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Examining challenges in adopting safety leading indicators for construction projects in South Africa

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Purpose: The construction industry has been observed to be one of the most dangerous sectors in which to work; thus, it has struggled to attract new employees and suffered from skill shortages. Another characteristic is adopting a reactive approach to preventing accidents instead of a proactive approach that implements safety-leading indicators. In contributing to achieving a safer construction industry, this study investigated the barriers to achieving a proactive approach to safety in the construction industry.

Method: The study adopted a quantitative approach. Data was collected by randomly administering a well-structured questionnaire to industry professionals in South Africa. One hundred and two questionnaires were collected and used as the basis for data analysis and interpretation by the study.

Result: The analysis of the collected data identified nineteen significant barriers which were clustered into two based on an exploratory factor analysis. The top three ranked significant barriers are Lack of Top management's commitment to safety, Lack of leadership training and Prioritising productivity over employee safety. The two clusters formed from the nineteen barriers through factor analysis are top management approaches to safety and Safety culture through employee-centric training and accountability.

Originality: Considering the accident data from South Africa, and the inherent benefits of implementing SLI to overcome this, this study provides critical insights for industry stakeholders and policymakers. It fills a gap that has not been filled in the developing country context before now.

KEYWORDS

SLI, proactive safety behavior, developing countries, construction project, health safety and environment (HSE)

1 Introduction

The construction industry grapples with significant challenges in ensuring the safety and wellbeing of its workforce, as it persistently records higher rates of fatalities, injuries, and illnesses compared to other sectors. This issue is prevalent in numerous developed countries, such as the United States, Australia, and New Zealand, where the fatality rate in the construction sector is triple that of other industries (Chen et al., 2018; Xu et al., 2023).

These alarming statistics emphasise the critical importance of addressing safety concerns within the construction industry.

Despite the abundance of safety-related research and the persistent endeavours of construction contractors to enhance safety performance, the industry is still grappling with mitigating the frequency of workplace accidents, injuries, and fatalities. One strategy is to include safety performance indicators in contractor safety initiatives to improve safety performance in the construction sector. These indicators are designed to measure the impact of accident prevention initiatives on safety outcomes, providing valuable insights to help companies better understand and improve their safety management processes (Rajendran and Asce, 2013). Researchers are actively developing new methods and metrics to effectively implement safety performance indicators, recognising their potential to significantly impact workplace safety in the construction sector (Manuele, 2009). Reiman and Pietikainen (2012) suggest that these safety performance indicators can serve as organisational mechanisms for evaluating and refining the functioning of a sociotechnical system, thereby making them valuable tools for safety management within organisations (Shaikh et al., 2020). By employing these indicators, construction companies can establish data-driven strategies to reduce the occurrence of accidents, injuries, and illnesses, ultimately leading to a safer work environment for all involved.

Previous research has examined various factors that influence how workers behave safely, such as their level of engagement in safety activities (Schwatka et al., 2016) and their motivation to comply with safety rules and procedures (Guo and Yiu, 2016). However, Rajendran and Asce (2013) adopted a different approach, by using a safety professional to assess worker safety behavior with a checklist. This method allowed Rajendran and Asce (2013) to explore the possible relationships between leading and lagging indicators of safety performance. He collected data on these indicators for a construction project over 37 weeks. Choosing appropriate leading indicators is crucial for improving safety performance. However, this choice depends on two main factors. Firstly, using leading indicators is tailoring them to the company or location. This is because not all companies and sites share the same risks, safety system designs, management structures, or degrees of risk (Leveson, 2015). Thus, rather than choosing indicators at random from the literature, one should instead use a safety model that considers the specifics of the organization and the projects it undertakes (Akroush et al., 2017). Secondly, leading indicators must be validated by showing their correlations to safety performance. This means that leading indicators should be able to predict or prevent lagging indicators from occurring (Stricoff, 2000). Therefore, leading indicators should be tested and evaluated on each site to ensure their reliability and usefulness.

Despite the importance of leading safety indicators in every context of construction globally, it is observed that they have not been implemented. Hence, most developing countries still struggle to achieve safe construction sites (Okoro and Musonda, 2016; Adekunle et al., 2022; Adekunle et al., 2023). A critical study of the safety challenges identified in these studies compared to the inherent benefits in its implementation. It, therefore, begs the question of what is hindering its implementation. Consequently, the study aims to identify the onsite safety practices that are barriers to implementing safety leading indicators in the construction industry.

2 Safety leading indicators in the construction industry

Safety indicators in the construction industry are categorized into leading and lagging indicators, serving distinct purposes in measuring and improving safety performance (Akroush et al., 2017). Leading indicators focus on accident prevention efforts and are proactive measures that change before industry trends emerge. Safety concerns have heightened due to high injury and fatality rates in construction, drawing attention from lawmakers, employers, and scholars. In contrast, lagging indicators assess accident outcomes, providing retrospective data on safety performance (Agumba and Haupt, 2012). While their utility as future workplace safety predictors is debated, they offer crucial insights into past events. However, lagging indicators have limitations in driving proactive safety management (Grabowski et al., 2010; Hinze et al., 2013). Consequently, leading indicators have garnered increasing attention for their preventative nature (Hinze et al., 2013; Guo and Yiu, 2016; Lingard et al., 2017; Xu et al., 2023), enabling construction firms to develop intervention strategies to address deficiencies before incidents occur (Hinze et al., 2013).

Hinze et al. (2013) emphasize that relying on lagging indicators does not significantly enhance safety performance unless an accident has already occurred. Leading indicators facilitate early process improvements, significantly influencing overall safety. Rajendran and Gambatese (2009) argue that proactive safety management, through leading indicators, offers greater benefits to construction safety performance. Leading indicators assess construction safety processes and allow timely interventions when issues are detected. They enable real-time evaluation of process efficacy, reducing injury risks (Hinze et al., 2013). Leading indicators are divided into passive and active categories (Hinze et al., 2013). Passive indicators, planned before work commencement, are often documented but not necessarily measured for effectiveness (Alruqi et al., 2019). Examples include safety policies and training programs (Hinze et al., 2013; Xu et al., 2021). Active indicators measure the execution and quality of safety management during work, providing feedback and learning opportunities. These include pre-task safety meetings, safety audits, near-miss reporting, and safe behavior incentives (Hallowell et al., 2013).

Hinze et al. (2013) identify nine key elements of a successful safety program, including management support, safety staff, planning, education, employee participation, safety behavior incentives, accident investigations, substance abuse prevention, and subcontractor management. These elements should be regularly monitored as leading indicators. Akroush et al. (2017) surveyed Tennessee construction firms, identifying 48 safety performance indicators, with larger firms having more structured safety programs. Hallowell et al. (2013) classify safety-leading indicators into owner-led, contractor-led, and vendor-led categories. Guo and Yiu (2016) propose a four-step model for developing leading indicators: conceptualizing the system, operationalizing constructs, generating indicators, and validating them. Their model produced 32 indicators for a hypothetical project, addressing various safety aspects, such as safety plan existence and supervisor support.

Client organizations often evaluate contractors based on safety management leadership and worker training during procurement

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TABLE 1 An overview of safety leading indicators.

References	PPE	Site audits	Training	Near Miss	Incentive	Sub contractor safety measures	Personnel safety culture	Organization commtiment	Client engagement	Upper-management involvement	Pretask safety meeting	Hazard and accident analysis
Leadership (2019)		Y	Y			Y	Y					
Rajendran and Asce (2013)				Y		Y	Y				Y	
Sparer et al. (2015)			Y			Y	Y					
Lingard et al. (2017)			Y	Y								
Niu et al. (2017)			Y				Y					
Hinze et al. (2013)		Y	Y	Y					Y			Y
Xu et al. (2023)		Y	Y					Y	Y			
Hallowel and Gambatese (2009)			Y							Y		
Choudhry et al. (2008)	Y									Y		
Salas and Hallowell (2016)				Y					Y	Y		Y
Hallowell et al. (2013)			Y								Y	
Cheng et al. (2013)												Y
Aksorn and Hadikusumo (2008)	Y						Y					
Guo and Yiu (2016)					Y			Y				
Agumba and Haupt (2012)							Y	Y				
Alruqi et al. (2019)			Y						Y			Y
Biggs and Biggs (2013)			Y		Y							

TABLE 2 Respondents demographic background.

Highest educational qualification	Percent
Diploma	17
Bachelor degree	35
Honours degree	31
Masters degree	17
Job title	Percent
Project manager	11
Architect	8
Civil Engineer	11
Construction health and safety agent	7
Construction health and safety manager	11
Construction health and safety officer	10
Construction manager	12
Designer	2
Mechanical engineer	12
Project engineer	5
Project planner	2
Quantity surveyor	9
Organisation	Percent
Consultant	26
Contractor	29
Government	6
Client	39

(Liu et al., 2019), though these may not reflect actual safety performance (Oswald et al., 2018). Salas and Hallowell (2016) propose a comprehensive approach to measuring safety-leading indicators, identifying seven variables predictive of future injury rates, including near-miss reporting and upper management participation. Alruqi et al. (2019) found that regular use of active indicators, like pre-task briefings, positively impacts future safety performance. Xu et al. (2021) conducted a systematic review, identifying 16 leading indicators categorized into organizational, operational, and cognitive/behavioral aspects.

Sinelnikov et al. (2015) argue that using leading indicators to communicate safety goals, especially to senior management, fosters a positive safety culture. Near misses, identified as critical leading indicators, provide learning opportunities by analyzing potential hazards (Rajendran and Asce, 2013; Wanberg et al., 2013). Effective strategies to reduce near misses include PPE usage and adherence to safety procedures (Dilkhaz and Neamat, 2019). Evaluating subcontractor safety is also crucial, with models proposed by Guo and Yiu (2016) and Sparer et al. (2015) offering methods to assess performance based on leadership and behavior observations. Training is another essential leading indicator, enhancing worker safety knowledge and attitudes (Guo and Yiu, 2016; Schwatka et al., 2016; Niu et al., 2017; Oladiran and Onatayo, 2019). Regular safety talks, such as toolbox meetings, improve safety communication and information sharing (Lingard et al., 2017). Table 1 presents various safety leading indicators in literature.

TABLE 3 Frequency of accidents witnessed.

Frequency of witnessing accidents	Percent
Never	3
Occasionally	38
Sometimes	32
Often	25
Always	2

3 Research method

This research adopted a similar approach to (Adekunle et al., 2022; Akinradewo et al., 2022; John et al., 2023). A thorough review of the existing study on safety leading indicators was critically done. Afterwards, a well-structured questionnaire was distributed among construction industry professionals on the practices constituting barriers to implementing safety leading indicators in the South African construction industry. Questionnaires have been adopted to understand and gather respondents' perspectives on various concepts in the construction industry (Oke et al., 2021; Aliu et al., 2022a; Ikuabe et al., 2022). The questionnaires for this study were distributed using an online survey platform.

Responses were gathered from different professionals in the industry, as outlined in the demographic details (Table 2). The research instrument was divided into two sections; the first section dwells on the respondents' demographic information, while the second section presents the respondent's site safety experience (Table 3) and the factors of barriers to SLI adoption to the respondents (Table 4). The response from the questionnaire was duly analysed using the mean, standard deviation, and exploratory factor analysis. The choice of analysis tool adopted was to understand the most significant factors ranked based on the average of the responses. Also, the factors were clustered through factor analysis based on the relationship within them. A total of one hundred and two responses were gathered and adopted for the study. The Cronbach alpha coefficient of 0.974 was achieved for the study, showing that the instrument is reliable.

4 Findings

This section presents the findings of the study starting with the background information of respondents.

4.1 Background information of respondents

This section presents the characteristics of the study respondents. It helps to properly identify the respondents' suitability through an assessment of their details for the study.

TABLE 4 Barriers to SLI implementation.

Barriers	Mean	Std. Deviation
Lack of Top management's commitment to safety	4.7	0.772
Lack of leadership training	4.64	0.811
Prioritising productivity over employee safety	4.64	0.823
Not reporting incidents and near misses	4.57	0.795
Lack of employee training	4.54	0.904
Under-reporting of incident in order to receive incentives	4.52	0.959
Costs saving	4.51	0.99
Ineffective enforcement of H&S rules	4.49	1.04
Absence of reporting system	4.48	1.01
Ambiguity in implementation	4.47	0.989
Insufficient safety budget	4.45	0.999
Rigid organisational business model	4.43	1.057
Top management is not willing to adopt new initiatives	4.43	0.977
Employees are reprimanded when reporting incidents or near misses	4.43	1.13
Lack of incentives	4.4	1.073
Lack of best practices or benchmark	4.4	0.953
Substandard tools and equipment	4.37	1.06
Unskilled workers	4.34	1.183
Insufficient health & safety laws	4.02	1.4

As presented in Table 2, the majority of the respondents possess bachelors degree (35%), 31% have honours degree, while diploma (17%) and Masters degree holders are 17% of the respondents. It can also be observed that construction managers and mechanical engineers having 12% respectively, constitute the major profession of respondents. Other professionals forming the respondents of the study include project managers (11%), civil engineers (11%), construction health and safety manager (11%), and other professionals, which are presented in Table 2. The respondents work for client organisations (39%), contracting firms (29%), consulting firms (26%) and government/ public clients (6%).

To understand the respondents' experience in terms of witnessing accidents on Construction sites (Table 3). It is observed that most of the respondents witnessed accidents occasionally (38%) while 32% witnessed it sometimes. Only 3% responded that they had never witnessed an accident on the construction sites.

4.2 Barriers to implementing safety leading indicators

The respondents were presented with nineteen barriers in the form of practices that hinder the implementation of safety leading indicators in the construction industry. All the barriers presented achieved a mean score higher than 3.00, which means that all the barriers are significant (Akinradewo et al., 2022). Furthermore, the results reveal that the lack of top management support is the most significant and highly rated by the respondents. Other barriers making up the top five include lack of leadership training, the practice of prioritising productivity over employee safety, not reporting incidents and near misses and lack of employee training. Although ranked as the bottom five, they are also significant barriers, as earlier stated. The bottom five ranked barriers are lack of incentives, lack of best practices or benchmark, substandard tools and equipment, unskilled workers and insufficient health and safety rules.

Although there is a dearth of studies focusing on unearthing the barriers to the implementation of SLI in the construction industry, this is because existing studies are mostly focused on identifying SLI and establishing its benefits over safety lagging indicators. However, the identified barriers are very critical if the implementation of SLI is to be achieved in the construction industry. Thus, to implement SLI in construction, all the identified barriers must be overcome.

4.3 Exploratory factor analysis

To achieve further meaning from the collected data, it was subjected to EFA. This was done with the intent to explore and further understand the correlation pattern within the barriers. Firstly, tests were conducted to determine the adoption of EFA based on the results and the study sample's adequacy. To achieve

TABLE 5 Communalities of barriers to SLI implementation.

Communalities	Initial	Extraction
Lack of Top management's commitment to safety	1	0.869
Lack of best practices or benchmark	1	0.675
Lack of leadership training	1	0.857
Lack of employee training	1	0.734
Not reporting incidents and near misses	1	0.636
Insufficient safety budget	1	0.684
Top management is not willing to adopt new initiatives	1	0.619
Employees are reprimanded when reporting incidents or near misses	1	0.656
Insufficient health & safety laws	1	0.664
Unskilled workers	1	0.784
Ineffective enforcement of H&S rules	1	0.793
Under-reporting of incident in order to receive incentives	1	0.679
Production over employee safety	1	0.775
Substandard tools and equipment	1	0.837
Costs saving	1	0.77
Ambiguity in implementation	1	0.814
Lack of incentives	1	0.822
Absence of reporting system	1	0.819
Rigid organisational business model	1	0.803

Extraction Method: Principal Component Analysis.

this, the communalities of the barriers were analysed (Table 5), and it was revealed that all the barriers achieved values between 0.6 and 0.9, thus indicating the appropriateness of EFA. This aligns with (Aliu et al., 2022b). In addition, two tests were conducted to determine the suitability and factorability of the research instrument for factor analysis. These tests are the Kaiser-Meyer-Olkin (KMO) estimate of sampling adequacy and the Bartlett sphericity test. The KMO achieved a value of 0.925, which is above the threshold of 0.6. The Bartlett sphericity test was significant at 0.000, which is less than 0.05. These results indicate that the EFA can be adopted as the variables for the study are factorable and suitable for the analysis.

Table 6 presents the total variance of the factors retained having Eigen values of 13.251 and 1.039 being retained. The table shows two components have been retained, explaining 69.741% and 5.467% of the variance, respectively, and cumulatively explaining 75.207%of the variance. Consequently, there are two clusters from the EFA.

4.3.1 Cluster 1 – Top management approach to safety

This cluster consists of twelve factors, they are "Substandard tools and equipment" (82.8%), "Lack of incentives" (82.4%), "Rigid organisational business model" (79.5%), "Absence of reporting system" (79.4%), "Ambiguity in implementation" (79.1%), "Unskilled workers" (78.1%), "Insufficient health & safety laws" (76.9%), "Costs saving" (75.7%), "Ineffective enforcement of H&S rules" (74.5%), "Top management is not willing to adopt new initiatives" (64.7%), "Insufficient safety budget" (64%), and "Employees are reprimanded when reporting incidents or near misses" (59.2%). A critical look at these factors reveals that they are centred on the approach or practices of the top management as regards safety proactiveness. The top management constitutes a critical decision making cadre (Aghimien et al., 2021) whose decisions critically determine what happens on the site. For instance, they determine the budget allocation, the type of tools and equipment provided for employees, the type and availability of PPE, and budget allocation for safety among others. One of the factors indicates the unwillingness of top management to adopt new initiatives and innovations to achieve a proactive approach to safety. In the current era, there are different technologies and innovations to achieve the prevention of accidents. This is due to the disruptive nature of technology to transform the construction industry across all aspects (Adekunle et al., 2021; Ejohwomu et al., 2021). In addition, technology has been identified as a critical enabler of safety on construction sites (Adekunle et al., 2023). The unwillingness or rigidity of top management to adopt new technologies and innovation thus leads to sticking to the *status quo* of the construction industry being a dangerous industry and unattractive to new employees due to its unsafe nature. Consequently, top management of construction organisations plays a critical role in the implementation of SLI in the construction industry and must be open to new ways of

TABLE 6 Total variance explained and matrix for barriers to SLI implementation.

	Component		% Of variance
	1	2	
Substandard tools and equipment	0.828		70
Lack of incentives	0.824		
Rigid organisational business model	0.795		
Absence of reporting system	0.794		
Ambiguity in implementation	0.791		
Unskilled workers	0.781		
Insufficient health & safety laws	0.769		
Costs saving	0.757		
Ineffective enforcement of H&S rules	0.745		
Top management is not willing to adopt new initiatives	0.647		
Insufficient safety budget	0.64		
Employees are reprimanded when reporting incidents or near misses	0.592		
Lack of leadership training		0.869	5
Lack of Top management's commitment to safety		0.815	
Lack of best practices or benchmark		0.776	
Lack of employee training		0.714	
Prioritising productivity over employee safety		0.708	
Under-reporting of incident in order to receive incentives		0.656	
Not reporting incidents and near misses		0.641	

implementing safety, allocate sufficient budget for safety, and ensure the purchase of appropriate tools, among others, to achieve a proactive approach to safety.

4.3.2 Cluster 2 – Safety culture through employee centric training and accountability

Seven factors were loaded on this cluster; they are: "Lack of leadership training" (86.9%), "Lack of Top management's commitment to safety" (81.5%), "Lack of best practices or benchmark" (77.6%), "Lack of employee training" (71.4%), "Prioritising productivity over employee safety" (70.8%), "Under-reporting of incident in order to receive incentives (65.6%), and "Not reporting incidents and near misses" (64.1%). In a study articulating the safety experience of construction workers on construction sites, Adekunle et al. (2023) observed that workers receive inadequate safety training. It is thus not surprising that this cluster is made up mainly of factors centred on safety training as a barrier to achieving the implementation of SLI in the construction industry. In achieving a proactive approach to safety, there is a need for proper training for new employees. This requires an intentional training regime. Linked to the first cluster is a commitment of the top management to putting in place a defined accident and near misses reporting to achieve the development of a proper proactive framework for accident prevention. Top management must also prioritise productivity over the safety of employees. Thus proper PPE and equipment must be put in place, especially at heights and dangerous working positions, with proper housekeeping rules. Workers must be properly trained in the use of equipment and PPEs, and the same must be used by workers at every time.

5 Implications of the study

The study identifies the barriers to adopting SLIs in the construction industry using South Africa as a case in point. From the findings, the study has diverse implications for research and industry stakeholders. It has contributed to the existing knowledge in this regard. It has also provided a foundation for the contextual understating of SLI adoption especially from the developing country perspective. The study encourages an adoption of employee and site workers centric safety approach on construction sites. Regular training and safety meetings should be institutionalized to foster a culture of safety and continuous improvement. These training programmes should be developed to enhance workers knowledge and skills in this regard. Stakeholders through the knowledge of the barriers can adopt comprehensive SLIs that is context specific which help address proactively the issues of safety.

Through the study findings policymakers can use the study's findings to develop regulations that mandate the use of leading indicators in construction projects, thus driving industry-wide adoption. Safety performance criteria, including leading indicators, should be integrated into the contractor selection process to ensure that safety is prioritized from the project's inception. So also at the organizational level, firstly, Senior management must demonstrate a commitment to safety by prioritizing the use of leading indicators and allocating necessary resources for their implementation. Secondly, Construction firms should establish clear roles and responsibilities for safety management across all levels of the organization, from top management to on-site workers. Thirdly, Safety audits and near-miss reporting systems should be enhanced to provide timely feedback and facilitate continuous safety improvements. Fourthly, Safety leadership training for supervisors and managers can ensure that they are equipped to enforce safety protocols and foster a positive safety culture.

6 Conclusion

This study articulated the barriers to the implementation of SLI in the construction industry in order to achieve a proactive approach to safety. Hence achieving a safer construction industry. From the data gathered from industry professionals in the South African construction industry, it was observed that nineteen barriers form the constraints to achieving SLI in the construction industry. Further analysis using exploratory factor analysis clustered these barriers into two these are top management approaches to safety and Safety culture through employee centric training and accountability. There is a need to adopt a more proactive approach as against a reactive approach to tackling the high accident rate prevalent in the construction industry. Top management is considered a critical player and enabler as critical decisions are taken by the top management of construction organisations. These decisions go a long way to determine how safety is achieved on construction sites. These decisions centre on safety training regimes, timely and accurate reporting of near misses and accidents, the adequate budget allocated to safety, adoption of new technologies, initiatives and innovations for safety, provision of proper tools, equipment and PPE for workers use, strict safety monitoring process, non-prioritisation of productivity over the safety of workers among others. There is also the need for policies to be employee centric as a leading indicator to achieve safety on construction sites. Despite the novelty of the findings, care must be taken to generalise them as the study was conducted in South Africa. Future studies can be conducted in other developing countries, and the results can be compared to see if the results are context-dependent. Further studies can also be conducted using a qualitative approach.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

SA: Conceptualization, Formal Analysis, Investigation, Writing–original draft, Writing–review and editing. DO: Data curation, Validation, Writing–original draft. IE: Investigation, Project administration, Writing–review and editing. CA: Methodology, Supervision, Writing–review and editing.

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