Behaviour-based safety in the construction industry: a systematic review

Seguridad basada en el comportamiento en la industria de la construcción: una revisión sistemática

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RESUMEN

La industria de la construcción es una de las más vulnerables a los riesgos laborales a nivel mundial. Por esta razón, la psicología ha propuesto varias estrategias de prevención, destacando entre ellas la Seguridad Basada en el Comportamiento. Las revisiones sistemáticas anteriores sobre este enfoque revelan ciertas limitaciones. En ese sentido, el objetivo de este estudio fue realizar una revisión sistemática de la literatura científica publicada entre 2012 y 2022 para determinar la efectividad de la BBS en la industria de la construcción. Siguiendo los criterios PRISMA, se identificaron inicialmente 3457 registros. Para el proceso de cribado, se usó el software Rayyan, reduciendo a una muestra de nueve registros científicos. Los resultados ponen en evidencia que el 90% de los casos, la BBS mejoró el desempeño de seguridad. Basado en el marco metodológico y los objetivos establecidos, este estudio representa una valiosa aportación al campo de la psicología de la seguridad y la salud ocupacional.

Palabras clave: seguridad basada en el comportamiento, salud ocupacional, modificación conductual, cultura de seguridad, industria de construcción.

ABSTRACT

The construction industry is one of the most vulnerable to occupational hazards. Psychology has, therefore, proposed various prevention strategies, with Behavior-Based Safety being one of the most prominent. Previous systematic reviews of this approach have discovered areas for improvement. The purpose of this study was to conduct a systematic review of the scientific literature published between 2012 and 2022 to determine the effectiveness of BBS in the construction industry. A total of 3,457 records were initially identified according to PRISMA criteria; Rayyan software was used for screening, reducing the sample to nine scientific records. The results show that BBS improved safety performance in 90% of cases. With its proposed methodological framework and objectives, this study makes a valuable contribution to occupational health and safety psychology.

Keywords: *behaviour-based safety, occupational health, behavioural modification, safety culture, construction industry.*

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INTRODUCTION

During the Industrial Revolution, health and safety conditions were poor. This was partly due to the large number of workers but mainly because of the need for an effective safety culture among employees and employers. As a result, many workers suffered injuries, mutilations or even died in tragic accidents (Arias, 2012). These unfortunate events highlighted the need to enact reforms to protect workers' lives. For example, a Spanish decree was passed to prevent accidents in 1778 (De la Poza, 1990), the Welsh reformer Robert Owen implemented a program to improve the environmental conditions of workers (Podmore, 1906), and German compensation laws were introduced in 1868 (Obregón, 2012). The need for worker safety also triggered historical events such as the Chicago Uprising (Green, 2007) and the scientific management models (Carro & Caló, 2012).

The creation of the ILO in 1919 was a significant event in the evolution of labour relations and workers' rights protection (Ruggie, 1982). International regulations such as OHSAS 18001 and ISO 45001 established the standardisation of occupational health and safety principles. Both frameworks seek to improve employee safety, minimise risk in the workplace, and create safer, healthier working conditions (Oviedo-Quiñonez et al., 2018). However, despite institutional efforts, alarming accident rates continue to be reported worldwide.

The ILO (2019) reports that approximately 2.78 million workers die annually from work-related accidents and occupational diseases. In 2021, a total of 2.88 million non-fatal accidents resulting in at least four days of sick leave, together with 3,347 fatal accidents, were recorded in the European Union. This is equivalent to approximately 860 non-fatal accidents for every deadly accident (Eurostat, 2020). The situation in Latin America is similar. According to the Mexican Social Security Institute (IMSS, 2022), 352,461 workplace accidents were recorded, injuring 227,155 men and 125,306 women. The Ministry of Labor and Employment Promotion (2023) reported 38,628 workplace accidents in Peru. The Superintendency of Occupational Hazards (2021) registered 318,067 accidents and occupational diseases in Argentina. Within this sphere, the construction industry is notorious for its accident rate (Eurostat, 2020; Zhu et al., 2016), three to four times higher than of any other work activity (ILO, 2015).

Within this framework, the theoretical and methodological contributions to promoting healthy occupational environments can be divided into four approaches (Dyreborg et al., 2015). The first is the attitudinal approach, prioritising information and messages through campaigns, followed by the climate and culture approach influencing values and leadership management. The structural approach prioritises prevention by modifying the physical environment and the control of regulations, and finally, the behavioural approach modifies risky behaviours through techniques such as feedback and incentives. The behavioural approach, Behavior-Based Safety (BBS), has the most significant empirical evidence (Geller, 2011; Saari, 1998) of the models described.

Scott Geller has been credited with conceptualising BBS (Geller, 1991). BBS is defined as applying the principles and methods of behavioural psychology to industrial safety (Krause et al., 1997). Although the study of the human factor in accident prevention dates back to the last century (Heinrich, 1931; Komaki et al., 1978), according to the bibliometric analysis of the scientific literature, the past decade has seen an increase in scientific production on BBS (Abd et al., 2021).

Skinner's contributions are the theoretical pillars of BBS, which defines behaviour as the interaction between subject and environment (Skinner, 1974), making external variables directly responsible for behaviour (Leahey, 2005) and enabling the prediction and control of behaviour. A key influence for this author was the law of effect (Thorndike, 1911), stating that reinforced behaviour tends to be repeated. In contrast, punishment tends to eliminate or decrease the frequency of this behaviour (Skinner, 1974).

BBS models have been developed based on behaviourism's contributions to industrial safety. These include the Dupont proposal using the STOP method, the Gueller model with its DO IT process, and the McSween proposal emphasising safety culture (Martínez-Oropeza, 2015). Based on this diversity, BBS has primarily reinforcement and feedback programs (Meliá, 2007).

The BBS process establishes a series of procedures (Geller, 2005). First, the conditions of the organisation are evaluated, including the state of the facilities, absence of conflict and management commitment. According to the ABC model (Antecedent, Behavior, Consequence), work behaviour is functionally analysed to identify and examine critical behaviours. BBS action is then planned, considering the design, inter-

vention method and control methods, complemented by the development of training material. Later, behavioural observations are made to obtain a baseline of critical behaviours. The intervention is subsequently implemented using feedback and reinforcements. Key behaviours are controlled and recorded to finetune the program by evaluating the intervention features (Meliá, 2007).

Systematic reviews of BBS have been found to have certain limitations. For example, some are based on unclear behavioural safety procedures (Cox & Jones, 2006) or have poor methodological quality (Grindle et al., 2000; McAfee & Winn, 1989). Others are outdated (Krause et al., 1999), while others have heterogeneous statistical treatment (Tuncel et al., 2006). Moreover, none of the studies was based on a methodological framework that organises and guarantees quality data collection and presentation, such as the PRISMA Statement (García-Peñalvo, 2022). No analysis of BBS in the construction industry has been conducted, justifying the need for a rigorous, systematic review (Manterola et al., 2013).

The guiding question for this research was: How effective is Behavior-Based Safety according to a review of scientific publications on experimental programs implemented with construction workers between 2012 and 2022? The study's purpose was to conduct a systematic review of the scientific literature published between 2012 and 2022 to determine the effectiveness of BBS in the construction industry.

METHOD

Pre-registration

The PRISMA 2020 statement (Page et al., 2021) was followed for methodological rigour. As a first step, this review protocol was registered in advance in the International Prospective Register of Ongoing Systematic Reviews (PROSPERO) database with the code CRD42022382951 during the principal investigator's research project in 2022.

Eligibility criteria

The PICO strategy (P-Population I-Intervention, C-Comparison, O-Outcome (Stone, 2002) strategy was used to maximise evidence recovery. The analysis was as follows: P-construction sector employees, I-BBS, C-not applicable, O-effectiveness findings. Based on this analysis, the following eligibility criteria were established. Experimental studies on implementing BBS, studies conducted on construction employees, studies published in journals belonging to the Q1, Q2, Q3 and Q4 quartiles of the Scimago Ranking between 2012 and 2022 and, exceptionally, studies from doctoral theses with experimental designs.

The ethical principles for psychologists (International Union of Psychological Science [IUPsyS], 2008) were respected, and the four quality criteria —credibility, applicability, consistency, and neutrality (Guba, 1989)—were considered.

Study Selection Process

The process involved the following stages: question, search, selection and analysis (Pizarro et al., 2021). During the first stage, researchers KHM and RDM conducted a preliminary search of platforms such as the Campbell Collaboration and the Cochrane Library to ensure no reviews addressed the same issue.

During the second stage, researchers KHM and RDM explored the databases based on content coverage, prestige and practical utility (Falagas et al., 2008). Three multidisciplinary databases (Scopus, Science Direct and Web of Science) and one specialised database (Pubmed) were used. The doctoral theses were searched in Open Access Theses and Dissertations (OAT). The search terms used were "behaviour-based safety." "behaviour-based safety programs," "unsafe behaviours," "safety performance," and "safety observations." The search syntax for each database is shown in Figure 1. Researchers KHM and RDM completed the search on 10/29/2022.

During the third phase, 3457 studies were initially identified. In the semi-automatic software Rayyan (Ouzzani et al., 2016), researchers KHM and RDM excluded 164 studies because they were duplicates. Subsequently, 3,293 studies were screened for the factors indicated in Figure 2, yielding a final sample of nine studies. The information matrix was developed in the fourth stage.

RESULTS

The screening process yielded nine studies that met the inclusion criteria (Table 1). Eight of the studies selected were scientific articles, and one was a doctoral thesis. The findings are described in detail in the following sections.

Figure 1

Search Syntax for Each Database

Database	Search Syntax
Scopus	(TITLE ("behaviour-based safety programmes" OR "behaviour based safety" OR "behavioural safety programmes" OR "safety observations" OR "organizational behaviour management")) OR (KEY ("behaviour-based safety programmes" OR "behavior-based safety" OR "behaviour based safety" OR "behavioural safety programmes" OR "safety observations" OR "organizational behaviour management" OR "safety culture")) AND (TITLE-ABS-KEY (construction*)) AND NOT (TITLE (stude* OR clinic* OR patien* OR review OR hospital))
Science Direct	Title, abstract, keywords: (behaviour-based safety programmes" OR "behavior-based safety" OR "behaviour based safety" OR "behavioural safety programmes" OR "safety observations" OR "organizational behaviour management" OR "safety culture")
Web of Science	#1 TS= ("behavior-based safety" OR "behaviour safety programs" OR "safety observations" OR "organizational behaviour management" OR "safety performance") #2 TS= (construction* OR industr* OR accide*) #3 TI= (stude* OR clinic* OR patien*) #4 (final): (#1 AND #2) NOT #3 ("behavior-based safety" OR "behaviour based safety" OR "behaviour safety programs" OR "safety observations" OR "organizational behavior management") AND (construction* OR industr*)) NOT (child* OR schoo* OR medic* OR patient*)
Open Access Theses and Dissertations	("behavior based safety" OR "unsafe behaviours" OR "safety behaviour" OR "safety performance" AND construc*

Figure 2

PRISMA Flowchart

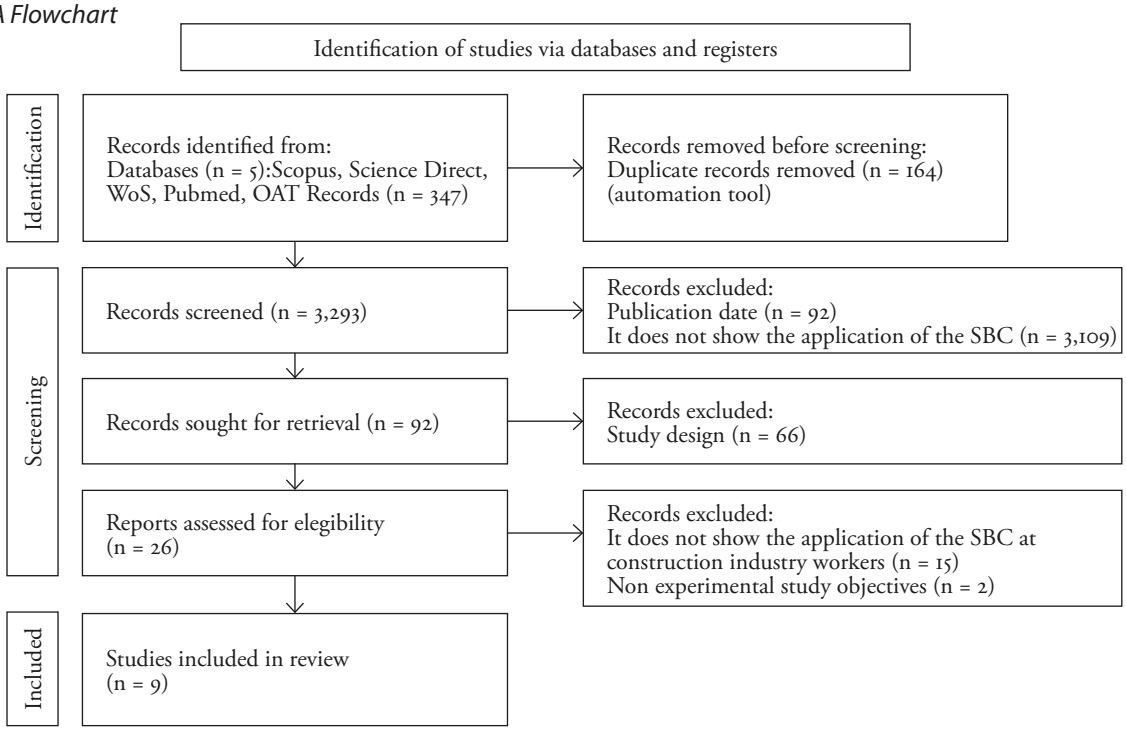

Table 1

Studies Included in the Review

No	Study	Objective	Study design	Results	Key behaviours
1	Becerrill (2013)	Reduce the number of workplace accidents in the Spanish construction sector by implementing behavioural intervention	Multiple baseline design, a particular type of single-case experimental design	Study I: At baseline, ISG ranged from 36.46% to 80.38%, with a mean of 60.82% and a standard deviation 15.38. In the intervention phase, ISG ranged from 65.63% to 92.96%, with a mean of 84.5% and a standard deviation of 8.02. Study II: At baseline, ISEAB ranged from 41.88% to 95% with a mean of 77.59%, whereas in the intervention phase, this index ranged from 81.08% to 94.12% with a mean of 88.27%. As expected, this index showed an improvement of 10.68%. Study III: At baseline, ISEAB ranged from 41.88% to 95% with a mean of 77.59%, whereas in the intervention phase, this index ranged from 81.08% to 94.12% with a mean of 88.27%. Study IV: At baseline, ISEAB ranged from 41.88% to 95% with a mean of 77.59%, whereas in the intervention phase, this index ranged from 81.08% to 94.12% with a mean of 88.27%. As expected, this index showed an improvement of 13.35%.	Worker behaviour (such as proper posture), personal protective equipment, order and cleanliness; work equipment; ancillary items (scaffolding, ladders), limitation systems, fall prevention and electricity and lighting
2	Choudhry (2014)	Implement BBS in safety management based on tested techniques for changing labour behaviour	Quantitative (safety performance measurement) and qualitative (semi-structured interviews) methods were used	In the personal protective equipment category, safety performance scores ranged from 82% at the end of week three to 92% at week nine. The cleaning category rose from 83.7% at the end of the third week when the intervention was introduced to 92.9% during the ninth week. In the access to heights category, subcontractors implemented a safety campaign when working at heights, with scores of 91% and 93% in weeks two and three, respectively. During the following weeks, scores improved from 87.5% in week five to 92.5% at the end of the data collection period. The safety performance score in the plant and equipment category was 91% when the goal-setting session was organised. Safety performance scores continued to increase, reaching 93.6% during the ninth week, exceeding the established target of 92%.	Personal protective equipment (PPE), cleaning, access to heights, plants and equipment and scaffolding

Table 1 *(continued)*
Studies Included in the Review

2				Safety performance in the scaffolding category scored 83% at the end of the third week. Scores increased each week during the intervention period, approaching 93.3% during the ninth week and exceeding the established goal of 92%.	
3	Guo et al. (2018)	Implementing BBS in Singapore's construction industry	Pre-post intervention	In the lifting operations category, the baseline for unsafe behaviour was 13.1%. The average from week one to five during the intervention was 12.04%. In the excavation category, the baseline for unsafe behaviour was 14.2%. The average during the intervention from week one to five was 18.18%. In the excavation category, the baseline for unsafe behaviour was 20.8%. The average during intervention from week one to five was 21.50%. In the excavation category, the baseline for unsafe behaviour was 5.9%. The average for the intervention from week one to five was 7.55%. In the excavation category, the baseline for unsafe behaviour was 14.6%. The average for the intervention from week one to five was 15.45%. In the plant equipment category, the baseline for unsafe behaviour was 8.2%. The average for the intervention from week one to five was 8.20%. In the traffic management category, the baseline for unsafe behaviour was 7.6%. The average for the intervention from week one to five was 7.97%. In the personal protective equipment use category, the baseline for unsafe behaviours was 11.0%. The average for the interventions from week one to five was 13.30%.	Lifting opertions, excavation, work ing at heights, work and access platforms, manual handling, hot work, plant equipment, traffic management
4	Lee et al. (2014)	Compare the effects of specific and overall feedback on safety performance	ABCB intra-subject experimental design	During the overall feedback stage, safety performance improved substantially in three of the four target items (Items 2, 3, and 4). The average safety percentages for the three items increased from 75.64%, 41.77%, and 45.75% during the baseline condition to 100%, 74.90%, and 72.95%. When specific feedback was introduced in the next phase, safety performance was slightly higher for items 3 and 4 (83.19% and 86.48% respectively).	Behaviour 1: Representative(s) were assigned and on-site to provide temporary traffic control through the construction work zone

Table 1 *(continued)*
Studies Included in the Review

4				When overall feedback was reintroduced in the final phase, the confidence percentages for items 3 and 4 decreased slightly from 83.19% and 86.48% to 80.08% and 81.11%, respectively.	Behavior 2: Construction vehicles were only parked in a designated area to avoid creating a safety hazard by obstructing the line of sight of other drivers. Behaviour 3: Workers engaged in appropriate cleaning practices within the workplace by removing combustible scrap, debris, and other hazardous waste during construction. Behavior 4: Workers wore appropriate personal protective equipment in all operations, such as hard hats, gloves, and safety-toe footwear.
5	Li et al. (2014)	Implement BBS with Proactive Construction Management System (PCMS) technology to improve construction industry safety	Experimental design	The overall SI scores for the two subcontractor teams during the two-week baseline were 64.12% and 63.96%, respectively. In the intervention phase, the overall score of the two subcontracting teams increased to 87.25% and 92.55%, respectively.	Fall hazards, crane hazards, traffic hazards, and hazards due to placing PCMS labels in the wrong place
6	Oostakhan et al. (2012)	Implement the BBS program at a construction site	Experimental design	The safety performance index of the experimental group during the nine weeks of intervention rose from 66% to 92%.	Worker behaviours (such as looking at the stairs and avoiding letting go of the hose until it is empty) Fall prevention

Table 1 *(continued)*
Studies Included in the Review

7	Zhang and Fang (2013)	Implement BBS by incorporating it into the safety management routine in the construction industry	Experimental design	During the three-week baseline, the average performance scores for Site A and Site B were 64.12% and 64.17%, respectively. In the first two intervention cycles, when the authors provided training and assistance to site safety officers during the process, performance scores increased to 82.77% and 89.35%, respectively. After the authors' participation ended, both sites' performance remained relatively high, with an average score of 86.75% on site A and 92.25% on-site B.	Personal protective equipment (PPE), manual handling, work platform and access, lifting operation, hot work, work at heights, plant and equipment, excavation and traffic management
8	Chen and Tian (2012)	Implement BBS and evaluate its associated effects on construction projects	Experimental design	BBS achieved remarkable performance in accident prevention, while employee IS improved by 15% from baseline during the experiment.	They did not specify critical behaviours
9	Choudhry (2012)	Implement BBS and evaluate its associated effects on construction projects	Implement BBS and evaluate its associated effects on construction projects	At baseline, safety performance on Project A was 86%. The score increased each week during the intervention period, reaching 92.9% in the ninth week, exceeding the established goal of 92%. In Project B, the safety performance score was 81.5% during the fifth week, increasing to 93.5% by the end of week eight. The average scores for all categories in Project C showed improved safety performance. The score was 90% during the fourth week, rising to 92% by the end of week eight.	Personal protective equipment, cleaning, access to heights, plants and equipment, and scaffolding

Table 2
Summary of Scientific Evidence of BBS when Intervening with Reinforcement

Author and Year	Type of Intervention	Result
Choudhry (2014)	Reinforcement/Feedback (Duration: nine weeks)	Safety performance improved from 86% (at the end of the third week) to 92% during the ninth week
Li et al. (2015)	Reinforcement/Feedback (Duration: nine weeks)	The two work teams' baseline safety index is 64% and 63%. Following the intervention, it increased to 87% and 92%.
Guo et al. (2018)	Reinforcement/Feedback (Duration: 30 weeks)	Mixed effectiveness: mixed results.

Table 3

Summary of Scientific Evidence of BBS when Intervening with Reinforcement

Author and Year	Type of Intervention	Result
Choudhry (2012)	Feedback (Duration: eight weeks)	Safety performance improved in Project A (92%), Project B (93%) and Project C (92%).
Chen and Tian (2012)	Feedback (Duration: seven weeks)	The safety index improved by 15%.
Oostakhan et al. (2012)	Feedback (Duration: nine weeks)	The safety index of the experimental group improved from 66% to 92%.
Becerril (2013)	Feedback (Duration: nine weeks for both buildings 1 and 2)	Study 1 showed an improvement in the General Safety Index from 60% to 84%. Study II showed an improvement in the Safety Index of behaviour and personal protective equipment from 77% to 88%. Study III showed a decrease in the unsafe behaviour rate from 84% to 82%. Study IV showed an improvement in the Safety Index of behaviour and personal protective equipment from 69% to 82%.
Zhang and Fang (2013)	Feedback (Duration: eight weeks)	Safety performance improved at Site A (64% to 82%) and Site B (64% to 89%).
Lee et al. (2014)	Feedback (Duration: twenty-four weeks)	Safety performance improved from 57% to 79%.

Reinforcement and Feedback

Two reinforcement studies found that BBS proved effective in increasing safe behaviours (Choudhry, 2014; Li et al., 2015), and one reported mixed effectiveness (Guo et al., 2018). At the same time, all six studies showed that feedback was effective in increasing safe behaviours (Becerril, 2013; Chen & Tian, 2012; Choudhry, 2012; Oostakhan et al., 2012; Lee et al., 2014; Zhang & Fang, 2013).

Socio-demographic Characteristics

In a study conducted in Spain, BBS was implemented in a project that included constructing a building and an educational centre with workers with an average age of 30 (Becerril, 2013). Five studies were found that implemented BBS in China, four in building construction projects (Choudhry, 2014, 2012; Chen & Tian, 2012; Zhang & Fang, 2013), and one in a housing construction project (Li et al., 2015). One study applied BBS in Singapore for a tunnel construction project (Guo et al., 2018), and another used it in South Korea for a road construction project, with workers with an average age of 56 (Lee et al., 2014). Finally, one study applied BBS in Iran with subcontractors (Oostakhan et al., 2012).

Was BBS Effective in the End?

Overall, 90% of the studies included (Becerril, 2013; Chen & Tian, 2012; Choudhry, 2012, 2014; Lee et al., 2014; Li et al., 2015; Oostakhan, 2012; Zhang & Fang, 2013) showed significant improvement in safety indices after applying BBS. As for the type of intervention, 67% of the studies only used feedback (Becerril, 2013; Chen & Tian, 2012; Choudhry, 2012; Lee et al., 2013; Oostakhan, 2012; Zhang & Fang, 2013), with 33% using both reinforcement and feedback (Choudhry, 2014; Guo et al., 2018; Li et al., 2015).

Regarding the category of personal protective equipment use, it was found that BBS can positively

impact the increase in the frequency of this behaviour (Becerril, 2013; Choudhry, 2014; Lee et al., 2014; Zhang & Fang, 2013). Other behaviour categories that achieved positive results were order and cleanliness (Becerril, 2013; Lee et al., 2014) and heavy-load traffic management (Becerril, 2013; Guo et al., 2018; Lee et al., 2014). According to the findings, BBS was an effective intervention for accident prevention, contributing to the continuous improvement of occupational health and safety systems.

DISCUSSION

Eight of the nine studies included showed a significant increase in safe behaviours when BBS was implemented, with behavioural programs being the most successful in improving occupational health and safety in the construction industry (Becerril, 2013; Chen & Tian, 2012; Choudhry, 2012, 2014; Lee et al., 2014; Li et al., 2015; Oostakhan, 2012; Zhang & Fang, 2013). These findings are similar to previous reviews analysed in other industrial sectors, confirming the effectiveness of the behavioural approach for accident prevention (Grindle et al., 2000; McAfee & Winn, 1989; Tuncel et al., 2006). Behaviourism provides a solid body of knowledge for explaining human behaviour (Skinner, 1974; Thorndike, 1911; Watson, 1913) and is the theory underpinning the practice of BBS (Geller, 2005).

Regarding the studies analysing BBS when the intervention included reinforcement, two out of three concluded that it was effective because they showed a significant increase in safe behaviours (Choudhry, 2014; Li et al., 2015). However, reinforcement does not consistently achieve the desired results. In this review, one study showed that BBS displayed mixed effectiveness (Guo et al., 2018). The authors of this study attributed it to three reasons: goal commitment, punishment and financial incentives.

Regarding the first reason, job performance often decreases if a worker behaves safely, creating more significant pressure to achieve the goal and paying less attention to the safety process. A possible explanation for this event could be found in the safety climate model. For Zohar (1980), the safety climate encompasses eight factors, foremost among which are management attitudes towards safety and the effects of the workplace on safety. The problem could lie in these two factors, which may have explained why several workers in the study significantly modified their safety behaviour.
At the same time, punishment created more significant conflict among the collaborators, who looked askance at the safety observers. Based on this second reason, there is evidence that managers can use behavioural observation reports to "punish" workers, for example, by increasing the workload, creating dissatisfaction and mistrust (Cox & Jones, 2006). It has been proven that psychosocial risks such as a high work pace and low social support can significantly influence accidents, with these factors being highly detrimental to worker health (Pujol-Cols & Lazzaro-Salazar, 2021).

Regarding the third reason, it was evident that one group of workers received incentives while the other did not, creating a negative link between rewards and access. When workers realized that behaving safely failed to reap the rewards, they modified their behaviour. The functional analysis of behaviour can explain this (Skinner, 1974). However, what happened to the workers who only observed these consequences yet modified their behaviour? Vicarious learning could provide more insight into this (Bandura & Walters, 1977). This type of learning is based on the imitation and observation of models. Whether or not the model is relevant to the individual, behaviours can be shaped by observation based on the consequences the model receives (Manz & Sims, 1981). When workers observed that their colleagues failed to receive rewards for their safe behaviour (Guo et al., 2018), they probably saw no reason to adopt safe procedures.

All the studies using BBS with feedback were found to be effective because they revealed a significant increase in safe behaviours. Previous reviews have shown similar results, highlighting the reinforcement of safe behaviours and decreased workplace accidents (Grindle et al., 2000; McAfee & Winn, 1989). BBS has proven to have a positive impact on increasing the use of personal protective equipment (Becerril, 2013; Choudhry, 2014; Lee et al., 2014; Zhang & Fang, 2013), order and cleanliness (Becerril, 2013; Lee et al., 2014) and heavy-load traffic management (Becerril, 2013; Guo et al., 2018; Lee et al., 2014).

More than half the studies were conducted in China (Chen & Tian, 2012; Choudhry, 2012, 2014; Zhang & Fang, 2013; Li et al., 2015). These findings are similar to bibliometric studies, indicating that Asian countries have higher scientific production (Abd et al., 2021). In addition, some studies reported that they implemented BBS for eight (Choudhry, 2012), nine (Oostakhan et al., 2012) or 30 weeks (Guo et al., 2018). Other studies show a similar time range (Jiménez et al., 2011; Lingard & Rowlinson, 1997; Mattila

& Hyödynmaa, 1998). These findings suggest that the length of time BBS is implemented depends on the possibilities and needs of each organisation. However, this does not mean that behavioural techniques and procedures cease to be valid.

This systematic review differs from other reviews in that it adhered to the international PRISMA 2020 parameters (Page et al., 2021), used semi-automated software (Ouzzani et al., 2016; Zaugg et al., 2011), and included bibliometric contributions (Abd et al., 2021). This study, therefore, contributes to the corpus of knowledge of psychology applied to occupational health and safety.

Limitations

Although this review met its stated objectives, potential limitations were identified, which will be described below. The eligibility criteria restricted the years of publication to a set period, a criterion supported by bibliometric contributions (Abd et al., 2021), meaning that scientific articles and doctoral theses outside this range were excluded. At the same time, despite being based on behavioural psychology (Skinner, 1974), BBS has been criticised because of its emphasis on external variables such as reinforcers and the exclusion of features such as safety climate and culture from analysis (Oliver et al., 2006; Zohar, 1980). It is worth mentioning that there are models in the scientific literature that attempt to incorporate behavioural and organisational features for the prevention of occupational accidents, considering environmental conditions, information, feedback and leadership (Meliá, 1995) as well as multifaceted interventions (Dyreborg et al., 2022).

This systematic review will interest professionals wishing to innovate occupational health and safety systems in the construction industry. We also hope it will contribute to incorporating new health policies and improve organisations' detection and intervention of risk behaviours.

CONCLUSIONS

The objectives proposed in this systematic review have been achieved based on the findings. Eight of the nine studies showed that BBS contributed to reinforcing safe behaviours and significantly reduced the rate of occupational accidents, which is particularly relevant to the construction industry. We hope this study will be a valuable contribution to the field of psychology applied to occupational safety and health.

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Conflict of interest

The authors of this article declare that they have no conflict of interest.

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