.1. The New Millennium (2000s)

An omnipresent and significantly high number of accidents and deaths in this sector suggests a disconnect between regulatory frameworks and their actual implementation on construction sites [132]. For instance, despite a booming construction sector in Sri Lanka, 2019 saw 40 fatal and 59 non-fatal accidents, largely due to the lack of an institutional mechanism for safety management and outdated legislation [133]. In the United States, the construction industry accounted for 20.5% of work fatalities in the private sector in 2014, highlighting the inefficacy of safety plans [134]. In Europe, despite increasingly strict laws, the number of construction accidents has not decreased significantly, highlighting the inefficacy of current regulations [135].

Implementing SSoWs encounters numerous BB&C issues, which can vary significantly between sites due to various factors (e.g., historical, economical, psychological, technical, procedural, organisational and environmental issues) [136]. Among these factors, the organisational factor has a significant impact on safety performance (ibid). Small construction firms that operate as subcontractors in the construction industry face obstacles in influencing safety decisions because of their position in the inter-organisational hierarchy, even though they are directly exposed to occupational health and safety (OHS) risks [98]. The recruitment of workers in small construction companies for safety programmes is impeded by high worker turnover, economic pressures, and time constraints, resulting in low participation rates [99]. The evolving role of clients in construction safety, shifting from traditional risk transfer methods to proactive involvement, highlights the importance of pre-planning and the safety records of contractors [137]. Cheng et al. [138] proffer that it is necessary to consider the bespoke variations specific to each site when implementing construction safety plans. Subcontractors often depend on occupational health and safety specialists for compliance without truly comprehending or actively participating in the process [100].

The literacy levels of construction workers also present difficulty in creating well-documented SSoWs. Indeed, these SSoWs can be hindered by several factors, including a low level of safety knowledge among workers, a lack of attention to safety, inadequate training, worker fatigue and the use of poor-quality materials [138]. A critical BB&C is insufficient safety knowledge among designers, along with a limited comprehension of construction procedures, which, when combined, hinders the incorporation of safety considerations during the design stage [79]. Engineering and construction professionals encounter challenges such as insufficient safety expertise and a limited understanding of construction processes when they try to enhance the involvement of designers in construction safety (ibid). Indeed, Aksorn Hadikusumo [139] states that inadequate supervision can result in the failure of safety plans.

According to Mahalingam and Levitt [140], differences in cultural perceptions of safety among project participants from different countries can engender conflicts and delays in international construction projects. In addition, the increasing expenses associated with labour and materials may force individuals with a vested interest to engage in risky behaviour and compromise safety measures, which could ultimately result in catastrophic events [141]. Choudhry et al. [142] believe that the intricacy of implementing efficient SSoWs across various sites is among the most critical BB&C. Therefore, implementing SSoWs encompasses integrating safety as a core principle, providing training and addressing concerns related to productivity [142].

3.4.2. 2010–2020

The primary factors that contribute to the implementation of SSoWs are the inherently high-risk nature of the work [91]; a lack of awareness regarding potential risks [92]; insufficient safety measures [84]; the complexity of subcontractor management [97]; and limited space on site [87]—all of which result in frequent accidents [91]. Sherratt [143] outlines several key factors that must be addressed to implement effective construction safety plans. These include addressing inconsistent safety constructions; managing varying discourses; resolving conflicts between safety engagement and enforcement; and fostering a cohesive safety culture across different sites (ibid). The primary factors contributing to the implementation of SSoWs are insufficient commitment from management, errors in judgement and lack of employee involvement [144]. Safety awareness levels (and concomitant policies) may vary across different sites [145] due to discrepancies between decisions made in the boardroom and actual practices on site, as well as obstacles related to human factors [146]. Overcoming these challenges requires enhanced leadership abilities and a deep comprehension of safety education [147]. In addition, Debnath et al. [148] argue that when implementing SSoWs, various challenges may present themselves, including the need to consider costs, the lack of evidence regarding the effectiveness of safety measures, and the pressure to minimise public disruption. These challenges may vary across different construction sites due to competitive tendering; hence, contractors may fail to adequately prioritise insurance premiums, safety training, the hiring of physicians and investments in PPE [19]. According to Ulubeyli et al. [106], the implementation of SSoWs is hindered across sites, particularly in emerging economies, due to the lack of importance workers place on training and their unwillingness to use PPE. Vitharana et al. [149] proffer that variations in safety practices between developed and developing countries pose a significant obstacle to the implementation of SSoWs. Therefore, it is essential to standardise safety practices. Wong et al. [150] state that the main BB&C to implementing good occupational health and safety practices in small construction firms are cost, time constraints, and a lack of safety awareness. These factors hinder the implementation of SSoWs across different construction sites. Hubner [151] believes that human attitudes toward finding safety training "boring", "irrelevant", and "already know it all" are frequently observed among BB&Cs. These attitudes have a negative impact on safety practices and the values of the organisation. Zoufa and Ochieng [152] discuss the impact of migrant worker influx and industry fragmentation on safety in the construction sector. The implementation of SSoWs is influenced by various hazards, such as dust, heavy loads, and adverse weather, which may differ from one site to another [153]. Nnedinma [154] posited that self-regulation and adherence to safety protocols are crucial components of any construction safety plan. However, it is important to note that the commitment level to safety and high work pressure can potentially impact the effectiveness of these safety plans. McCabe et al. [155] identified how longitudinal studies have demonstrated that safety performance has improved over time. However, a strong correlation between interpersonal conflicts at work and safety outcomes exists, suggesting that there is an ongoing challenge in establishing a consistent safety culture (ibid). A lack of adequate safety education in tertiary institutions in developing nations exacerbates the inadequate implementation of safety protocols among construction companies by constraining students' ability to effectively oversee safety measures in the workplace [156]. Moreover, Maund et al. [157] identified several key factors that influence SSoWs, including normative case factors, perceptions of safety duties, policy operationalisation, organisational position, professional beliefs, and specialist knowledge. Challenges in implementing SSoWs include asynchronous knowledge sharing, subcontracting issues, and inadequate communication between teams. Oswald et al. [96] asserted that there are variations in the application of practices to conform to regulations across different sites, primarily due to the communication of BB&Cs on international and multinational construction projects. These variations give rise to tensions and injustices, as well as communication breakdowns, which can be attributed to differing safety expectations and the impracticality of relying on informal translators.

3.4.3. Post 2020

After 2020, implementing SSoWs encountered other major challenges caused by factors such as regulatory environments, levels of technological adoption, and organisational cultures [122]. An absence of clearly defined contractual safety obligations is a significant obstacle to implementing SSoWs (ibid). Famakin et al. [74] found that the implementation of SSoWs is hindered by the insufficient enforcement of regulations, limited resources, and differing site conditions. Liu [158] asserted that BB&Cs incorporate resilience, digital safety, data utilisation, and intelligence integration, with variations in how these are implemented. The utilisation of technology as a proactive measure to enhance safety performance brings about certain challenges, such as the reluctance to consistently use it and obstacles to adopting technology, despite its capacity to improve safety conditions [76].

Moreover, industries such as construction have adopted novel safety protocols to address the challenges caused by the COVID-19 pandemic [159]. These measures have brought about challenges in ensuring compliance, as well as addressing issues of ignorance and superstition among workers [160]. Consequently, the implementation of effective safety protocols has become more complex [161]. According to Andersen and Grytnes [162], there is variation in how individuals and groups perceive risk and safety, which, in turn, affects their willingness to cooperate on safety matters. It is essential to comprehend these distinctions to effectively address and implement SSoWs for BB&Cs. Vigneshkumar and Saravanamuthu [163] stated that the primary BB&Cs when implementing SSoWs are on-site health and safety, economic costs, legal liabilities, the availability of manpower and instability in the supply chain. These factors may differ depending on the size of the contractor and sector they are employed in (e.g., utilities or civil engineering) [164].

The United States (US) construction industry recognises the engineer's vital role in ensuring worker safety. However, a significant number of construction labour fatalities are attributed to equipment and contact collisions, highlighting a deficiency in safety practises and design criteria [165]. In addition, the distinctive characteristics of the US construction industry (such as the use of scaffolding formwork and the emphasis on safety during excavation) give rise to specific safety management requirements (e.g., working at heights and material handling) [166]. In Hong Kong, the implementation of safety initiatives, such as the safe working cycle, encounters challenges related to tight project schedules, limited site space, and insufficient promotion and support [167].

The implementation of digital technologies in construction site safety management is hindered by challenges such as decreased productivity caused by wearable sensors, the requirement of technical training, and ongoing monitoring [168]. A reason for the low rate of acceptance of new technologies to reduce occupational safety and health (OSH) risks in developing countries such as Malaysia is due to the absence of OSH regulations and laws, limitations in technology, high costs, and weak safety culture in this sector [166]. The construction industry in these countries face challenges in implementing digital technologies for safety planning due to a shortage of in-house knowledge, training and awareness, high purchase costs and reluctance to embrace change [81].

The conservative nature of the construction industry also hinders the implementation and understanding of advanced digital technologies (such as the Internet of Things (IoT)) for enhancing safety. This is due to concerns regarding investment, technical assistance, and efficacy [169]. Moreover, in developing nations, this sector encounters a significant challenge in risk assessment due to a dearth of construction expertise among safety leaders, thereby impacting the accuracy and effectiveness of safety risk assessments [101]. Important issues identified are the client's overall approach to responsibilities, the fragmentation of the supply chain, and insurance issues [170]. These factors can impede the ability of roles such as the Principal Designer to effectively manage health and safety risks (ibid). In addition, the implementation of innovative technologies such as Unmanned Aerial Systems (UASs) in safety management has its advantages. However, it faces challenges in effectively promoting corrective actions due to the inflexibility of construction processes and the limited availability of resources [171]. Construction Safety and Phase Planning (CSPP) documents for airport construction projects faces challenges due to the scarcity of data on optimal procedures and the variations in global requirements [172]. Challenges faced in implementing safety programmes are due to the absence of a unified national governance framework in some developing countries. This underscores the significance of regulatory environments in either facilitating or impeding safety practices [113,173]. Therefore, the coverage of the existence of BB&Cs necessitates applying diverse approaches in order to implement the construction of SSoW plans, which differ significantly across various sites and regions due to variations in regulatory, technological, and cultural factors [25]. Figure 2 illustrates the BB&Cs of implementing Safety I- and II-enabled SSoWs between 2000 and 2024.

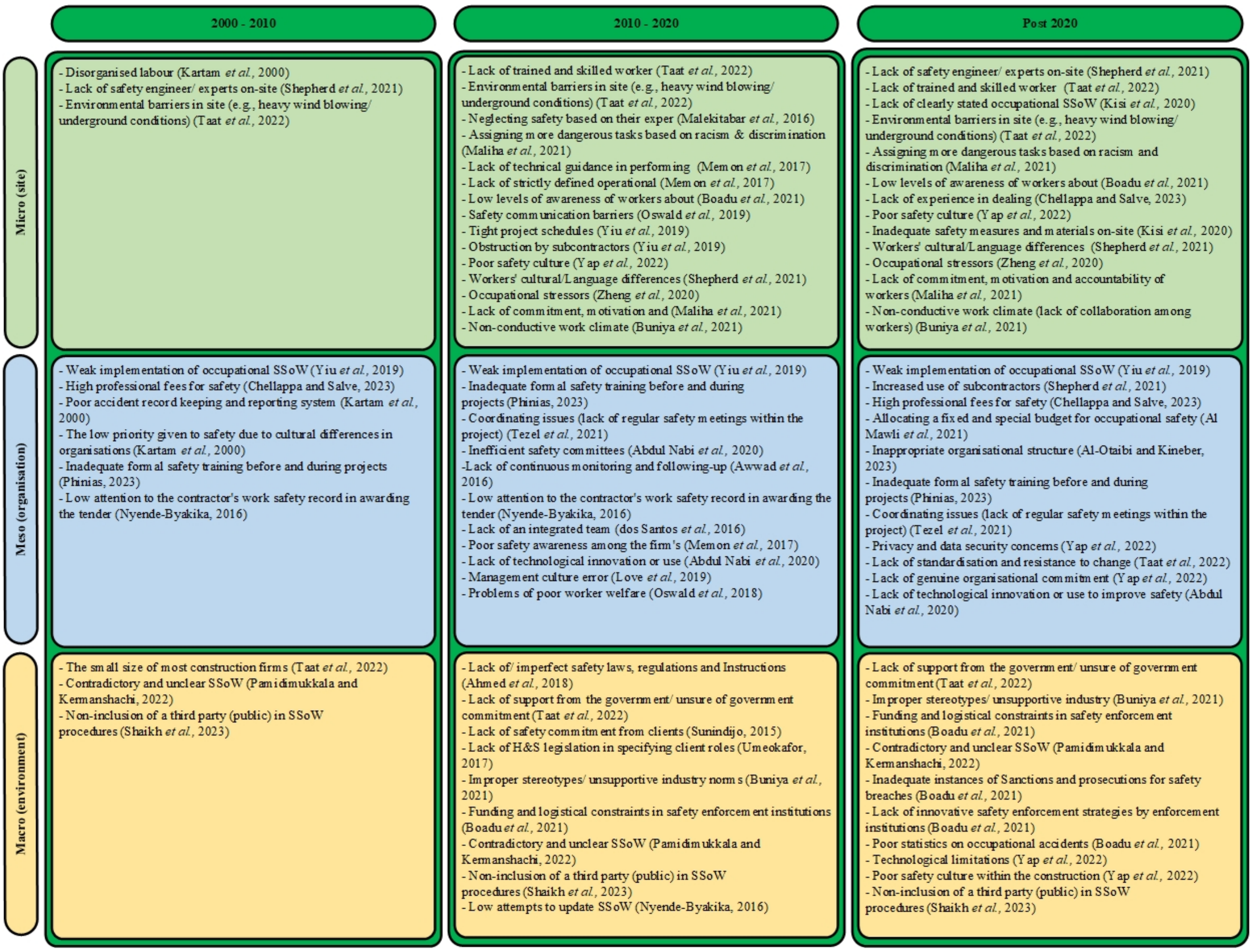

Figure 2. BB&Cs of implementing Safety I- and II-enabled SSoWs between 2000 and 2024 [24,53,73,78,80–84,88,90,92–94,97,101,103,105,111,113,117,120,122,124,125,130,131].

4. Discussion and Implications

Implementing Safety I And II in the construction industry has encountered numerous BB&Cs, primarily stemming from the industry's inherent risks and the complexity of construction projects—refer to Figure 3. The traditional nature of the construction industry poses challenges in adopting and integrating modern technologies, such as advanced Industry 4.0 innovations (e.g., IoT, concrete printing, augmented reality) [32,71]. In the context of Safety II, which focuses on improving resilience and adaptability in different circumstances, BB&Cs take a more nuanced approach. Obstacles to integrating new technologies for OSH risk mitigation include the absence of comprehensive national safety policies (notably in some developing countries) [129]; inadequate supervision [122]; the limited ability to prosecute companies that violate health and safety standards [94]; a lack of genuine organisational commitment to safety [103] and high costs [81]; and weak safety culture within the industry [103,113]. In addition, the efficacy of Safety II practices is impeded by technical BB&Cs to communication, such as the absence of internal proficiency and training in safety management technologies [169,174] and performance-related obstacles to communication arising from deficiencies in technical expertise and interpersonal skills [170]. The construction industry's inadequate safety record is further exacerbated by the BB&Cs to implementing health and safety programmes, such as resistance to change [81], expensive software purchases [101], and concerns about privacy and data security [103]. These factors collectively contribute to the sluggish adoption of new technologies aimed at reducing occupational safety and health risks, underscoring the necessity of a coordinated endeavour to tackle these obstacles and enhance safety outcomes in the sector.

To successfully adapt to change and use Safety I and II approaches, stakeholders must possess a comprehensive understanding of safety knowledge. The effective implementation of these SSoWs requires a balanced integration of both approaches. This can be achieved through several strategies such as "training and education" [29], "effective leadership" [175], "culture enrichment" [176], "technology and data utilisation" [177], "continuous improvement" [178] and "stakeholder engagement" [15].

4.1. Strategies for Facilitating the Implementation of Safety I- and II-Enabled SSoWs

The implementation of Safety I and II frameworks in the construction industry involves addressing various BB&Cs and adopting innovative strategies to create safer working environments. Overcoming these BB&Cs to safety implementation is a multifaceted challenge that requires addressing site, organisational, and environmental issues. Research across various contexts provides insights into effective strategies for overcoming these BB&Cs. One of the primary strategies for implementing these frameworks is enhancing communication and collaboration among stakeholders [179]. Effective communication is crucial for identifying potential hazards and sharing best practices, which aligns with the principles of Safety I. Additionally, fostering a culture of open communication supports the Safety II approach by encouraging workers to report near-misses and deviations from standard procedures, which can provide valuable insights into system resilience [28]. Open and transparent communication channels allow for the free flow of information regarding safety issues and solutions. Encouraging employees to report safety concerns without fear of retribution can lead to the early identification and mitigation of potential hazards [180]. This requires establishing a non-punitive reporting system that focuses on learning and improvement rather than blame.

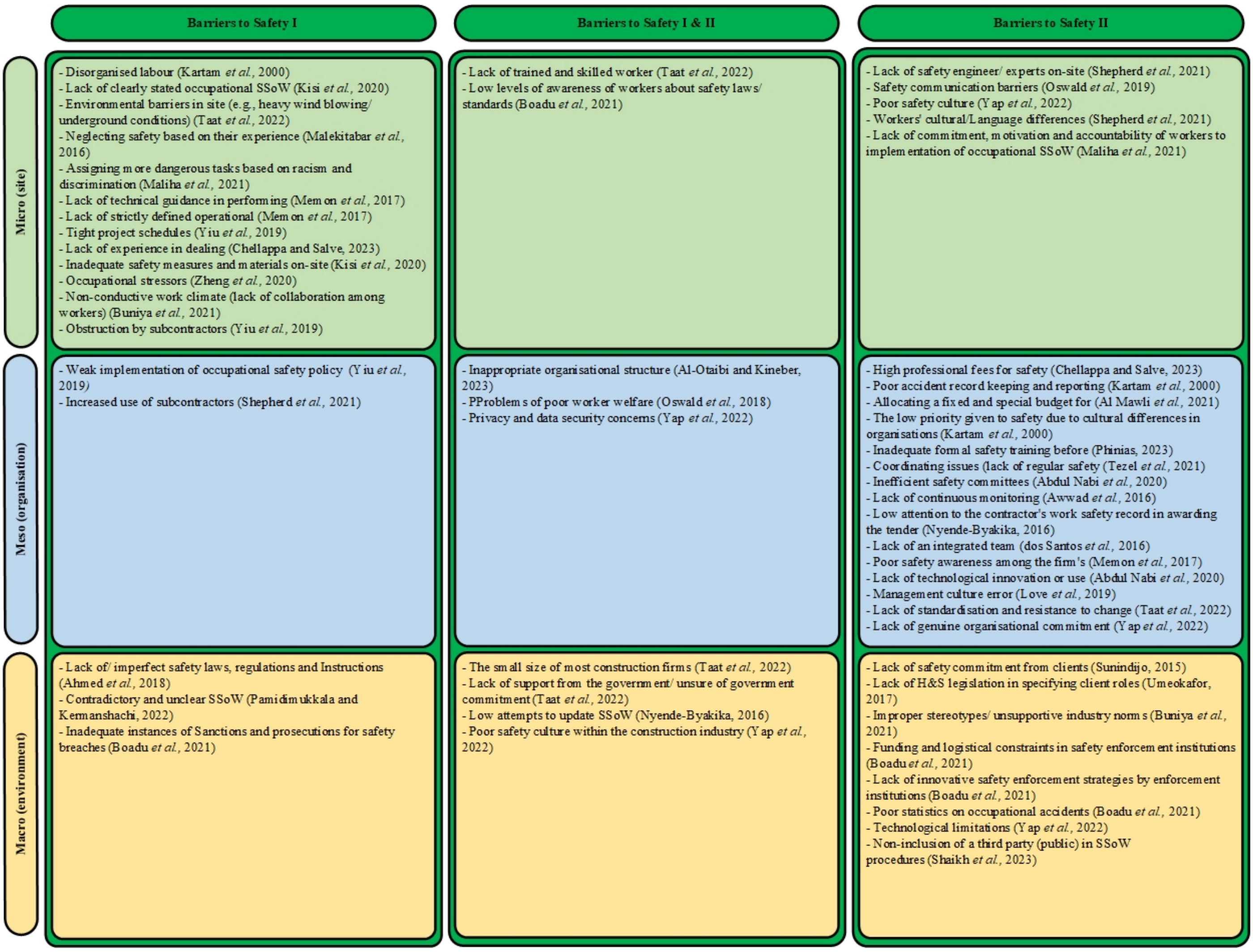

Figure 3. Classifications of BB&C based on Safety I and Safety II [24,53,73,78,80–84,88,90,92–94,97,101,103,105,111,113,117,120,122,124,125,130,131].

Organisations must allocate sufficient resources, including time, personnel, and financial investment, to support safety initiatives. This includes investing in safety equipment, technology, and infrastructure that can prevent accidents and enhance overall safety [181]. Additionally, integrating safety into the core business strategy ensures that it receives the necessary attention and resources. Training and education are also vital components because they equip workers with the core knowledge and skills needed to identify and mitigate risks proactively. Providing comprehensive safety training helps employees understand the importance of safety protocols and how to implement them effectively. This training should be continuous and adaptive to address emerging safety challenges and technologies [29]. Moreover, involving employees in safety planning and decision-making processes can enhance their commitment and adherence to safety measures because they feel a sense of ownership and responsibility [175]. This dual focus ensures that workers are not only aware of standard safety protocols but also understand the importance of adaptability and resilience in dynamic work environments [177,182]. Addressing the BB&Cs to implementation requires a multifaceted approach. Overcoming common BB&Cs (e.g., resistance to change, a lack of resources, and insufficient stakeholder engagement) involves engaging all levels of the organisation in the safety process, from top management to frontline workers, to ensure buy-in and support for safety initiatives.

One innovative strategy is the integration of technology and data analytics to enhance safety protocols. The use of advanced digital tools and platforms can significantly improve the monitoring and management of safety practices [26]. For instance, the application of machine learning algorithms and data-driven decision-making processes can predict potential safety hazards and suggest preventive measures [183]. This approach allows for the real-time monitoring and proactive management of safety risks, thereby reducing the likelihood of accidents and enhancing overall safety performance [184]. Technologies such as wearable safety devices can provide real-time data on site conditions, enabling proactive risk management and supporting the Safety I framework. Simultaneously, these technologies can help identify patterns and anomalies in work processes, contributing to the Safety II approach by highlighting areas where system resilience can be improved [10].

Leadership commitment and organisational culture play a crucial role in the successful implementation of these safety frameworks [175]. Leaders must demonstrate a commitment to safety by allocating resources, setting clear safety objectives and fostering a culture that values safety as a core organisational priority [185]. Leadership plays a pivotal role in setting the tone for safety practices and ensuring that safety is integrated into the organisational ethos [186]. This commitment is essential for overcoming resistance to change and ensuring that safety initiatives are integrated into everyday work practices [187]. Additionally, organisations should focus on continuous improvement by regularly reviewing and updating safety practices based on feedback and new insights [15]. Furthermore, regulatory compliance and external audits can drive safety improvements. Adhering to industry standards and regulations ensures that organisations meet minimum safety requirements. External audits provide an objective assessment of safety practices and can identify areas for improvement, helping organisations to align with best practices [176]. Furthermore, fostering a strong safety culture within organisations is a critical component of effective safety implementation. This involves promoting safety as a core value and ensuring that all employees are committed to maintaining high safety standards. Training programmes, leadership commitment, and employee engagement are key elements in building a robust safety culture. By prioritising safety at all levels of the organisation, companies can create an environment where safety is integrated into every aspect of operations [64]. Finally, addressing psychological and behavioural aspects is important. Understanding the psychological factors that influence safety behaviour, such as risk perception and motivation, can help tailor interventions that encourage safe practices. Behavioural interventions, such as incentives for safe behaviour and consequences for unsafe actions, can reinforce the desired safety culture [188].

Another strategy involves the adoption of a systems-based approach to safety management. This involves understanding the complex interactions between different components of a system and how they contribute to safety outcomes. By focusing on the whole system rather than individual elements, organisations can identify and address the root causes of safety issues more effectively. This holistic perspective is essential for developing comprehensive safety strategies that are resilient to various challenges [178]. Furthermore, adaptive safety practices are essential for implementing Safety I- and II-enabled SSoWs because they emphasise flexibility and responsiveness to the dynamic nature of work environments [7]. These practices allow organisations to navigate the complexities of safety management by integrating adaptability into their safety protocols, which is crucial for addressing both anticipated and unforeseen challenges [189]. One of the key aspects of adaptive safety practices is regulatory flexibility. This concept refers to the ability to modify safety practices within the existing regulatory framework, enabling organisations to adopt innovative compliance strategies that enhance safety without compromising legal obligations [128]. By leveraging this flexibility, organisations can tailor their safety management systems to better fit their unique operational contexts, thus fostering a more resilient safety culture. Moreover, the integration of compliance strategies that allow for flexibility is vital. These strategies ensure that safety practices not only meet regulatory standards but also adapt to the realities of the work as it is performed rather than merely as it is planned [25]. This distinction between "work-as-done" and "work-as-imagined" highlights the necessity for safety practices that can evolve based on real-world experiences and feedback, which is a cornerstone of adaptive safety management. Incorporating the principles of resilience engineering further enhances adaptive safety practices. This field focuses on how systems can recover from disruptions and adapt to changing conditions, thereby improving overall safety performance [57]. By viewing organisations as complex adaptive systems, safety management can be approached with a mindset that embraces self-organisation and continuous improvement, which is essential for effective safety management in dynamic environments [178]. Additionally, the concept of dynamic equilibrium in safety management emphasises the need to balance competing demands while adapting to changing conditions [177]. This balance is crucial for maintaining safety standards while allowing for necessary flexibility in practices. Feedback loops within safety systems also play a significant role, as they enable organisations to learn from past incidents and continuously refine their safety practices [190]. By documenting and analysing safety incidents, organisations can identify areas for enhancement and adapt their safety strategies accordingly, ensuring that they remain effective and relevant in the face of evolving challenges [ibid].

In conclusion, implementing Safety I and II frameworks in the construction industry requires a comprehensive strategy that includes enhancing communication, allocating sufficient resources, providing training, involving employees in safety planning, leveraging technology, ensuring leadership commitment, fostering a supportive organisational culture, and adopting systems-based approaches (see Figure 4). By addressing these areas, construction companies can effectively manage safety site BB&Cs, leading to safer and more resilient work environments. This integrated approach not only helps in preventing accidents but also enhances the overall efficiency and adaptability of construction operations.

4.2. Research Limitations

Despite the theoretical contributions made by creating a detailed framework for implementing Safety I- and II-enabled SSoWs to handle and control BB&Cs, there remain some limitations to this research. Specifically, the review-only papers included were published in English, which means that relevant research conducted in other languages was not included. Moreover, the uneven distribution of publications across different geographical regions poses a hindrance to drawing comprehensive results and creates difficulties in comparing countries and BB&Cs. Furthermore, the BB&Cs illustrated in Figure 3 should not be assumed as forming a cogent and definite categorisation; while the importance of each BB&C was considered, they were grouped based on the percentage of their relation to Safety I and II. For example, if BB&Cs were determined to have a higher correlation with Safety I, they were classified as BB&Cs to Safety I, or if the correlation between BB&Cs and both Safety I and II was strong, they were classified as BB&Cs for Safety I and II. In addition, although barriers, bottlenecks, and challenges have distinct characteristics, they were combined and referred to as BB&Cs. Dividing them provides a significant advancement in understanding, thus allowing for a clear (and more nuanced) demonstration of the challenges associated with Safety I and II.

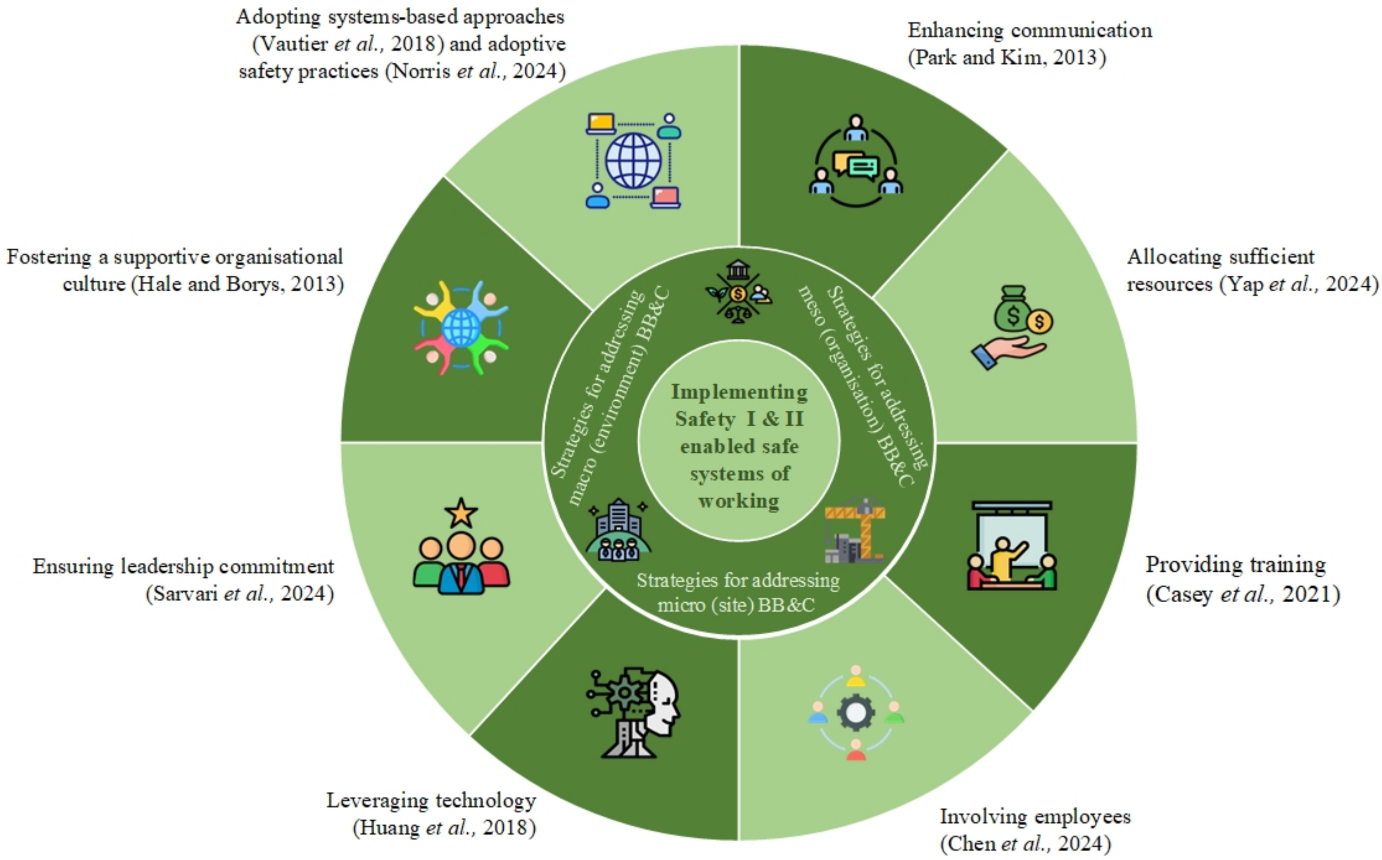

Figure 4. Strategies for facilitating the implementation of Safety I and Safety II [15,28,29,64,177,181,184,189,191].

4.3. Future Work

Future research should aim to address this limitation by actively seeking out and including studies from underrepresented regions, thereby enriching the overall understanding of BB&Cs in diverse safety contexts. Moreover, as mentioned, the current framework groups these elements based on their correlation with Safety I and II, which may oversimplify the complexities involved. Future studies should focus on refining this categorisation by distinguishing between the unique characteristics of barriers, bottlenecks, and challenges. A more nuanced approach would enhance the clarity of the relationships between these elements and their respective impacts on safety management practices. By dividing BB&Cs into distinct categories, researchers can better understand the specific challenges associated with Safety I and II. This advancement would not only improve the analytical framework but also facilitate the development of targeted interventions to address the identified challenges more effectively. Furthermore, implementing Safety I and II strategies in construction projects encounters multiple obstacles, as identified in various studies [13,15,57]. Future research can synthesise the findings to address these BB&Cs.

- Increasing risk awareness: future research should prioritise and develop techniques aimed at augmenting risk awareness and rectifying misperceptions through specialised training and educational initiatives tailored to construction professionals [29];
- Developing industry standards: To tackle the issues of tight project schedules, insufficient dedication to safety and the absence of safety regulations and policies, future research should investigate strategies to enhance industry standards and cultivate a culture that prioritises safety. This may entail the creation of frameworks to enhance safety governance and policy formation that can be adjusted to suit the requirements of nations [176];

- Upgrading governance and policy frameworks: An additional crucial element in implementing Safety I- and II-enabled SSoWs is establishing a governance structure to enhance safety performance. Subsequent investigations should focus on developing and executing appropriate governance frameworks customised to various regions' distinct regulatory and cultural environments [113];
- Incorporating safety into design processes: Further investigation should also examine the advancement of alternative project delivery systems, such as Design–Build, which could more efficiently incorporate safety issues starting from the design stage [192];
- Utilising technology to address organisational and systemic obstacles: Future studies should explore methods to address obstacles related to organisational, infrastructure, expenses, and system integration. One such approach is to create a framework that combines IoT and other upcoming technologies with current safety management approaches [26];
- Developing risk and safety management models: future studies must prioritise the creation of models capable of accurately delineating the interconnections between the BB&Cs and provide guidance for the formulation of culturally and geographically suitable risk management methods [191];
- Developing flexible safety protocols: insufficient safety protocols and excessive psychological stress in the workplace on construction sites are additional significant BB&Cs in the execution of Safety I and II initiatives. Given the circumstances, future research must focus on creating strong and flexible safety protocols that can be quickly updated in response to changing conditions, such as those encountered during a pandemic [5].

Cross-regional collaboration is imperative for advancing safety practices globally because it helps overcome the limitations posed by geographical disparities in research and ensures that safety practices are both effective and inclusive. Such collaboration can enhance the quality and quantity of safety research, ultimately improving the effectiveness of universally applicable interventions aimed at eliminating BB&Cs and implementing SSoWs. Generally, future research should prioritise the development of comprehensive frameworks and techniques that effectively tackle various obstacles to executing Safety I- and II-enabled SSoWs. By focusing on the aforementioned specific areas, future research has the potential to enhance the efficacy and global implementation of safety policies in building projects.

5. Conclusions

The present scoping literature review provides a comprehensive list of BB&Cs that hinder the implementation of Safety I- and II-enabled SSoWs in the construction industry. An initiative model was used to group the identified BB&Cs as follows: micro-, meso- and macro-thematic clusters. A chronological review of the literature revealed that academics have shifted their focus from analysing the BB&Cs of the micro (site)-group to the other two groups (i.e., meso- and macro-groups). Indeed, there has been an increasing focus on the meso- and particularly macro-groups in recent years (Figure 2). This may be attributed to the implementation of Safety I- and II-enabled SSoWs and the shift towards the development of balanced approaches that incorporate both Safety I and Safety III approaches [15]. The analysis of these categories has shown that most of the BB&Cs in the micro-group are associated with the Safety I approach, whereas BB&Cs in the meso- and macro-groups mostly pertain to the Safety II approach. Furthermore, several BB&Cs within these three groups can be deemed suitable for both Safety I and II approaches. The implementation of Safety I and II practices in the construction industry encounters various challenges, including the technological adoption of BB&Cs as well as organisational and regulatory obstacles. The objective of Safety I and II practices is to improve safety management, but they face unique and intersecting BB&Cs (such as contradictory and unclear SSoWs, non-conductive work climates, the neglect of safety based on experiences and lack of continuous monitoring and follow-up). The impact of technological advancements on safety performance is substantial, particularly in relation to the integration of digital technologies and IoT devices [26]. Primary concerns encompass the exorbitant expense of technology [103], the absence of internal proficiency [81], and apprehensions regarding the dependability and efficacy of these technologies [26]. Moreover, the construction industry's conservative nature and its reluctance to embrace change further hinder the incorporation of cutting-edge safety solutions. Organisational and regulatory bodies also play a vital role in managing, reducing, and eliminating BB&Cs toward implementing Safety I- and II-enabled SSoWs.

Although centralised governing structures exist for executing Safety I- and II-enabled SSoWs, the methodical execution of safety programs still encounters regulatory difficulties in certain countries. In addition, the effectiveness of key safety management roles is impacted by deficiencies in technical expertise, interpersonal abilities, and the overall approach of clients towards their responsibilities. The construction sector's fragmented supply chain and insurance policies further complicate the situation. The lack of clear insurance policies in construction projects adds another layer of risk, as contractors and clients often face uncertainties regarding financial losses, professional liability, and defects liability [193]. This ambiguity in insurance coverage can lead to inadequate risk transfer and insufficient protection for all parties involved, exacerbating safety issues. Additionally, the construction supply chain's vulnerability to interruptions and cascade failures, particularly at key risk nodes located upstream and downstream in the supply chain, further destabilises the industry, making it challenging to maintain safety standards [194]. Moreover, the integration of safety practices into the supply chain is crucial for mitigating risks and ensuring worker well-being, but this requires rigorous supplier vetting, certified materials, proper handling procedures, and regular safety training. These are often neglected due to the fragmented nature of the supply chain [195]. This fragmentation arises from the disjointed relationships among various stakeholders, including contractors, subcontractors and suppliers, which can hinder the effective communication and collaboration necessary for robust safety management. To address these challenges, several overcoming strategies can be implemented. First, enhancing the technical expertise and interpersonal skills of safety management personnel is crucial. Deficiencies in these areas can lead to ineffective safety program execution, as safety managers must be equipped to communicate effectively and foster collaboration among diverse stakeholders [97]. Furthermore, clients' approaches to their responsibilities play a pivotal role in shaping safety outcomes. A proactive client's responsibility approach can drive improvements in safety culture and performance across projects [176]. Moreover, the construction sector must adopt a more integrated approach to risk management that emphasises network-level cooperation rather than relying solely on dyadic relationships. This shift can facilitate better coordination among all parties involved, allowing for a more cohesive safety management strategy that addresses the unique risks posed by the fragmented supply chain [21]. Furthermore, strengthening the institutional framework and safety culture within the construction industry is vital. This involves not only regulatory compliance but also fostering an environment where safety is prioritised and all stakeholders are engaged in the safety management process. By involving government agencies and private organisations in safety initiatives, the construction sector can build a more robust safety culture that mitigates the risks associated with fragmentation and enhances overall safety performance [81]. The BB&Cs related to safety culture and knowledge should not be underestimated. The industry's deficient safety culture, coupled with concerns regarding privacy and data security, hinders the implementation of new technologies for safety management. The lack of knowledge related to BB&Cs, such as insufficient awareness and education regarding safety technologies, further exacerbates site safety situations.

Ultimately, these safety BB&Cs (reported upon within this present research) pose ongoing challenges that require inventive and environmentally friendly solutions to improve safety I- and II-enabled SSoWs and protocols in the construction industry. Overall, the implementation of Safety I and II to address BB&Cs is complex and involves the triumvirate of sites, organisations, and the environment. Addressing BB&Cs necessitates implementing strategies that tackle systemic problems, encourage comprehension and adaptability, and cultivate a culture of safety and ongoing enhancement across various sectors. By addressing these areas, organisations can create an environment where safety is prioritised and continuously improved, ultimately leading to a safer workplace for all employees. The synthesis of the research findings highlights the importance of a holistic strategy that considers both organisational and individual factors in promoting safety. This study's outcomes serve as a form of guidance and elucidation for safety practitioners and experts in critical safety industries and for continuous learning organisations with higher safety maturity levels.

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