

# Potential of adopting a resilient safety culture toward improving the safety performance of construction organizations in Nigeria

Mu'awiya Abubakar and Bello Mahmud Zailani  
*Department of Building, Faculty of Environmental Design,  
Ahmadu Bello University, Zaria, Nigeria*

Muhammad Abdullahi  
*Department of Quantity Surveying, Faculty of Environmental Design,  
Ahmadu Bello University, Zaria, Nigeria, and*

Abubakar Muhammad Auwal  
*Department of Building, Faculty of Environmental Design,  
Ahmadu Bello University, Zaria, Nigeria*

## Abstract

**Purpose** - Despite the efforts of organizations to improve safety performance, shortfalls of the strategies have been reported in numerous studies around the globe. However, previous studies in countries with more organized construction sectors show that adopting a resilient safety culture by organizations has a tendency of improving safety performance. As safety culture is dynamic which differs with geographical context, the purpose of this paper is to achieve two objectives: testing the causal relationship between safety performance and resilience safety culture in the Nigerian construction environment; and determining the key components for ensuring the resilience of construction organizations with regards to safety.

**Design/methodology/approach** - Quantitative research approach was used. Data was collected using a structured questionnaire. The population of the study comprises small and medium construction organizations predominantly across the Northern region in the Nigerian built environment. A total of 180 questionnaires were distributed to construction managers and safety managers in respective organizations to serve as respondents to the study. Partial least square - structural equation modeling (PLS-SEM) was used to test the relationship between safety performance and resilience safety culture. While principal component analysis was used determining the key components for ensuring the resilience of construction organizations with regards to safety.

**Findings** - Findings of this study revealed that resilient safety culture has a significantly strong positive relationship with safety performance. Safely hazard recognition and effective safety response altitude were identified as the key components for guaranteeing a resilient safety culture.

**Practical implications** - With a view to achieve a consistently high safety performance, organizations have to acknowledge and anticipate unexpected hazardous events and provide the necessary safety resources to manage them. Furthermore, there is also the need to create awareness on recognized safety concerns on safety hazards, coupled with a dynamic risk response altitude to ensure consistent improvement in safety performance.

**Originality/value** - This study presents an alternative to the slow and reactive safety culture of the Nigerian built environment. This study builds on existing literature, and the findings explore the



potential impact of adopting a resilient safety culture in construction organizations in Nigeria. This study provided further insights into key factors organizations need to focus on to ensure resilient nature. To the best of the authors' knowledge, no prior study in this regard was conducted in Nigeria despite its apparent need.

**Keywords** Construction organizations, Safety culture, Safety performance, Resilient engineering

**Paper type** Research paper

## Background

The construction industry experiences the largest proportion of accidents and fatalities, which makes it among the most hazardous across the globe (Törner and Pousette, 2009; Tam and Fung, 2012). The alarming rates of construction accidents in both developed and developing countries, is not commensurate with the percentage of workforce used by the industry in comparison with others. The construction industry in many developing countries has been reported to account for about 11% of all occupational injuries and 20% of deaths (Arumugam and Thirumurthy, 2007), while in the developed nations, the sector uses between 6% and 10% of the total workforce but accounts for between 25% and 40% of work-related deaths (Lingard, 2013). Moreover, the International Labor Organization lamented that one in every six fatal accidents at work occurs on construction sites (ILO, 2005). This shows the extent of danger associated with working in construction and the need to constantly devise hazard control measures to keep workers and stakeholders safe on construction sites. Construction site accidents are mainly caused by worker's unsafe behaviors and organization's nonchalant attitude toward safety hazards (Fang and Wu, 2013; Feng, 2015). This is largely due to the fact that workplace safety is a complex phenomenon and the subject of attitudes and safety performance in construction industry is even more complex (Choudhry *et al.*, 2008). As such, developing and maintaining a positive safety culture is crucial for improving the safety performance of construction projects and organizations. Moreover, safety cannot be guaranteed by legislation or regulations alone, nor should it be the sole responsibility of the employer, the employees must also commit themselves to safety as an important enabler of successful project delivery (Baig, 2001). Construction organizations have traditionally adopted a holistic safety management strategy with emphasis on two types of responses, prevention and protection, to reduce workers' exposure to on-site hazards (Mitropoulos *et al.*, 2005; Feng, 2015). However, recent studies have exposed the shortcomings of such safety management approaches (Fung *et al.*, 2020; Trinh and Feng, 2020; Trivedi and Yadav, 2020). It has been argued that the dynamic nature of construction projects, which manifest in the complexity of technology, job tasks and organizational structures of construction projects have brought about changes and uncertainties in the nature of safety risks. This has, therefore, undermined the effectiveness of traditional safety management approaches (Dekker, 2012). This is because the effectiveness of traditional safety management approaches is largely dependent on the extent to which safety risks are known or can be made known (Hollnagel, 2008). As traditional approaches tend to be institutionalized through policies, plans, procedures and processes for safety management, they are not easily and readily adaptable to the dynamic nature of construction works and the emerging and unforeseen safety risks being encountered (Wachter and Yorio, 2014). This inadequacy calls for alternatives that can address the challenges faced by the traditional safety management methods.

A resilience engineering approach has the potential of advancing an organization's capability to enable foresight and recognize and anticipate the changing shape of risks before occurrence of adverse events (Woods and Hollnagel, 2006). Resilience safety culture, which originates from the resilience engineering approach builds on the organization's cognitive, behavioral and managerial capabilities to "anticipate, monitor and learn" to manage safety risks and build an ultra-safe organization (Shirali *et al.*, 2016). The approach has been recognized as a potential solution to the lack of effectiveness of traditional safety management and safety culture approaches in responding to the changing and unforeseen safety risks associated with the increasingly complex nature of sociotechnical systems (Pecillo, 2016; Fung *et al.*, 2020).

The concept of resilient safety culture is gaining grounds in construction research and practice. Several studies have emerged in recent years, emphasizing the need for a paradigm shift with regards to the safety culture of construction organizations (Feng and Trinh, 2019; Garg *et al.*, 2019; Fung *et al.*, 2020; Trinh and Feng, 2020; Trivedi and Yadav, 2020). Findings of these studies provide insights into the mechanisms by which resilient safety culture can be entrenched in construction organizations. Feng and Trinh (2019) noted that construction organizations can develop a resilient safety culture by systematically responding to regular and irregular threats and uncommon events in the construction environment. Different dimensions of resilient safety culture have been reported to have positive impact on organizational safety performance (Fung *et al.*, 2020; Trinh and Feng, 2020; Trivedi and Yadav, 2020).

The previous studies were conducted in countries with relatively more organized construction sectors such as India, Vietnam and Hong Kong, where there are safety regulations guiding the activities of construction organizations. In Nigeria, however, the construction industry is characterized by near absence of safety regulations and low awareness of safety principles among construction workers (Smallwood and Haupt, 2005; Kheni *et al.*, 2008; Okeola, 2009). Poor compliance with Health and Safety principles and practices in construction activities in Nigeria manifest due to lack of monitoring and enforcement of safety policies and standards (Adebisi *et al.*, 2020; Nouban and John, 2020). More so, as construction practices vary with environments (Gunhan and Arditi, 2005), and safety culture is dynamic in relation to operational and geographical contexts. This makes it impracticable to generalize the findings of the existing studies to all construction environments. Therefore, this study enriches the literature by exploring the potential impact of resilient safety culture on safety performance of construction organizations in the Nigerian construction industry and determining the key components that shape organizational resilience, with a view to ameliorating the safety challenges faced in the industry.

## Literature review

### *Traditional safety culture*

Safety culture is often treated as a subset of organizational culture, where beliefs and values refer specifically to matters of health and safety (Clarke, 1999). As noted by Williams *et al.* (2020), safety culture is defined as the values, belief, customs, traditions and methods disseminated by members in an organization (Kartikawati and Djunaidi, 2018). Many studies have attempted to develop a theoretical model of safety culture. However, there are two commonly used models of safety culture which include; *Layer models* (Reason, 1997; Guldenmund, 2000) and *Triads models* (Geller, 1994; Cooper, 2000). Layer models describe safety culture with the assumption that if the content of organizational culture is understood, it allows for analyzing and improving safety aspects of culture. However, layer

models of safety culture are often criticized for lacking the means to objectively assess safety culture and disregarding the dynamic nature of culture (Cooper, 2000; Choudhry *et al.*, 2008). In contrast, triad models of safety culture as shown in Figure 1 focus on the interaction between psychological, behavioral and situational elements in safety management (Cooper, 2000; Geller, 1994).

Geller (1994) proposed a total safety culture model based on the shortcomings of aforementioned models that recognize the dynamic and interactive association between person, environment and behavior. Cooper (2000) also developed a reciprocal model of safety culture that contains three elements: internal psychological factors (how people feel), safety-related behaviors (what people do) and objective situational features (what the organization has). Hence, triad models of safety culture provide a framework that could be used to measure and examine the reciprocal interactions between psychological, behavioral and contextual safety-related factors in different settings.

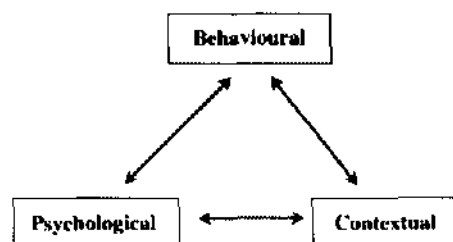
#### *Organizational resilience nature*

Pillay *et al.* (2010) identified the three dimensions of organizational resilience, which include *cognitive resilience*, *behavioral resilience* and *contextual resilience*. Cognitive resilience is a capability that enables an organization to interpret and analyze unfamiliar situations and figure out how to respond; behavioral resilience comprises the established routines that enable an organization to learn and implement new routines and fully use its resources; and contextual resilience comprises interpersonal connections, resource stocks and supply lines that provide the foundation for quick actions under uncertain settings that pose potential risks to organizations (Lengnick-Hall *et al.*, 2011). According to Pecillo (2016), the fundamental idea behind resilience engineering is that, in a world of limited resources, irreducible unpredictability and multiple conflicting goals, an organization manages safety risks proactively and creates safety via four resilience capabilities, which includes anticipating, monitoring, responding and learning as shown in Figure 2.

#### *Resilient safety culture*

The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies and patterns of behavior that determine the commitment to and the style and proficiency of an organization's health and safety management. Organizations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety and by confidence in the efficacy of preventive measures.

As shown in Figure 3, safety culture and resilience engineering can be suggested to have evolved over five different ages of safety as noted by Pillay *et al.* (2010). The study traced the evolution and development of safety culture and resilience engineering as strategies for



Source: Trinh *et al.* (2019)

Figure 1.  
Triad model of safety  
culture

managing safety. The first era, from the 19th century to the end of Second World War is commonly identified as the technological era plagued by accidents due to mechanical faults. Operator error was predominant in the second era between the two World Wars and the 1970s, which led to it being tagged the behavioral and human factors era. The third era was the socio-technical era between the 1970s to the 1980s which saw organizations as complex systems with accidents emanating from interactions of components within the system. The fourth era was the cultural era from the 1980s down to the 21st century which has recently evolved as noted by Borys *et al.* (2009) into the fifth era known as the adaptive or resilience era.

Resilient safety culture is characterized by continuous improvements to safety performance and the capacity to have foresight, recognizing and anticipating the changing shape of safety risks in complex socio-technical systems (Trinh *et al.*, 2019). Akselsson *et al.* (2009) defined resilient safety culture as “an organizational culture that fosters safe practices for improved safety in an ultra-safe organization striving for cost-effective safety management by stressing resilience engineering, organizational learning and continuous improvements.”

Trinh *et al.* (2019) noted that the concept of resilience engineering has some implications on safety management. This is majorly because resilience engineering theory is based on

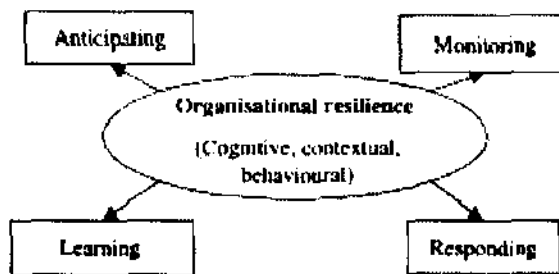


Figure 2.  
Capabilities of  
organizational  
resilience

Source: Trinh *et al.* (2019)

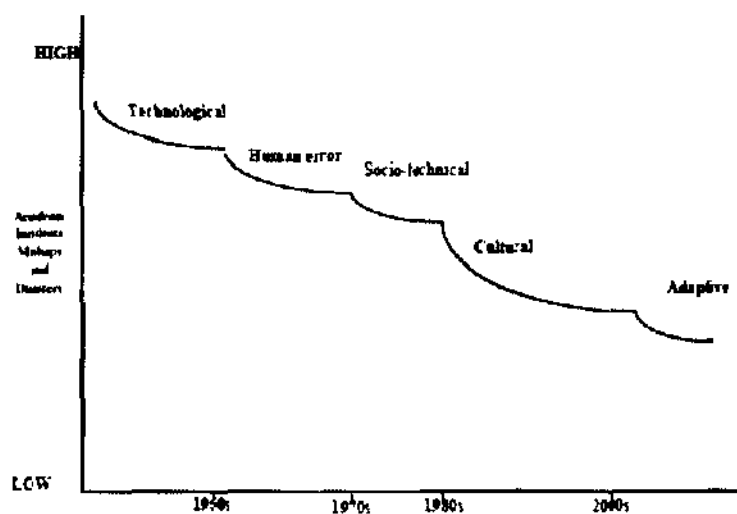


Figure 3.  
Evolution of safety  
management

Source: Pillay *et al.* (2010).

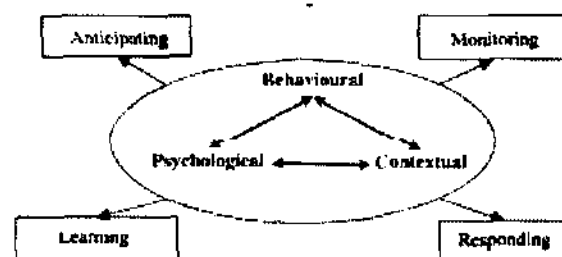
four resilience processes or capabilities which can serve as the theoretical basis for developing and implementing resilient safety management practices for safety performance improvement in all working environments as shown in Figure 4.

Organizations are always implementing new risk control strategies to improve their respective organizational safety performance. However, many do not have an adequate process in place to measure the effectiveness of its risk control strategies. Safety programs cannot be successful if it does not have a continuous improvement process in place to periodically “check” its effectiveness and recommend solutions to make it even better (Lingard, 2013). Resilient safety culture aims to achieve consistently high safety performance, which is characterized by continuous improvement in performance and capability to create foresight, recognizing and anticipating the changing shape of safety risk in complex sociotechnical systems (Trinh *et al.*, 2019).

#### *Safety performance measurement*

Safety performance measures or indicators provide organizations with empirical understanding of the efficiency and effectiveness of their safety programs instituted to prevent safety hazards and accidents. Undoubtedly, the accuracy of safety indicators largely reflects on the effectiveness of safety programs in organizations (Lingard *et al.*, 2017). Indicators of safety performance have varied in literature with quantified lagging indicators such as number of accidents and injuries over time being the most prominent, while leading indicators as a measure of organizational safety performance is being used rarely (Oswald, 2020; Walaski, 2020). Evidently, the literature is clear on the distinctions between leading and lagging indicators. However, Hinze *et al.* (2013) puts it more aptly in stating that the fundamental difference between the leading and lagging indicators lies in the type of response that is elicited by them when the measures indicate that performance is not as desired. With leading indicators, the response is usually proactive in nature, which manifest in immediate changes in the safety process of the organization with the sole intention to eliminate accidents and injuries. However, with lagging indicators, the response is reactive in nature as a response is made after injuries have already occurred and the response is initiated to try to prevent the occurrence of further injuries. The key differences between leading and lagging indicators could be better presented as shown in Table 1. These distinctions were derived and adapted from the numerous definitions of leading and lagging safety indicators provided by different authors in literature.

Although safety indicators give a more holistic overview of how well construction organizations adhere to health and safety practices in the execution of various tasks when used collectively, It was noted that lagging indicators only provide adequate indication that will necessitate the need for change in the safety culture and behavior of the organization



Source: Trinh *et al.* (2019)

**Figure 4.**  
Resilient safety  
culture

subsequent to injuries and casualties (Hinze *et al.*, 2013). Grabowski *et al.* (2007) and Mengolini and Debarberis (2008) argued that past performance is a poor predictor of future results and that lagging indicators do not provide enough insight to effectively avoid future accidents which puts the value of lagging indicators amongst safety professionals in question. In addition, lagging indicators are inherently subject to down play, as the decision to record an accident is often neglected due to the negative connotations often associated with reporting such accidents (Oswald *et al.*, 2018). In contrast, Toellner (2001) presented leading indicators as measurements that clearly reflect actions taken to prevent accidents as work is being executed.

Recent studies have addressed various aspects of leading indicators in the construction industry; which include identifying proactive safety metrics (Hallowell *et al.*, 2013; Oswald, 2020), measuring and controlling the indicators (Hinze *et al.*, 2013; Walaski, 2020), investigating their relationship to worksite injury (Salas and Hallowell, 2016) and measuring how they relate and cycle over time (Lingard *et al.*, 2017). Leading indicators could be broadly classified into two taxonomies, namely, "Passive and Active" (Sinelnikov *et al.*, 2015). On one hand, passive indicators are those that provide an earlier indication of the probable safety performance to be realized within a firm or on a project. While they may be somewhat predictive on a macro scale, they are less effective as being predictive on a short-term basis. In simpler terms, passive indicators do not largely have a direct impact on the safety performance of organizations or projects; they rather only project the potential safety performance of the organization or project (Lingard *et al.*, 2017). On the other hand, active indicators are direct reflections of safety practices in organizations or projects and are more subject to change within a short period of time. Active indicators essentially disclose the aspects of safety program that are going well and areas for improvement. They represent both quantitative and qualitative measure of the actual implementation of the processes within a comprehensive safety management system (Hallowell *et al.*, 2013).

Along this line, Rajendran and Gambatese (2009) found over 300 proactive safety measures in the construction industry which included job hazard analysis, safety planning, safety auditing, emergency response plan and provision of personal protective equipment amongst many others. The study developed and validated a Sustainable Construction Safety and Health (SCSH) rating system based on the proactive measures, which resulted in a rating system consisting of 50 safety and health elements organized into 13 major categories. More so, Hallowell *et al.* (2013) identified over 50 potential active leading indicators, while a related Construction Industry Institute research identified over 100 leading indicators. Collectively, these measures were broadly classified into nine essential components which include upper management commitment to safety, safety considerations in staffing, safety planning, safety training and education, employee involvement in safety,

Leading indicators	Lagging indicators
Actionable, predictive and relevant to objectives	Retrospective
Allow preventive actions before hazard manifest	Require corrective actions to prevent recurrence
Measure effectiveness of control systems	Measure failures of control systems
Measure inputs and conditions	Measure outcomes
Identify weakness through risk control system	Identify weakness through incidents
Evolve with change in organizational safety culture	Static regardless of organizational safety culture
Provide proactive monitoring of desired state	Provide reactive monitoring of undesired effects

**Sources:** Toellner (2001), Grabowski *et al.* (2007); Salas and Hallowell (2016), Oswald (2020); Walaski (2020)

**Table 1.**  
Difference between  
leading and lagging  
safety indicators

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rewards and recognition for safe behavior, inspections and investigation, substance abuse programs and active reporting systems for accidents and injuries. These essential components have been repeated and validated by several researchers using both descriptive and inferential analytical techniques (Salas and Hallowell, 2016).

#### *Method and data*

Quantitative research approach was used in addressing the objectives of the study. Data was collected using a structured questionnaire designed in three sections. The first section inquired about the demography of the respondents and their respective organizations. The second section inquired about the safety performance of the organizations, while the third section inquired about the resilient safety culture of the organizations.

The population of the study comprises of small and medium construction organizations predominantly across the Northern region in the Nigerian built environment. Total population of 332 construction organizations was derived, and Krejcie and Morgan's (1970) formula was used to calculate the minimum sample size required at 95% statistical confidence level. Subsequently, a total of 180 questionnaires were distributed to construction managers and safety managers in respective construction organizations to serve as respondents to the study. However, out of the total number distributed, only 75 were retrieved and used for analysis which represents 41.7% response rate. As observed by Williams *et al.* (2020), the low response rate is consistent with previous works using questionnaires in the construction industry, mostly in developing countries like Nigeria:

$$\text{Sample Size} = X^2NP(1 - P)/ME^2(N - 1) + X^2P(1 - P)$$

where X = chi-square value (3.841), N = population size; P = population proportion assumed to be 0.05; and ME = margin for error as 0.05.

Partial least square – structural equation modeling (PLS-SEM) was used to address the first objective of the paper, which involves testing the relationship between safety performance and resilience safety culture in the Nigerian construction environment. This is consistent with previous works on testing relationships and complementary to covariance-based (CB) SEM techniques and suitable for path models including both formatively and reflectively measured constructs. (Sarstedt *et al.*, 2017). The PLS-SEM approach was considered more appropriate than the CB-SEM approach for this study because:

- PLS is distribution free and, hence, suitable for data from unknown distributions (Falk and Miller, 1992); and
- PLS does not require a large sample size (Fornell and Bookstein, 1982; Sarstedt *et al.*, 2017).

Principal component analysis (PCA) was used to address the second objective of the paper, which entails determining the key components for ensuring the resilience of construction organizations with regards to safety. This was achieved by further simplifying the resilient safety components proposed by Trinh *et al.* (2019). The Varimax rotation method with Kaiser normalization with rotation converged in three iterations was adopted using the Statistical Package for the Social Sciences (SPSS) computer package.

*Main model variables*

Perceptual measures were used for both constructs in the main model. This measure has been found to produce reliable and valid results in management and organizational studies as noted by Ketokivi and Schroeder (2004) in Bjorvatn and Wald (2018). Each construct was measured using multiple item scales that were assessed on a five-point Likert scales (1 – very low, 2 – low, 3 – moderate, 4 – high, 5 – very high). The exogenous variable (resilient safety culture) was initially modeled as a formative model with 18 indicators. This measurement scale was adapted from Trinh *et al.* (2019) and restructured to fit the current study. More so, the endogenous (safety performance) variable was initially modeled as a reflective model with 14 indicators. These indicators were drawn from the SCSH Rating System developed by Rajendran and Gambatese (2009), which was found to be a valid tool for measuring the potential safety performance of construction organizations and projects. In all, the initial model was made up of 32 indicators.

However, a pilot survey was carried out to ascertain the validity and reliability of the measurement scales for both constructs. Experts in construction safety were asked to assess the measurement items for similarities and accuracy to measure the constructs. A Cronbach's alpha reliability test was conducted to test the reliability of the measuring items. However, as discussed in subsequent sections, due to the failure of the initial model to meet convergent reliability and validity criteria, some of the indicators were dropped in both the endogenous and exogenous measurement models. This resulted to a 19-indicator model with 9 formative indicators for the exogenous variable and 10 reflective models for the endogenous variable as shown in Table 2.

*Evaluation of measurement model*

According to Hair *et al.* (2014), measurement of reflective models is different from that of formative models. Reflective models were measured based on the individual loadings of each indicator which ranges from 0 to 1. The threshold for each indicator loading to ascertain its contribution to the model is 0.70. Whereas formative models were measured based on the outer weights of the indicators and the significance of the outer loadings. To establish reliability and validity, any inconsistent or insignificant indicators were considered to be removed according to the following set of rules:

- individual constructs and their indicators with Cronbach's alpha and a composite reliability index less than 0.7 are considered to lack internal consistency (Hair *et al.*, 2014);
- indicators with factor loadings less than 0.4 are considered inconsistent, indicating a low level of convergent validity (Bagozzi *et al.*, 1991);
- individual constructs with an average variance extracted (AVE) value less than 0.5 are considered unacceptable, indicating a low level of convergent validity (Fornell and Larcker, 1981); and
- an indicator's outer loading on the associated construct should be higher than any of its correlations on other constructs, whereas the square root of the AVE value of a construct should be greater than the correlations between the construct and other constructs in the model to establish adequate discriminant validity (Hair *et al.*, 2014).

Constructs	Indicators	Interpretation	
Safety performance	SP3	Pre-task safety planning conducted by both supervisors and workers as daily tasks	
	SP4	Safety inspections are done to identify hazards or safety violation	
	SP5	Safety hazards and accident analysis report and review for construction process	
	SP6	Owner of project is involved in safety aspects	
	SP7	Safety performance record are reported and maintained	
	SP8	Workers are involved in safety aspects such as safety decisions and feedback to top management	
	SP9	Safety committee effort in providing the required safety resources	
	SP12	Provision of personal protective equipment for all workers	
	SP13	Reward system for positive and safe work behavior	
	SP14	Random drugs and alcohol test to prevent substance abuse among workers	
	Resilient safety culture	RSC14	The organization monitors work condition
		RSC11	The organization assess needed safety resources
		RSC17	Workers refuse to work when it is not clear on how to execute the work task
		RSC19	The organization acknowledges unexpected hazardous event
RSC2		The organization draws conclusions when any dangerous event occurs	
RSC1		The organization listens to feedback from workers	
RSC21		The organization have knowledge and procedure level for identifying potential hazards regarding work tasks	
RSC22		The organization create awareness of major safety concerns on sites	
RSC24	The organization create alert for hazardous works		

Source: Survey, 2020

Table 2. Constructs and corresponding measurement items

## Results

### Demographic data

Demographic data regarding the respondents and their respective organizations were inquired. This gives an overview of the nature of respondents and further qualifies the data. Figure 5 shows the nature of construction projects handled by respective organizations in the past five years. A large percentage of the respondents representing 44% of the total population reported their firm handling only Building works. Whereas 29.3% reported

Building Construction works
  Civil Engineering works  
 Both Building and Civil works

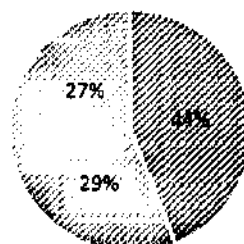


Figure 5. Nature of works performed by the organizations

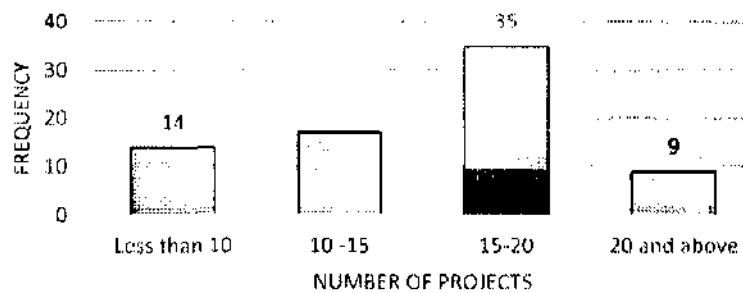
handling only civil construction works. However, 26.7% of the respondents noted their firm is involved in both building and civil engineering works.

Figure 6 shows the number of projects handled by the organizations in the past five years. A large percentage of them (46.7%) reported handling 15 to 20 projects within the span. A total of 22.7% handled 10 to 15 projects, while 18.7% handled less than 10 projects. Only 12% of the respondents reported handling 20 projects and above within the time frame.

*Model reliability and validity measurement*

The Cronbach's alpha, composite reliability and Dijkstra–Henseler's rho\_A are measures of internal consistency reliability, and all are expected to be 0.70 or higher (Hair *et al.*, 2014). As evident in Table 3, the model satisfies these conditions. However, the initial AVE is below the acceptable 0.50 level. The poor score of AVE shows that convergent validity has not been achieved. In other words, the indicators with which the latent variables were measured did not converge on their associated constructs. Therefore, some indicators were dropped to improve the reliability and validity for the reflective model as provided in (Hair *et al.*, 2017).

PLS-SEM relies on a nonparametric bootstrap procedure (Efron and Tibshirani, 1986; Davison and Hinkley, 1997) to test coefficients such as outer weights, outer loadings and path coefficients for their significance. This is majorly because it does not assume the data to be normally distributed. As such, bootstrapping was deployed to ascertain the significance of the outer loadings and outer weights of the formative model using an alpha protection level of 5% and 5,000 independent subsamples. The conservative no sign change option of the bootstrapping algorithm was used. The standardized confidence interval estimation method was chosen at 95% confidence level. Table 4 shows the *p*-values for both outer weight and outer loadings of all indicators in the formative model. All but three indicators had significant outer loadings whereas all had insignificant outer weights. However, as noted by Hair *et al.* (2014), indicators are accepted when outer loadings are significant and outer weights are



**Figure 6.**  
Number of projects handled in the past five years

	Cronbach's alpha		rho_A		Composite reliability		(AVE)	
	Initial	Improved	Initial	Improved	Initial	Improved	Initial	Improved
Resilient safety culture			1	1				
Safety performance	0.883	0.891	0.904	0.901	0.903	0.912	0.412	0.514

Source: Survey, 2020

**Table 3.**  
Reflective model reliability and validity

Indicator	Loadings	<i>p</i> -values	Weights	Resilient safety culture
RSC1	0.00		0.245	
RSC10	0.77		0.631	
RSC11	0.00		0.576	
RSC14	0.00		0.895	
RSC17	0.02		0.69	
RSC19	0.00		0.533	
RSC2	0.00		0.91	
RSC21	0.00		0.285	
RSC22	0.00		0.028	
RSC24	0.00		0.582	
RSC6	0.23		0.618	
RSC7	0.09		0.599	

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**Table 4.**  
Significance level of outer weight and loadings (formative model)

**Source:** Survey, 2020

insignificant, as such RSC10, RSC6 and RSC7 were eliminated. Furthermore, no critical levels of collinearity (i.e.  $VIF > 5$ ) were detected. Thus, the measurement model was deemed sufficiently robust to conduct the structural equation modeling.

#### *Assessing path significance for hypothesis testing*

Goodness-of-model fit is assessed differently in PLS-SEM from the approach used in covariance-based SEM (Hair *et al.*, 2017). Specifically, a PLS-SEM structural model is evaluated on the basis of how well it predicts the endogenous constructs (Hair *et al.*, 2017). Hence, we evaluate the inner (structural) model by considering collinearity, path coefficients and coefficients of determination ( $R^2$ ). Testing each set of predictor variables in the model for possible collinearity, all variance inflation factor (VIF) values were found to be well below 5, suggesting a model free of collinearity.

The path coefficient between an exogenous variable and an endogenous variable shows how much of an increase or decrease in the exogenous variable affects the endogenous variable (Lowry and Gaskin, 2014). Figure 7 shows the effect of resilient safety culture on safety performance with a path coefficient  $\beta = 0.867$ ,  $p < 0.05$ . The path coefficients, having standardized value from  $-1$  to  $+1$ , represent the hypothesized relationships among the constructs. Estimated path coefficients, close to  $+1$ , represent strong positive relationships and estimated path coefficients close to  $-1$  represent strong negative relationships (Hair *et al.*, 2014). As such, resilience safety culture has a strong positive relationship with safety performance in the Nigerian construction industry.

#### *Assessing predictive power of the model*

The coefficient of determination ( $R^2$ ) is the square of the correlation between an endogenous construct's actual and predicted values. It represents the amount of variance in the endogenous construct explained by all the exogenous constructs linked to it. The  $R^2$  value ranges from 0 to 1 with higher values indicating higher levels of predictive accuracy. According to Hair *et al.* (2014),  $R^2$  values of 0.75, 0.50 or 0.25 for endogenous latent variables can, as a rough rule of thumb, be respectively described as substantial, moderate or weak. The  $R^2$  is the number shown in the circle that represents the endogenous construct. Figure 7 shows a predictive value of (0.751,  $p < 0.05$ ).

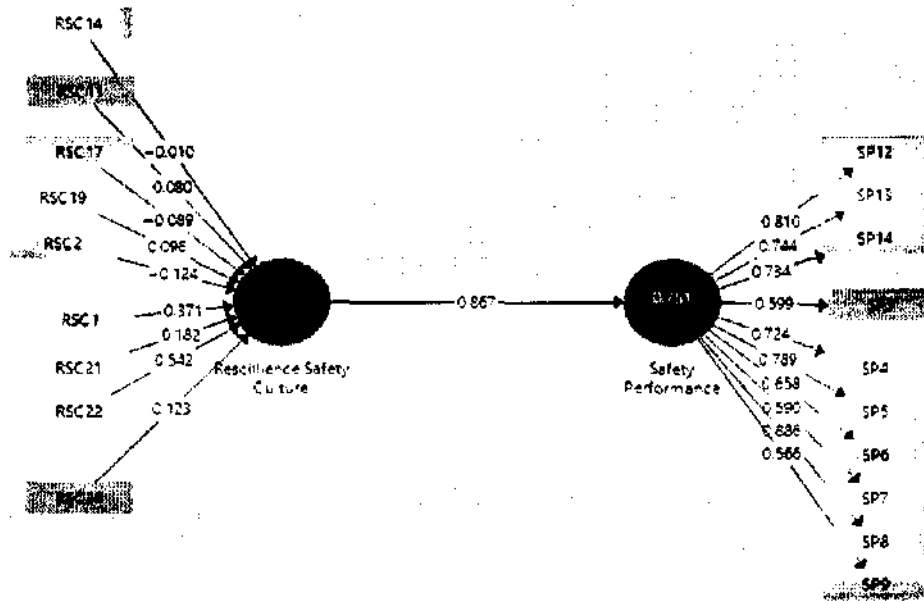


Figure 7.  
Structural model

*Principal component analysis*

Subsequent to the establishment of the causal relationship between resilient safety culture and safety performance, the second objective of this paper was addressed using the PCA tool to define metrics for organizational resilience. The Kaiser–Meyer–Olkin result presented in Table 5 supports the PCA conducted and defines its sampling adequacy with an alpha value of 0.75 which according to Kaiser (1974) is an acceptable value for factor analysis and PCA.

Table 6 shows the categorization of the factors into two major components based on the Eigen values of the resulting components having a value greater or equal to 1, while Table 7 shows the rotated component matrix for the two components. Result of the PCA show that the extracted components can explain 65.7% of the cases of resilience safety culture in construction organizations.

Looking at the rotated component matrix results in Table 7, the first component could be interpreted to indicate the need for organizations to ensure a consistent safety hazard recognition capacity. Key factors that include monitoring work conditions, acknowledging unexpected hazardous event, creating awareness on major safety concerns and creating alert for hazardous works form the basis for this component. Safety hazard recognition as a component explains 51% of the variance in safety resilience culture in construction organizations. Elatedly, the second component which explains about 15% of the variance in safety resilience culture builds on factors that include listening to feedback from workers,

Kaiser–Meyer–Olkin		0.725
Bartlett's test of Sphericity	Approx. chi-square	365.048
	df	36
	Sig.	0.000

Note: Survey, (2020)

Table 5.  
KMO and Bartlett's  
test

Component	Total	Initial Eigen values	
		% of Variance	Cumulative %
1	4.596	51.064	51.064
2	1.317	14.635	65.699
3	0.774	8.6	74.3
4	0.752	8.355	82.654
5	0.444	4.935	87.59
6	0.421	4.681	92.27
7	0.342	3.802	96.072
8	0.259	2.883	98.956
9	0.094	1.044	100

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Note: \*Values in bold indicate components extracted  
Source: Survey, 2020

**Table 6.**  
Principal component  
analysis

Variables	Codes	Component	
		1	2
The organization listens to feedback from workers	RSC1	0.154	0.811
The organization draws conclusions when any dangerous event occurs	RSC2	0.241	0.855
The organization assess needed safety resources	RSC11	0.525	0.459
The organization monitors work condition	RSC14	0.719	0.257
Workers refuse to work when it is not clear on how to execute the work task	RSC17	0.123	0.736
The organization acknowledges unexpected hazardous event	RSC19	0.855	-0.088
The organization have knowledge and procedure level for identifying potential hazards regarding work tasks	RSC21	0.639	0.529
The organization create awareness of major safety concerns on sites	RSC22	0.719	0.483
The organization create alert for hazardous works	RSC24	0.767	0.225

Source: Survey 2020

**Table 7.**  
Rotated component  
matrix

organizational attitude in the event of danger and attitude of workers when safety of work is not ensured. Collectively, the factors show a strong inclination toward instilling an effective and dynamic safety response attitude in construction organizations to ensure resilience safety culture.

## Discussion

### *Resilience of organizations and safety performance*

Safety management has been a major concern for construction organizations for as far back as human evolution. Construction organizations have traditionally adopted a holistic safety management strategy emphasizing two types of responses, *prevention and protection*, to reduce employee exposure to on-site hazards (Mitropoulos *et al.*, 2005; Feng and Trinh, 2019). However, in recent years, the inherent complexity in technology, work tasks and organizational structures of construction projects has led to the changing and unforeseen shape of safety risks and poses challenges for traditional safety management approaches (Dekker, 2012). Despite continuing efforts to reduce the number of accidents, the Nigerian

built environment like most other construction environments around the world is plagued with construction accidents during and after construction.

The construction industry remains one of the most hazardous industries in most countries (Törner and Pousette, 2009; Tam and Fung, 2012). Regardless of the continued effort, the industry globally still has a high rate of occupational accidents. This as noted by Wachter and Yorio (2014) is largely due to the fact that traditional safety management approaches tend to be institutionalized through policies, plans, procedures and processes, which are not easily and readily adaptable to the natural and inevitable changes in work being conducted and the emerging and unforeseen safety risks being encountered. The effectiveness of traditional safety management approach is largely dependent on the extent to which safety risks are known or can be made known (Hollnagel, 2008).

The built environment in Nigeria as aptly noted by Okeola (2009) is highly unstructured and in constant flux state which makes it prone to high level of health and safety challenges. Regardless, the safety culture and attitude of construction managers and organizations in Nigeria have been reported to be nonchalant toward safety issues, with almost absolute lack of safety laws and regulations. Despite these unfavorable dynamics, this study found a strong correlation between adopting a resilient safety culture and improved safety performance of organization in the Nigerian built environment. This is in line with the findings of Trinh *et al.* (2019) in the study of resilient safety culture in the built environment in Vietnam. The result of the regression between resilience safety culture and safety performance with path coefficient ( $\beta = 0.867, p < 0.05$ ) shows that adopting a more proactive safety culture characterized by the capacity to have foresight, recognize and anticipate the changing shape of risks before adverse events occur also has the potential to significantly improve the safety performance of construction organizations in Nigeria. Furthermore, the  $R^2$  value of 0.75 shows that adopting a resilience safety culture influences safety performance of the industry. Resilience safety culture explains 75% of the variance in safety performance of the Nigerian built environment.

#### *Improving safety performance of organizations*

As construction organizations continue to strive for improved performance toward safety, adequate measurement of existing safety practices provides a yardstick for the future potentials. However, what is evident from literature is that traditional safety management strategies although being predominantly used in the construction industry, are ineffective in prompting improvements in safety practices and performance. Certainly, the underlying assumption that measuring the absence of safety directly reflects the presence of safety is unjustifiable, and by viewing performance solely through an “unsafety” measurement perspective, we risk interpreting that a less safe project has a better safety performance. It is evident that most definitions incline on safety being a state or condition of avoiding harm or danger. Thus, measuring accident and injury statistics actually contradicts the measurement of safety, but rather quantifies the manifestations of lack of safety. Furthermore, these measures are often susceptible to manipulation, as Dong *et al.* (2011) found loss-time injuries to have been under-reported. Similarly, fraudulent compensation claims can occur through inflated accident and injury statistics (Oswald *et al.*, 2018). Therefore, there is more risk of manipulation of the statistic than the actual management of safety when such measures are adopted, which can be detrimental to accurate safety measurement and performance (Oswald *et al.*, 2018). This study builds on previous works on measures for improving the safety performance of construction organizations, notably the work of Trinh and Feng (2019) which focused on improving the resilience of construction organizations toward imminent safety challenges. The study identified various indicators of

safety resilience of construction organizations. However, for organizations to effectively ensure resilience toward imminent safety challenges, key measures need to be put in place.

The PCA result in this study ultimately defines two broad metrics that defines safety resilience of organizations, which includes safety hazard recognition metrics and safety attitude metrics. This finding asserts that positive attitude toward safety issues and the ability of workers and employees in an organization or project to identify safety hazards are strong reflectors of safety performance. Safety hazard recognition measures reflect on the ability of managers and workers to sense, analyze and extract physical or mental stimuli that indicates the existence of a hazardous situation in a complex and dynamic scenario of construction environments (Albert *et al.*, 2014; Namian *et al.*, 2016). Thus, key factors that include monitoring work conditions, acknowledging unexpected hazardous event, creating awareness on major safety concerns and creating alert for hazardous works reflect on safety hazard recognition capability of the organization. Similarly, Lingard and Turner (2017) found that embracing of healthy behaviors by workers is influenced by factors playing around the individual, family, workplace and industry levels and that safety cases and risky behaviors are manifestations of safety attitudes of construction workers (Leung *et al.*, 2010). Evidently, the assertion based on the findings of this study on safety attitude and hazard recognition is not far-fetched from existing literature as hazard recognition capability and safety attitude have been identified as a fundamental requirement for addressing the health and safety challenges encountered in construction activities (Namian *et al.*, 2016a, 2016b). Haslam *et al.* (2005) observed that 42% of accidents involve inadequate hazard identification and appraisal skills of workers, while Bahn (2013) reported that novice workers failed to recognize an average of 57% of hazards in occupational environments in Australia. Relatedly, Kundu *et al.* (2016) noted a strong positive correlation between positive safety attitude and overall safety performance. Thus, organizations on the course for continuous improvement of their safety performance should ensure adequate hazard recognition capability amongst workers and also ensure positive safety attitudes with prompt response toward safety related issues.

### Conclusion

The study assessed the impact of resilient safety culture on safety performance of construction organizations in the Nigerian built environment. Findings of the study shows that resilient safety culture has a strong positive relationship with safety performances of construction organizations. Resilient safety culture has the potential to improve the safety performance of the Nigerian construction industry which has been largely characterized by having a nonchalant attitude toward safety. With a view to achieve a consistently high safety performance, organizations have to acknowledge and anticipate unexpected hazardous events and provide the necessary safety resources to manage them. Furthermore, there is also the need to create awareness on recognized safety concerns on safety hazards, coupled with a dynamic risk response attitude to ensure consistent improvement in safety performance.

Although the findings of the study provide a potential for improved safety performance, it is limited by a number of factors. The low response rate is a major limitation to the study. The findings were reached based on data collected from 75 construction organizations across major cities in Nigeria which represent only 46.1% of the 180 questionnaires distributed. As such the interpretation needs to be contextualized. Nonetheless, the use of the PLS-SEM approach and bootstrapping technique with 5,000 resample reduced the potential problem caused by the relatively small sample size. Furthermore, the reliability and validity of self-reporting survey methods is also a concern due to possible biases from

respondents. However, this limitation was largely minimized in this study by ensuring voluntary participation and anonymity of respondents as well as confidentiality of respondents' responses. Also, a pilot survey was carried out to ensure comprehensiveness and clarity of the research instrument to avoid unintended error from respondents.

Further studies could be carried out with improved data across the country to put the findings in broader perspective. More so, the dimensions of resilient safety culture could be further assessed to ascertain the effect of the distinct dimensions on organizational safety. This could be achieved through longitudinal studies to be carried out on selected organizations to accurately observe the impact of changing safety culture on overall safety performance of the organization.

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**Corresponding author**

Mu'awiya Abubakar can be contacted at: [muawiyaabubakar1@gmail.com](mailto:muawiyaabubakar1@gmail.com)