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Tackling Challenges in Implementing Behavior-Based Safety (BBS): Construction Safety Culture Focus

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Abstract: The dynamic nature of the construction industry renders it inherently hazardous, leading to elevated rates of occupational injuries. Thus, it is imperative to explore diverse strategies aimed at mitigating these risks. One such approach is Behavior Based Safety (BBS), which targets the enhancement of safety performance by addressing the behaviors of construction workers. This study undertook a systematic literature review on BBS in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Through this research endeavor, the aim is to deepen the industry comprehension of the conceptual framework, operational mechanisms, and inherent limitations of BBS within the construction industry context. Exploring the intricacies of BBS offers valuable insights into its operational mechanisms and underlying principles within the construction context. The comprehensive review encompassed 14 scholarly articles published between 2010 and 2023, all cataloged within the American Society of Civil Engineers (ASCE) or ScienceDirect databases. Findings from these studies shed light on the effectiveness of BBS and its inherent limitations when applied within construction environments. It becomes increasingly evident that prioritizing safety culture might supersede the sole reliance on BBS methodologies within the construction sector.

Keywords: Behavior based safety (BBS), safety behavior, construction safety culture

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1. Introduction

The construction industry is one of the most dangerous industries. Construction workers are 5.5 times more likely to get killed than workers from other sectors (Al-Bayati et al., 2023). The impact of occupational injuries extends far beyond measure, as each injury sets off a ripple that affects families, colleagues, communities, and companies alike. Apart from human suffering, injuries also bring about financial strains, project delays, and potential fines, ultimately jeopardizing the company's profitability and reputation.

Behavior can be defined as any action or verbal expression. Psychologically, it refers to the actions or reactions of an individual in response to external or internal stimuli (Choudhry, 2014). In the context of this research, behavior refers to workers' observable actions and reactions regarding site safety. For years, a significant percentage of accidents (roughly 80%) have been attributed to unsafe behaviors (e.g., Li et al., 2020), highlighting the need to address and change these behaviors to improve safety performance. Zhang et al. (2017) suggested that behavior-based safety (BBS) contributes to overall site safety by reinforcing safe behaviors and eliminating unsafe ones. Also, Ko and Abdulmajeed (2022) identified that Behavior-Based Safety (BBS) is the second level of hierarchy of controls (i.e., administrative controls) as proposed by the National Institute for Occupational Safety and Health (NIOSH), see Figure 1.

BBS targets individual behaviors with the aim of modifying unsafe actions that contribute to incidents (Choudhry and Fang, 2008; Choudhry, 2012). It has evolved in response to the need for improved safety practices in the construction industry

(Zhang et al., 2017). This approach was based on the belief that overall safety could be improved by changing individual behaviors.

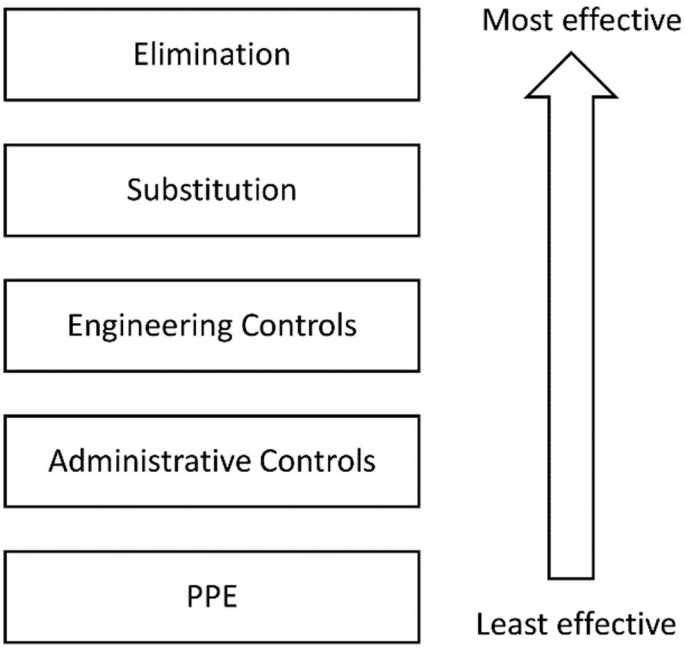

Fig. 1. Hierarchy of controls (Ko and Abdulmajeed, 2022)

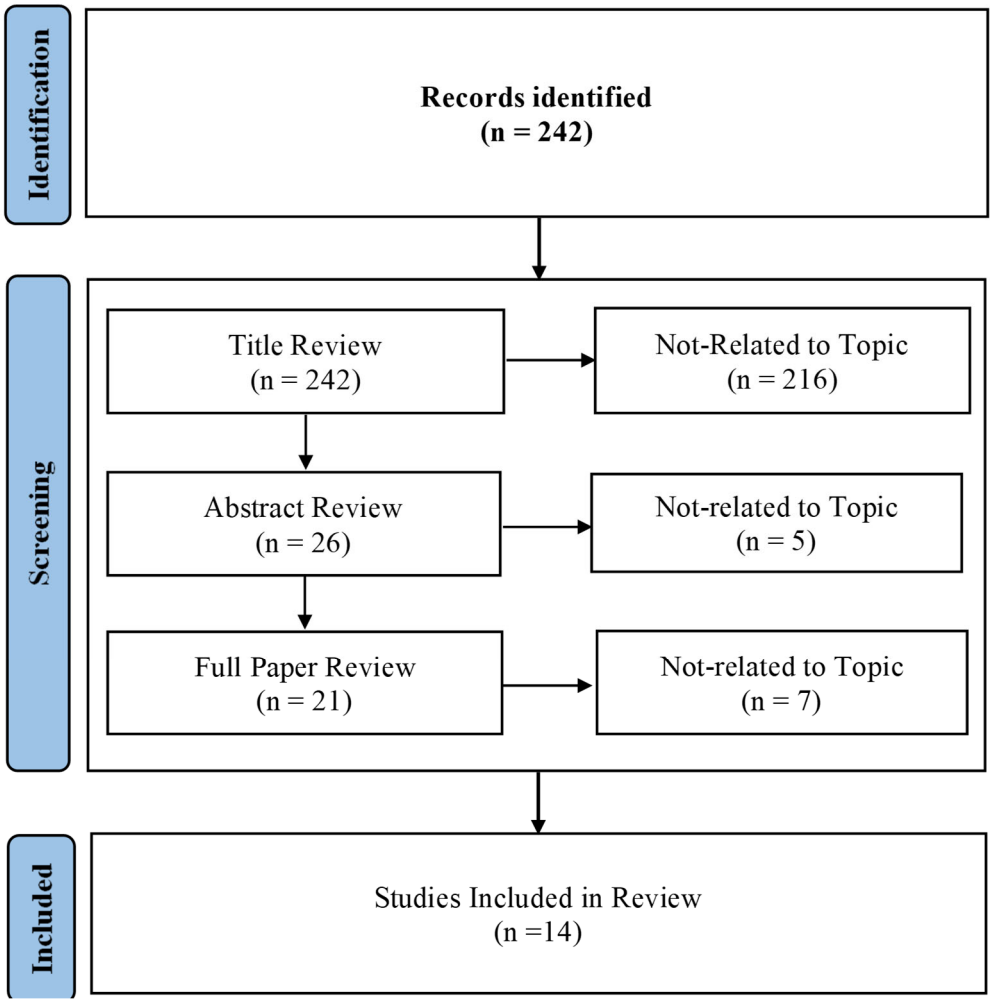

Fig. 2. Literature review methodology

2. Study Objectives and Literature Review Methodology

This study explores the BBS mechanism and its implementation challenges to comprehend its relationship with construction safety culture and climate. This study adopts the construction safety culture and climate definitions proposed by Al-Bayati et al. (2019). Accordingly, construction safety culture encompasses the policies and principles that guide safety decision-making, which manifest in the safety-related actions of upper management and safety personnel. In contrast, the construction safety climate represents the manifestation of these principles and policies in construction sites, demonstrated by the safety-related actions of frontline supervisors and field workers.

This study employed the PRISMA framework, a literature review methodology, to synthesize evidence. PRISMA outlines a standardized set of reporting items essential for systematic reviews and meta-analyses. It seeks to deepen comprehension and refine insights regarding the topic being explored. The initial step involved conducting an academic search on the topic using the ASCE and ScienceDirect databases. The review focused on articles published between 2010 and 2023, extracted from the ASCE and ScienceDirect databases using specific keywords related to BBS. A total of 242 results were obtained: 37 from ASCE and 205 from ScienceDirect. Utilizing the PRISMA flow chart, articles were systematically screened for relevance, excluding 216 articles during the title review phase. Subsequently, 26 articles underwent abstract review, with five excluded due to insufficient relevance. This left 21 articles for further examination. Following a full-text review, 7 additional articles were excluded due to a lack of discussion about the mechanism and implementation challenges related to BBS, resulting in a final selection of 14 articles for inclusion in the literature review. Figure 2 provides a systematic summary of the selection process undertaken for this research.

3. Literature Review Findings

The following subsections will present the findings gleaned from the literature review. Table 1 lists article titles, authors, and their purpose. It is essential to understand the structure of BBS, including its definition, mechanisms, and the individuals responsible for implementing it. The reviewed articles agreed that BBS aims to modify unsafe behaviors. BBS applies behavior analysis methods to correct and reduce unsafe behaviors, focusing on specific safety-related actions of workers. It involves observing and providing feedback to individuals to modify their behavior.

3.1. BBS Implementation – Mechanism

The mechanism of BBS consists of four steps: (1) observation, (2) unsafe behavior identification, (3) intervention, and (4) results evaluation.

- Observation: Observers are identified and trained to recognize unsafe behaviors and provide feedback (Fang and Wu, 2013). Observers could be chosen from workplace foremen and supervisors (Zhang and Fang, 2013; Guo et al., 2018). Setting goals is also important in this phase to establish clear objectives for the program (Li et al., 2015; Zhang and Fang, 2013; Li et al., 2016; Zhang et al., 2023). This step aims to develop an implementation plan and identify and prepare all needed resources to ensure successful implementation.
- Unsafe Behavior Identification: Observers should carefully monitor employees' behavior and record unsafe behavior. This stage is critical for collecting data on unsafe behaviors. Several safety metrics can be used in this stage, such as frequency measures (Guo et al. 2018), safety index score (Li et al. 2015), and tracking systems (Li et al. 2016). In addition, categories that need to be improved can be identified in this phase, such as PPE compliance, housekeeping, and scaffolding safety (Choudhry, 2014).
- Intervention: The data collected during the observation phase should be utilized to determine the interventions needed. The first set of interventions involve providing immediate feedback to employees engaging in unsafe behavior. Yuan and Kaiquan (2012) suggested that the observers should provide instant feedback to workers who act unsafely to educate workers about the importance of safety and encourage them to modify their behavior. Intervention plans should be realistic, discussed with workplace managers, and often implemented by field supervisors (Choudhry, 2012; Zhang et al., 2017; Guo et al., 2018). Intervention plans may include additional training and toolbox talks (Fang and Wu, 2013; Guo et al., 2018). Rewards for safe behavior and consequences for unsafe behavior can also be implemented to reinforce desired behaviors (Guo et al., 2018; Li et al., 2015). Finally, discipline measures (e.g., verbal warnings or removal from the site) can also be utilized (Guo et al., 2018).
- Evaluation: The effectiveness of interventions should be assessed by monitoring changes in safety behavior or by comparing safety metrics before and after the intervention. This involves tracking metrics such as the number of near misses or injuries over time, safety climate, and safety culture (Yuan and Kai-Quan, 2012; Jasiulewicz-Kacmarek et al., 2015; Li et al., 2015; Zhang et al., 2017). By comparing these metrics, organizations can assess the program's impact and make any necessary adjustments to improve safety performance further.

The implementation process of BBS may vary slightly to suit the project's requirements. For instance, Choudhry (2012) proposed the following phases: (1) identifying unsafe behaviors, (2) developing reliable measurements for these behaviors, (3) setting feasible goals for managing them, (4) providing feedback, and (5) evaluating and reinforcing the process. Most studies in this research suggest that BBS is primarily a top-down process where management takes the lead in its implementation. They concur that management should lead the implementation, offering training and necessary tools to ensure workers can safely perform their tasks. High management commitment has been identified as a critical determinant of BBS's success. Low commitment correlates with diminished safety performance (Choudhry, 2012; Choudhry, 2014; Yuan and Kai-Quan, 2012; Fang and Wu, 2013). Choudhry (2012) found that observers' commitment is crucial for implementing BBS effectively while independent of site management commitment. Ensuring the success of the BBS

methodology requires offering sufficient training and support to foremen, supervisors (Zhang and Fang, 2013), observers (Choudhry, 2012), and workers (Li et al., 2015; D. Fang et al., 2015).

Table 1. Articles included in the literature review

Author (Year)	Article Title	Purpose of Article
Choudhry (2012)	Implementation of BBS and the Impact of Site-Level Commitment	Pinpoint the key challenges associated with implementing the BBS approach
Chen and Tian (2012)	Behavior Based Safety for Accident Prevention and Positive Study in China Construction Project	Assess safety behavior and trends in behavioral change using the Safety Index (SI).
Xiongjun and Kaiquan (2012)	Study on Safety Management of Small and Medium-Sized Enterprises Based on BBS	Describe a tailored BBS management approach for small and medium-sized firms.
Zhang and Fang (2013)	A Continuous Behavior-Based Safety Strategy for Persistent Safety Improvement in Construction Industry	Assess the continuous BBS strategy by integrating the BBS practice into the management routine.
Fang and Wu (2013)	Development of A Safety Culture Interaction (SCI)Model for Construction Projects	Offer a clear definition of construction project safety culture distinct from existing definitions of organizational safety culture.
Choudhry (2014)	Behavior-Based Safety on Construction Sites: A Case Study	Formulate a managerial strategy for enhancing safety in construction site environments.
Jasiulewicz-Kaczmarek, et al. (2015)	Behavior Based Intervention for Occupational Safety – Case Study	Examine the core assumptions and procedural steps of BBS.
Fang et al. (2015)	Impact of The Supervisor on Worker Safety Behavior in Construction Projects	Discover management behaviors that can impact BBS.
Li, et al. (2015)	Proactive Behavior-Based Safety Management for Construction Safety Improvement	Assess an extension to the BBS approach.
Heng et al. (2016)	Intrusion Warning and Assessment Method for Site Safety Enhancement	Explore an innovative technology that automatically evaluates individual safety performance and delivers feedback.
Zhang et al. (2017)	Supervisor-Focused Behavior-Based Safety Method for The Construction Industry: Case Study in Hong Kong	Evaluate the efficiency and long-term viability of a supervisor-centered BBS approach.
Guo et al. (2018)	A System Dynamics View of A Behavior-Based Safety Program in The Construction Industry	Clarify the varied efficacy of the BBS program through the adoption of a systemic dynamic perspective.
Fang et al. (2020)	Computer Vision for Behavior-Based Safety in Construction: A Review And Future Directions	Develop computer vision for identifying unsafe behaviors from 2D images to enhance BBS.
Zhang, et al. (2023)	Impact of Owners' Safety Management Behavior On Construction Workers' Unsafe Behavior	Investigate the influence of owners' behavior on the unsafe behaviors of construction workers.

The literature suggested that BBS mechanisms that center on supervisors have demonstrated efficiency in enhancing project safety climate, providing guidance, and fostering worker participation and commitment (Zhang et al., 2017; Choudhry, 2012). Moreover, they have been correlated with notable improvements in safety-related behaviors among construction workers, ultimately enhancing overall safety performance. This underscores supervisory personnel's pivotal role in fostering a safety and compliance culture. A recent study by Al-Bayati et al. (2024) suggested that the influence of frontline supervisors on the safety performance of field workers is substantial, with a quantified effect of 0.59. This means that two firms with equivalent safety culture scores that differ by one point in the involvement of frontline supervisors are estimated to have a higher level of workers' safety behavior by 0.59. The dynamics of goal commitment, punishment, and monetary incentives can impact the effectiveness of BBS interventions (Guo et al., 2018), necessitating careful calibration of these elements. Finally, feedback mechanisms are critical for BBS and have been recognized as effective tools in

promoting safer behavior among workers (Jasiulewicz-Kaczmarek et al., 2015), highlighting the significance of consistent and constructive feedback.

3.2. BBS Implementation – Challenge

BBS utilization in the construction industry has a few critical challenges and limitations. Zhang and Fang (2013) argue that implementing BBS faces significant challenges, particularly in achieving persistent effects. Its implementation may foster a "culture of blame," wherein incidents are attributed to individual workers rather than addressing systemic issues (Guo et al., 2018). Maintaining the benefits of BBS over time poses challenges in the construction industry because of the sector's high turnover rates and the intricate nature of construction workplaces, which experience frequent changes. These industry traits contribute to uncertainty in BBS outcomes and hinder the sustainability of behavioral improvements (Zhang and Fang, 2013). Hence, BBS implementation requires consistent and effective execution to attain favorable results in the construction industry.

BBS focuses on changing individual behaviors to improve safety outcomes, operating on the premise that consequences influence behavior. Researchers and practitioners recognized the limitations of this individual-focused approach (Zhang et al., 2017). While BBS is primarily a top-down process involving management in its implementation, its success is amplified when workers are committed to safety. This challenge is attributed to BBS's focus on external antecedents and consequences for reinforcing safe behaviors (Cameron and Duff, 2007) while neglecting internal factors such as attitudes, awareness, and values (Geller, 2001). Therefore, prioritizing the organizational aspects of safety management is a more sensible approach to sustaining acceptable safety performance within construction workplaces.

Moreover, BBS relies on a comprehensive and continuous inspection process. As a result, inspectors need training and sufficient time to gather data, suggest interventions, assess outcomes, and achieve lasting improvement. Technological advancements may help detect unsafe behavior. Still, qualified individuals must follow up to ensure unsafe behaviors have been effectively addressed. Thus, BBS may not be feasible for micro and small construction firms. These firms often lack systematic safety operations due to the absence of a full-time safety manager/coordinator (Al-Bayati et al., 2023). As a result, there is a slim likelihood that these firms will implement BBS protocol in their workplaces. The time needed to implement BBS in construction sites fully might not be available because of constantly changing work environments and the generally short durations of construction projects (Li et al., 2016; Zhang et al., 2017). Finally, the information collected is shaped by individuals' viewpoints and might be affected by their biases, which could result in exaggerated findings (Zhang et al., 2023).

4. Concluding Remarks

This research sheds light on the role of BBS in managing construction safety. The construction industry is known for its high-risk nature and has witnessed numerous occupational incidents. Therefore, it is crucial to implement strategies to mitigate occupational risks on construction sites. BBS has emerged as a promising method to enhance safety practices, focusing on modifying behaviors to prevent accidents and improve overall safety performance. Supervisor-focused BBS methods, in particular, have shown value in improving safety climates, guidance environments, and worker participation and commitment (Zhang et al., 2017). Construction supervisors' involvement in managing safety is crucial to achieving higher levels of safety performance (Al-Bayati et al., 2024). Additionally, the reviewed articles highlight that high management commitment is crucial for the success of BBS initiatives, emphasizing the need for support and training for observers and everyone involved and the integration of feedback mechanisms into existing safety management systems. However, BBS implementation in construction faces significant challenges, including struggles in achieving persistent effects and the potential creation of a "culture of blame." Furthermore, BBS's individual-focused approach overlooks organizational factors. The recent safety management research explores the role of safety culture and climate and their influence on workers' behavior (Al-Bayati et al., 2019; Al-Bayati, 2021). This shift led to more comprehensive BBS programs that addressed individual behaviors and the broader organizational context.

It appears that the focus of BBS overlooks the broader context of safety management, including the influence of safety culture and climate, as well as the interactions between workers, supervisors, upper management, and safety personnel. BBS fails to consider how safety culture impacts workers' behavior. Recent research by Al-Bayati (2021) suggests that construction safety culture (i.e., the safety actions of upper management and safety personnel) significantly influences field workers' safety behavior. Unsafe actions by workers should be seen as quality issues, often stemming from lower levels of safety culture (Al-Bayati, 2021). Therefore, attempting to correct workers' unsafe behavior through instant feedback may not be effective. Addressing unsafe actions requires an evaluation of the organizational safety culture. Arayici and Coates (2012) argue that everyone should develop and practice organizational culture. Safety performance significantly improves on construction sites where management and workers are committed (Choudhry, 2014). Additionally, the nature of construction work, with its constantly changing environments and generally short project durations, may hinder the full utilization of BBS.

Author Contributions

Al-Bayati contributed to conceptualization, methodology, and analysis. De Abreu contributed to investigation, data collection, draft preparation, and manuscript editing. Ko contributed to conceptualization, methodology, draft preparation, manuscript editing, and funding acquisition. All authors have read and agreed with the manuscript before its submission and publication.

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Institutional Review Board Statement

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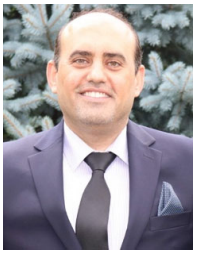

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