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Research Article

Proactive Approach to Measure Safety Management on Building Projects in Saudi Arabia

Rafiq M. Choudhry, Idrees Zafar, and Mansour Saleh Almatawa

Civil Engineering Department, College of Engineering, Imam Mohammad Ibn Saud Islamic University (IMSIU), Riyadh 11564, Saudi Arabia

Correspondence should be addressed to Rafiq M. Choudhry; rchoudhry@imamu.edu.sa

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Safety management is important throughout the world specifically on building projects, which are prone to accidents due to their unique operations, dynamic and ever-changing nature. In every country, contractors implement safety management systems (SMSs) to avoid accidents and comply with applicable laws, regulations and to provide safe work environments for their workers. Nonetheless, accidents still happen on many building projects in the country. The objective of this work is to measure safety management as perceived on building projects by employing a proactive approach in the Kingdom of Saudi Arabia to improve site safety. A survey instrument is utilized to gather data from building projects. Another questionnaire is used to conduct interviews with the key managers on the same projects. Analysis of the questionnaire survey is performed after entering the data into SPSS software by applying factor analysis and multiple linear regression. Factor analysis extracted two significant factors, including "management commitment, employee involvement, and safety training"—factor 1, and "project safety plan, safety committee, and safe use of equipment"—factor 2, which proactively measure the implementation of safety management on the building projects. The safety model obtained by multiple regression analysis identifies two significant contributors to the performance of the SMS. Analysis of the interviews complemented and validated the results of the questionnaire survey. The findings provide in-depth understanding of proactively measuring safety management on building projects for the construction industry practitioners to make project sites safer.

1. Introduction

Safety management is very crucial to the safety of stakeholders, whether they are workers, owners, consultants, contractors, or subcontractors [1, 2]. Numerous construction firms all over the world are applying safety and health management systems to decrease injuries, eradicate illness, and to support a safe job environment in their projects [1].

The Occupational Safety and Health Administration (OSHA) reports that 5,333 laborers died from job-related injuries in 2019 that amounts to 3.5 fatalities per 100,000 full-time workers, nearly 15 fatalities a day [3]. Almost 20% (1,061) of laborer casualties in private industry happened in the construction industry [3]. Nonetheless, construction is among the most dangerous industries due to its outdoor operations, which accounts for 1 in every 5 occupational fatalities [4–7]. This has not changed to the present time as the building projects are still one of the most dangerous workplaces [8–10] and Saudi Arabia is not different from rest of the world in project safety related accidents. Regardless of improvements in construction safety throughout the years, the accident rate remains the highest in the building sector of Saudi Arabia [11]. In the country, the total numbers of reported work accidents in 2014 were 69,241, and the construction industry accounted for 51.35% of these accidents [8].

World Bank development indicators revealed that the total laborers in Saudi Arabia were 16,137,535 in 2021 [12]. According to the General Authority of Statistics, the total number of construction workers employed in Saudi Arabia are 1.07 million in 2017. Saudis are accounted for 145,000, or 14% of the total and foreign workers are over 924,000 workers in the construction [13]. According to General Authority of

Statistics, the construction industry of Saudi Arabia accounted total injuries amounting to 16,968 cases as compare with other industries in the year 2018 [14]. A total of 12,842 laborers got injured during the first half of 2020 at a rate of 2,140 injuries per month [15]. Numerous workers are not registered and do not get a license, say electrician or plumber to work on the construction projects. In the country, the government hardly regulates safety on construction sites, the duty rests with the administration of each contracting firm, yet various firms do not adhere to the standard protocol [16].

According to the Mordor [17] report the Saudi construction market is likely to register an annual growth of more than 5% over the period from 2022–2027. The construction market is anticipated to observe meaningful growth and suggested beneficial potential due to the Saudi Vision 2030, and various ongoing reforms to diversify away from oil. Vision 2030, the increase in private sector financing, and the continuing reforms are estimated to be the progress drivers for the market in 2022 and beyond. The construction industry is among the leading in the Gulf Cooperation Council (GCC) states, with more than USD 825 billion worth of planned and unawarded projects [17]. In the industry, more than 5,200 construction projects are presently ongoing in Saudi Arabia at a value of USD 819 billion [17].

Traditionally, lagging indicators are employed in construction safety research. As accident costs are always after the event, reactive and frequently implied indicators, i.e., the achievement of safety is assessed by levels of system breakdown [18]. The objective of this work is to proactively measure safety management as perceived on building projects in Saudi Arabia to make construction sites safer. The study describes perceptions of the respondents to explain safety management situation and practices on numerous building projects for improving safety on construction sites. This work explains how a questionnaire could be developed, administered, and how the survey instrument could be improved. Although there has been a wealth of research in the Saudi construction industry [8, 10, 11, 16, 19], it was rare that measuring of safety management system (SMS) being attempted with a proactive approach. In the global context, there has been abundance of research on safety climate (e.g., [20–22]), it was hard to find measurement of SMS on construction projects. Some safety climate studies (e.g., [23]) found 15 factors and it had been difficult for the management to focus on the important factors. There appears to be a clear knowledge gap in the measurement of SMS. The results of this work make it easy for the management to focus on two significant factors of proactively measuring safety management for improving on-site safety. This paper makes a unique impact to the current body of knowledge of how to measure SMS proactively before accidents could happen to ensure success of safety management. Additionally, the findings of this work can provide in-depth understanding of proactively measuring safety management for the construction industry stakeholders to make construction sites safer. The next section reviews related literature on safety management in construction.

2. Literature Review

Occupational accidents are frequent, and the construction industry is known for its disappointing safety performance [24, 25]. Building construction is risky due to work at heights, open-air work, complex on-site equipment operations joined with work force behaviors [1]. A SMS is supposed to manage safety on construction project sites. It gives a systematic way to constantly recognizing and observing hazards and manage risks even though providing self-assurance that these control measures are efficient [1]. The management system provides safety, sets clear goals, preplanning, and measure safety performance. Once implemented, it turns into part of the organizational culture, the way individuals do their work safely [26].

Safety management is an essential part of the construction industry as safety problems result in fatalities and additional unfavorable outcomes in construction projects [27]. Notwithstanding the crucial significance of safety, severe accidents occurred in numerous building projects. Hinze et al. [28], Abdelhamid and Everett [29], and Abukhashabah et al. [30] have examined the root sources of accidents. Suraji et al. [31] revealed that the responsibility of project managers in preserving a safe project site cannot be misjudged. Authors revealed safety roles, the role of site safety [32, 33], the role of a designer [34], and the owner's role [35]. Choudhry et al. [18] presented a safety culture model to safeguard safety on site. Mohamed [36] presented the scorecard approach to benchmarking organizational safety culture in construction. Mohamed [21] identified factors concerning the safety climate and established that there is a positive connotation among the safety climate and safe behavior. Other authors such as Sawacha et al. [37] uncovered seven factors influencing the safety on projects in the United Kingdom. Langford et al. [38] recognized five factors that stimulate the attitudes of the workforce in construction.

Jaselskis et al. [39] found that management commitment as well as involvement is the utmost vital factor for safety. Park and Kim [40] revealed that safety management consists of planning-education-inspection paradigm. Al-Bayati et al. [41] presented a model to better understand the relationship between safety culture and safety climate and their influence on safety performance. Al-Bayati [24] presented the impact of construction safety culture and construction safety climate on safety behavior and safety motivation. Martínez-Aires et al. [42] presented a review article on BIM and safety management to identify potential hazards.

Safety management is a method of managing safety policies and practices concerning site safety [1, 32]. The International Labor Organization [43], Alves Dias [44], and Koehn and Datta [45] expressed the requirement of employing a safety system on project sites. Developed countries, such as the United States of America and United Kingdom had issued guidelines for safety systems such as standards of Occupational Safety and Health Administration for the construction industry [46] and the ISO 45001:2018—A Practical Guide to occupational health and SMSs [47], respectively. Nonetheless,

the application of safety and health management is not common in developing countries [2, 48].

Zou and Sunindijo [49] focused on the need for strategic safety administration consisting of strategy development, implementation, and evaluation in construction. Yiu et al. [2] presented a structural equation model for implementation of SMS. Dedobbeleer and Béland [50] checked Brown and Holmes's [51] model of safety climate between workers working on civil engineering projects. They revealed two factors: management commitment, as well as workers' involvement. The literature review indicates that a measurement of SMS was rarely carried out. The next section reviews the safety management situation in the context of Saudi Arabia.

2.1. Safety Management in Saudi Arabia. Safety management provides the tools and techniques for engaging in safe work practices. The notion of SMS is commonly recognized on construction projects in Saudi Arabia. The applicable construction safety laws and regulations are Labor Law issued under Royal Degree No. M/51 dated 23/8/1426 (September 27, 2005) by the Ministry of Human Resources and Social Development [52]. This law comprises 245 articles and the document is available online. Article 122 of this document states, "An employer shall take the necessary precautions to protect the workers against hazards, occupational diseases, the machinery in use, and shall ensure work safety and protection. He shall post in a prominent place in the firm the instructions related to work and workers' safety in Arabic and, when necessary, in any other language that the worker understands. The employer may not charge the workers or deduct from their wages any amounts for the provision of such protection."

The Ministry of Labor and Social Development has issued "Implementation of Risk Management and Safety Culture OSH Guidelines" to improve the Safety and Health systems and practices across the Kingdom of Saudi Arabia and the document is available online [53]. Risk management document is based on Health and Safety Executive [54] of the United Kingdom, OSHA [46] of the United States, and Workplace Safety and Health [55] of Singapore. This document sheds light on how to assess and manage risk at construction sites.

The Ministry of Human Resources and Social Development issued "Procedural Guidelines for Occupational Safety and Health for preventing the effects of exposure to direct sun and heat stress [56]" and the document is available online. This publication explains work procedures under high-atmospheric temperature conditions including controlling breaks in high temperature and humidity of the workplace. Additionally, the General Directorate of Civil Defense of the Ministry of Interior [57] has the authority to order closure of construction site and bring the cranes' booms down in case of sandstorm, disasters, or bad weather conditions. Civil Defense can stop the work immediately, if it is confirmed that the method of work, and the devices, machines, and mechanisms used on-site poses a danger to the lives of workers, or to the lives and property of others by the contractor. Contractors are obligated to inspect all machines, mechanisms, and devices on-site. They need to take documented safety measures on-site; all accidents and their causes need to be investigated. Contractors are required to provide personal protective equipment (PPE) and clothing necessary for all labor force on-site [52].

Despite all these rules and regulations, common incidents and accidents occur due to electrical shock, falling from a height, exposure to hazardous materials, getting hit by moving equipment, equipment and vehicle accidents, being struck by heavy construction equipment, burns, sunstroke, fractures, bruising, fainting, amputation, coma, and death [30]. Among the most famous accidents that occurred in this decade is the Makkah crane collapse. A construction crane collapsed on the Masjid Al-Haram in Makkah, around 05:10 pm on September 11, 2015, killing 107 persons and injuring 238 others [58, 59]. At that time, the Makkah city was ready to welcome the Hajj pilgrimage. This accident was considered the deadliest crane failure in recent history. The former most fatal incident was the failure of a crane in New York city on March 16, 2008, killing seven human beings [58]. The incident was noticed to have been caused by a sequence of individual error and strong storms [59].

In the context of Saudi Arabia, Jannadi [19] revealed six factors that were ranked by the safety offices and workers being "maintaining safe work condition" at the top and "safety training" as the 2nd important factor. Jannadi and Assaf [16] have assessed the level of safety practiced at construction projects in the Eastern Province of the country and found that large projects have better safety records than smaller ones. Mosly [8] studied the safety performance in Jeddah city related to small-to-medium sized projects. The study was conducted in the private sector under five groups involving general—construction sites, heights, and fall protection, PPE, machinery, and lastly excavation. The study was conducted through observation by site visits in May and June of 2015 during working hours and emphasized that there is an imperative need for enhancement of safety in the country. Mosly and Makki [11] revealed 13 factors influencing safety climate by collecting data from 401 employees employed on three large construction projects in the country. They concluded the important role of top management in safety on construction project. Abukhashabah et al. [30] identified the reasons for accidents on construction sites in Jeddah city and found lack of experience and lack of awareness among the 300 workers. Alsulami et al. [60] indicated that emotional intelligence plays a crucial role to improve the safety behaviors in construction workers in Saudi Arabia. Mosly [10] ranked 37 factors corresponding to their mean values over a survey questionnaire. They reduced 37 factors into 10 components that can help in improving safety performance on construction sites. Past studies suggest that the construction industry of Saudi Arabia is dangerous with high levels of injuries and deaths contrasted to the other industries [8, 10, 11].

Modern approaches promote a shift to utilizing proactive actions or leading indicators such as safety climate [61] and safety culture [18]. The literature review shows that measuring of SMS was not attempted with a proactive approach and this work adds to incremental advance from safety

management perspective in Saudi Arabia. Ho et al. [62] presented a questionnaire for safety management with 32 items. They prepared all 32 questions in an interrogative way and respondents needed to answer in a yes/no manner. This study presents a unique survey instrument that uses a Likert-type scale and an interview guide for conducting interviews. Interview guide is mainly based on the survey instrument. The literature review indicates that a little research was conducted to proactively measure safety management in a way as proposed in this study. Nonetheless, the literature review provided an understanding of designing a safety management questionnaire for the current study. The next section describes the research method and questionnaires development of this work.

3. Research Method

Research method is a way of explaining how a piece of research is carried out by the researchers [63]. It describes the techniques and procedures that are used to design the instrument to collect data and analyze information regarding a research topic. For this research, the steps involve are the following: (1) design and finalize survey questionnaire to collect quantitative data from building project sites to measure safety management; (2) design and finalize interview guide to obtain qualitative data about how SMSs are operational on the project sites; (3) analyze the quantitative data to measure SMS with Statistical Package for the Social Sciences v. 27 (SPSS) [64]; (4) analyze the qualitative data to complement quantitative results; (5) summarize the results; (6) discuss the results for improving safety management on construction sites of building projects.

Behavioral studies require a lengthy period and are not easy to assess by incorporating a survey [65]. Employees' perceptions of SMS require individuals to evaluate their construction project. A safety management survey is one that measures the essential elements of the management system comprising on commitment of the management to safety, training and education of the workforce, supervisory process, and employees' involvement [66]. Questionnaire design is the process of designing the questionnaire items of the survey instrument that would be utilized to gather data about a certain topic [67].

Safety management data are gathered out of a survey instrument and the results are reported in this paper after conducting analysis by SPSS v.27. Eight safety management interviews are also recorded with the key experts and to validate results of the survey instrument. Finally, the objective of research methodology is to ensure that the results are reliable, and the procedure is helpful in achieving the objective.

3.1. Survey Instrument. Guidance for design the survey instrument is acquired from the literature review including safety management publications (e.g., Choudhry et al. [1] and Ho et al. [62]). The questionnaire of Ho et al. [62] comprised on 32 items having six domains. The questionnaire presented by Choudhry et al. [1] consists of 52 items having eight domains. Nonetheless, items in both of above questionnaires ended with question marks indicating interrogative clauses for yes/no answers. The current instrument for the survey is constructed to collect data on a Likert scale. Therefore, all questionnaire items are newly designed for this study. To conclude the research method and the instrument, a workshop was organized in the Civil Engineering Department with 11 participants (3 academics, 4 project managers from the industry, and 4 students). A 65 items instrument was presented and discussed item by item. The survey instrument was checked for structural validity, content validity, and indecency of the words. The workshop participants were requested to point out if there is something intersecting among elements in the instrument. Their criticism was utilized to improve the survey instrument and to edit any improper language. In this workshop, a 59-item questionnaire was accepted. After this, the researchers carried out a pilot study to check the practicality, validity, and reliability of the instrument. During the pilot study, the instrument was given to five managers (two clients, three contractors), five safety managers (four contractors, one consultant), and five supervisors (two consultants, three contractors) as well as five workers of contractors. Based on their feedback, the instrument items were further modified for minor corrections, and to suit site safety management procedures operational on construction sites. The instrument in its concluding form (Appendix A) comprises on 59 questions related to safety management and are grouped into 14 themes containing: policy related to safety, safety committee and safety organization, education and training, management commitment and employees involvement, accident analysis and reporting, health and safety meetings, fall protection and toolbox talks, safety regulations and procedures, housekeeping and safety signs, inspecting and supervising hazardous condition, program of personal protection, supervision of equipment and plants, promotion of safety, and performance of SMS.

A cover letter is issued to certify that respondents understand that their responses would remain unknown from the project management. The respondents were not required to enter their name on the survey instrument. The first part of the questionnaire comprises seven questions and is associated with the respondents' overall information. The questions comprised the name of the project, firm name, and department of the respondent. The further questions included male or female, single or married, respondents' qualification (schooling, bachelor, higher), your position/designation (project manager, safety manager, engineer, supervisor, worker), do you work with client/consultant/contractor, and experience on construction projects. This section of the instrument checked the characteristics of the respondents. The second section comprised of 58 safety management questions that requested the contributors to tick the assertions utilizing a 5-points Likert-scale to facilitate statistical analysis of the responses. The third part comprises only one question and measured respondents' perception of safety management performance to conduct regression analysis.

3.2. Sample. The survey instrument is administered to clients, consultants, and contractors on building projects in the

country. There are 3,365 consulting companies and 175,471 contractors registered with the Saudi Council of Engineers [68] and Saudi Contractors Authority [69], respectively, in Saudi Arabia. The sample size representing the population is extracted using Equation (1) that had been generally utilized in publications [70–72].

$$n = n'/(1 + n'/N). \quad (1)$$

Here, n is the sample size from finite population, N is the total population $(175{,}471 + 3{,}365) = 178{,}836$. n' represents the sample size from countless population as shown in Equation (2), V is the standard error that is equal to 0.05 for the sample population for the confidence level 95%, S^2 is the standard error variance when $S^2 = P\,(1–P)$; where Maximum $p = 0.5$. Now, the sample size is calculated as follows:

$$n' = S^2/V^2, \quad (2)$$

$n' = (0.5)^2/(0.05)^2 = 100$

$n = 100/(1 + 100/(178{,}836) = 100$ (the acceptable sample size)

A sample should be a good representation of the population. An effort was made to gather data from different building projects in the country, by means of a judgmental sampling. Judgmental sampling is a technique where the investigators decide on items to be sampled based on their professional awareness [73]. The civil engineering department has a database of companies for conducting engineering training (or summer training) to final year students each year. With the help of this database and workshop participants, 42 project managers are finalized. These 42 project managers of building sites were approached to ask their employees to fill in the questionnaire. The purpose was to include all major cities or areas of the country representative in the study, and to bring more accurate results than by using other sampling techniques.

The sample included the input from stakeholders comprising the consultants, contractors/subcontractors, and clients of those building projects. The researchers uploaded the survey questionnaire in Google Docs and the link was shared with the 42 managers who already agreed that their employees would fill the questionnaire. These managers believe that their employees can acquire knowledge about safety management by joining in the study. These 42 managers reported that the survey link was shared with 252 prospective participants on their projects. The 42 managers involved their safety managers to follow-up with those participants with whom the questionnaire link was shared. Safety managers were in touch with the participants via WhatsApp. Finally, 176 filled questionnaires were downloaded by the researchers from the respondents via Google Docs. The response rate was excellent (69.84%). Black et al. [74] report that a response rate of 30% is excellent in the construction projects. Owen and Jones [75] described a response rate of 20% that is deemed good. To verify and prevent the bias problem, the writers chose to conduct an interview of one respondent from each building site and thus 42 interviews are conducted to examine conformity with the adopted method. The instrument that was completed by the same option or carelessly filled questionnaire were rejected to avoid a misrepresentation of the results. The sample was reduced to 165 from 176 hereunder titled as the sample.

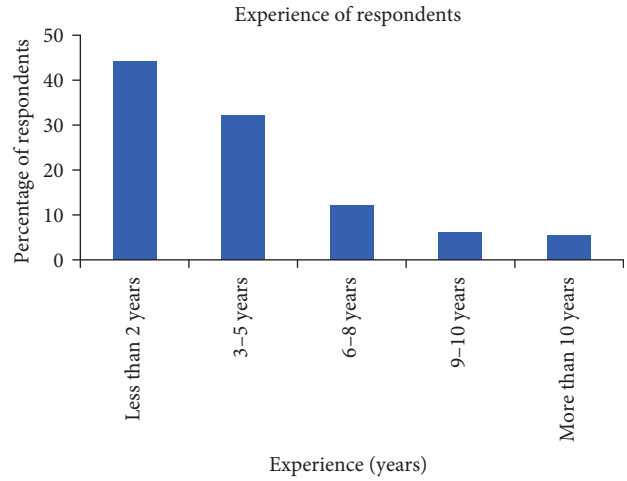

Figure 1: Working experience of respondents.

Of the 165 respondents, gender-wise, 86% participants are male and only 14% are female. Considering marital status, 57.6% of the respondents were single and 42.4% were married. When asked about the qualification, 25.6% of the respondents had schooling education, 62.9% were holding a bachelor's degree, 11.5% a higher education. When asked about their designation, 35.8% of the respondents were engineers, 17.0% were safety managers, 15.2% were project managers, 6.1% were supervisors and 26.1% were workers. Most respondents (42.4%) were working with contractors, 29.7% with consultants, and 27.9% were working with the clients. When asked about the construction industry experience, 44.2% of the sample has less than 2 years' experience, 32.1% had 3–5 years' experience, 12.1% had 6–8 years working experience, 6.1% had 9–10 years of experience, and remaining 6.1% possessed greater than 10 years of experience (Figure 1).

It is essential to point out that some project managers and safety managers possess considerable knowledge and experience in building high-quality structures. They have shown excellent interest in this work and filled the instrument carefully. They provided valuable information to the descriptive questions and thus qualitative data were collected by conducting eight management interviews. These eight management interviews were organized with four project managers, two safety officers, and two safety editors. All these managers were married and held a bachelor's or higher qualification. The ages of all these managers were over 40 years, and each having more than 10 years of experience in construction. Four interviews were organized face-to-face, and audio recorded. The remaining four interviews were conducted online via zoom and were video recorded. Based on the survey instrument, an interview guide was prepared comprising 14 questions (Appendix B). The method utilized

by Mullen [76] in asking the interview questions permitted managers to explain their story in a manner and style. Finally, looming questions come up with recurring words such as "please express your views on SMSs." How a SMS is developed, implemented, monitored, and audited periodically on your construction sites? In case a subject of significance did not come out during conducting the interview, the guide questions were utilized. Subsequently, eight detailed management interviews were conducted and recorded. Duration of each interview was from 45 to 60 min. These interviews provided rich data requiring open-ended answers. To analyze the eight management interviews a grounded theory method [77] was utilized. Related sections of dialog were linked and placed together in evolving situation-based description and details [78]. The researchers plan to discuss the results of these interviews later but first would like to explain more about quantitative data analysis.

The compiled quantitative data were investigated by statistical methods, namely as factor analysis (FA) as well as multiple regression to calculate the crucial factors concerning safety management and safety performance on construction sites. Principal component analysis (PCA) was also utilized to recognize the primary factors. Nonetheless, PCA is recognized as a valuable means for establishing the correlation of variables [79]. In this technique, variables are classified by their associations with one another, consequently, obviously determining the same fundamental factor [80]. Additionally, this study used Varimax rotation to support the clarification of the factors. The subsequent part describes the main results of the survey instrument.

4. Analysis and Results

4.1. Factor Analysis. This article uses a factor analysis approach to identify the fundamental group of components that influence safety management. By using SPSS v.27, the study conducted PCA with varimax rotation on 58 questions ($N = 165$). To check the hypothesis that the correlation matrix was an identity matrix, Barlett's test for sphericity was employed. The value of sphericity is high (χ^2 value = 6,210.571) and the related significance level was small (p-value ≤ 0.001), implying that the correlation matrix was not an identity. George and Mallery [80] reveal that factor analysis could be irrelevant with an identity matrix. According to them, a significance value <0.05 shows that the data set did not create an identity matrix. The authors George and Mallery [80] revealed that the KMO value (Kaiser–Meyer–Olkin Measure of Sampling Adequacy) must be more than the standard limit of 0.5 and if a value is more than 0.6, it is called mediocre, >0.7 is tolerable, >0.8 is commendable, and >0.9 is marvelous for a factor analysis (FA) to go ahead. In the current study, the KMO-value is 0.718, that is higher than the acceptable limit indicating suitable for factor analysis.

In total, 17 factors were extracted showing eigenvalues of 1 or higher from the 58 items survey instrument accounting for 74.07% of variance. While inspecting the scree plot obtained from the SPSS V. 27, it was observed that there is a clear-cut break in the 2nd and the 3rd factor. Pallant [79] indicated that the scree plot needs to be followed for better solution and recommended retaining two factors only. It was established that many items loaded intensely (more than 0.4) in the two factors and not many questions loaded on factors 3–17. This supported the idea that a two-factor result is more appropriate. Following the factor analysis approach ([79, 81]: p. 192), it was necessary to have a two-factor solution.

When having the two-factor result, 26.902% of variance was supported, contrasted with 74.074% elucidated by the 17-factor solution. In the SPSS output, results labeled communalities were inspected, which gave information about how the variance in every item was described. Values less than 0.3 show that the items did not suit with the other items in the components [79]. Therefore, items Q1.1, Q1.3, Q1.4, Q1.5, Q1.6, Q2.3, Q2.4, Q2.5, Q3.2, Q3.4, Q3.5, Q3.6, Q4.1, Q4.3, Q5.1, Q5.2, Q5.3, Q6.2, Q6.3, Q7.2, Q7.3, Q8.1, Q8.2, Q8.3, Q9.1, Q9.2, Q9.3, Q9.4, Q10.2, Q10.3, Q11.1, Q11.2, Q11.4, Q13.1, Q13.2, and Q13.3 had low communality values (Table 1). They showed the low loading in the Rotated Component Matrix. Following the Pallant [79], the researchers decided to improve the scale and removed those items which were having communality value below 0.300. Consequently, questions listed in Table 1 were removed from the scale to improve the measuring instrument.

As a final point, the 23 questions of safety management instrument are exposed to PCA using SPSS Version 27.0. Earlier to conducting final PCA, the fitness of the data set for FA is evaluated. The KMO-value was 0.842, surpassing the value of 0.50. The value of the Bartlett's test of sphericity was high with χ^2 value = 1,565.415 having p-value ≤ 0.001, thus establishing the suitability of the correlation matrix. Employing Catell's [81] scree test and in accordance with Pallant's [79] technique, it was obvious to keep two factors for this research. The two-factor result (Table 2) defended 43.350% of variance, wherein factor 1 contributes 31.171% and factor 2 provides 11.179%.

The findings of this research can be compared to other publications (e.g., Fang et al. [23]) having variance value of 47.6%. Varimax rotation was accomplished to explain the two-factors. The 23-safety management affecting variables were involved in these two extracted factors (Table 2). The output of SPSS 27.0–the scree plot from 23-items is presented in Figure 2. The output verifies that the two-factor model is sufficient for this research.

4.2. Explaining Underlying Safety Management Factors. Safety management influencing factors are listed in downward sequence of significance (Table 2). The researchers labeled each factor containing the set of distinct components it involved. The proposed factor name is totally subjective and new investigators can apply a unique name. One can suggest to all collection of items if true meaning of a given factor label are not clear. Nevertheless, the two-labeled factors are explained next.

4.2.1. Factor 1: Management Commitment, Employee Involvement, and Safety Training. Factor 1 comprises 15 items that are associated with management commitment, employee involvement, and safety training of workers toward safety management.

Table 1: Removed items list showing low communality values (<0.30).

Number	Item	Extraction
Q1.1	Health and safety policies are implemented to save workers and to avoid any accident at construction sites	0.022
Q1.3	Health and safety policy requires to assign safety supervisors for coordination and application of the safety on-site	0.017
Q1.4	Health and safety policy is clarified to new workers at the time of their orientation training before they start their work	0.165
Q1.5	Project safety plan is always implemented, monitored, and updated on the project	0.165
Q1.6	The company is providing medical facilities to their workers through proper medical insurance	0.132
Q2.3	The safety duties of all individuals and supervisors are defined clearly	0.129
Q2.4	Enough experienced safety officers and safety supervisors have been selected and involved for the construction project	0.246
Q2.5	It is necessary for the subcontractors to submit their site safety plans	0.189
Q3.2	The company provides induction training to workers and employees immediately after they join	0.236
Q3.4	The company has a computer-based training program that is used to test learned knowledge of trainees after selecting suitable tests from the data bank	0.214
Q3.5	First aid training is provided to each employee assuming supervisory roles on-site	0.252
Q3.6	Specific training is provided in areas related for safety regulations, electrical works, plumbing works, foundation and trenching, confined space entry, fall protection, equipment operation safety, blasting, asbestos abatement, fire protection, back-injury prevention, lead abatement, crane safety and rigging, and site traffic control	0.085
Q4.1	The top management emphasizes safety measures	0.202
Q4.3	Top management supports the workers fully with health safety policy	0.193
Q5.1	The company properly investigates every accident	0.235
Q5.2	Every accident is reported to the top management	0.233
Q5.3	The accident report is shared with employees and workers for their learning	0.174
Q6.2	Hazards of the projects are discussed with workers during these meetings	0.153
Q6.3	Subcontractors hold regular safety meetings	0.097
Q7.2	Fall protection arrangements (safety harness, safety belt, lanyard) are used during construction to ensure safety of workers	0.120
Q7.3	Health and safety supervisors give toolbox talks daily before the start of work on-site	0.147
Q8.1	The company has written health and safety rules for follow-up by the stakeholders	0.242
Q8.2	The company practice health and safety rules in letter and spirits as per the safety manua	0.233
Q8.3	Standard operating procedures (SOP) for performing construction work are clearly written and are available to perform the work safely	0.252
Q9.1	Housekeeping is done regularly to improve the health and safety environment	0.125
Q9.2	The materials are stored safely on the project site	0.247
Q9.3	Wasted and scraped materials are handled in a proper way to dispose of them	0.247
Q9.4	Health and safety signboards are written in Arabic and English languages on-site so that workers can understand those easily	0.264
Q10.2	Safety personnels perform safety inspections at frequent intervals	0.272
Q10.3	There are suitable procedures to make sure that actions are taken over safety inspections	0.102
Q11.1	The legal needs for supply of personal protective equipment (PPE) are mentioned in the safety plan of the project	0.184
Q11.2	A sufficient stock of selected PPE (safety gloves, safety helmet, safety shoes, safety harness, safety goggles, earmuffs, etc.) is always obtained	0.242
Q11.4	PPE of subcontractor's workers are checked on-site	0.218
Q13.1	Safety notice boards are installed so that workers can see safety material in their work time	0.282
Q13.2	Posters and safety signs are exhibited on-site	0.229
Q13.3	Safety awards (such as "best safe worker," "best safe foreman," "best safe construction site") are given to employees on annual safety performance	0.290

Employees realized that some workers feel uncomfortable by wearing PPE during the hot weather (Q11.5) meaning some workers feel uncomfortable in the hot weather. Nonetheless, they agree that PPEs are necessary for their own safety. The management makes sure that workers are not allowed to work under risky conditions (Q10.4). The management is responsible for implementing the safety and health training plan and it is updated and revised to address current needs (Q3.1). The management is responsible for providing safety booklets and safety manuals to workers when they join the company (Q3.7). The top management encourages and welcomes suggestions from the workers (Q4.4). This factor indicates that the company takes good care of their workers on-site (Q4.2). This factor shows that near misses are scrutinized to avoid accidents

Table 2: Factor structure obtained with varimax rotation.

Number	Item	Factor loading
Factor 1: Management commitment, employee involvement, and safety training; eigenvalue 7.169; % variance 31.171; cumulative % 31.171		
Q11.5	Some workers feel uncomfortable wearing PPE during the hot weather	0.770
Q10.4	The workers are not allowed to work under risky conditions	0.746
Q3.1	The safety and health training plan is updated and revised to address current needs	0.729
Q3.7	Safety booklets and manual are provided to workers when they join the company	0.722
Q4.4	Top management encourages and welcomes suggestions from the workers	0.700
Q4.2	The company takes good care of their workers on-site	0.672
Q5.4	The near misses are scrutinized to avoid accidents	0.633
Q2.1	The company has a health and safety committee to monitor safety	0.599
Q11.3	A system of issuance, replacement, and inspection of PPE is established on the project	0.574
Q7.1	Many accidents happen at construction sites due to falling from height	0.572
Q3.3	Workers get safety training related to their job on site	0.566
Q12.3	Operative are encouraged not to work with any faulty equipment	0.565
Q6.4	Management instructs supervisors and workers to follow safe work practices daily	0.557
Q2.2	Safety is the obligation of top management, and all decisions related to safety are taken with the help of the health and safety committee	0.554
Q10.1	Safety personnel maintain a register to list the hazards happened on the site	0.537
Factor 2: Project safety plan, safety committee, and safe use of equipment; eigenvalue 2.571; % variance 11.179; cumulative % 42.350		
Q1.5	Project safety plan is always implemented, monitored, and updated on the project	0.731
Q2.6	Health and safety committee motivates workers to develop safety culture among them	0.707
Q6.1	Health and safety meetings are conducted regularly in the company	0.683
Q12.2	Operators always have the equipment that is required to complete the job of the project	0.613
Q12.1	Plants and equipment utilized on the project is appropriate for the work and their operators are well trained	0.563
Q7.4	The health and safety personnel demonstrate how to use equipment safely on the project site	0.539
Q8.4	The workers are made accountable if they break the health and safety procedures	0.522
Q1.2	The organization shows its commitment to health and safety policy, rules and regulations related to safety	0.505

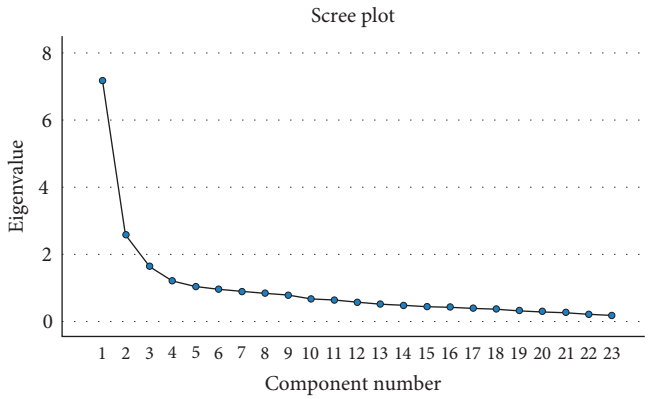

Figure 2: Scree plot of 23 items of safety management.

(Q5.4) on construction projects. The company has a health and safety committee to monitor safety (Q2.1). There is an established system of issuance, replacement, and inspection of PPE on the project (Q11.3). There may be other reasons, but many accidents happen on construction sites due to falling from height (Q7.1). SMSs are implemented in the country, and all workers have received job-specific safety training on site (Q3.3). Operatives are encouraged not to work with any faulty equipment (Q12.3). Management instructs supervisors and workers to follow safe work practices daily (Q6.4). Safety is the obligation of top management, and all decisions related to safety are taken with the help of the health and safety committee (Q2.2). Health and safety personnel maintain a register on-site to list the hazards that happened on the site (Q10.1).

4.2.2. Factor 2: Project Safety Plan, Safety Committee, and Safe Use of Equipment. Factor 2 comprises eight items related to safety plan, safety committee, and safe use of construction equipment on-site. Respondents view that project safety plan is always implemented, monitored, and updated on the projects (Q1.5). Health and safety committee motivate workers to develop safety culture among them (Q2.6). Respondents believe that health and safety meetings are conducted regularly in the company (Q6.1). Respondents perceive operators always have the equipment that is required to complete the job of the projects (Q12.2). Respondents realize that plants and equipment utilized on the project are appropriate for the work and their operators are well trained (Q12.1). Respondents' views that the health and safety personnel demonstrate how to use equipment safely on the project site (Q7.4). The workers are made accountable if they break the health and safety procedures (Q8.4). The organization shows its commitment to health and safety policy, rules, and regulations related to safety (Q1.2).

Table 3: Results of stepwise multiple regression.

Independent variable (safety management factor)	Unstandardized coefficients (β)	Standardized coefficients (β)	Adj. R^2	R^2 change	t-Value	Sig. ($p \leq$)
y Intercept (i.e., constant)	3.630	–	–	–	59.399	0.001
Factor 1: management commitment, employee involvement, and safety training	0.349	0.407	0.161	0.166	5.910	0.001
Factor 2: project safety plan, safety committee, and safe use of equipment	0.217	0.254	0.221	0.064	3.680	0.001
Dependent variable: please estimate the overall safety and health of your project (Q14.1).						

4.3. Safety Management Model and Performance of Safety. A model is called a regression model that can correlate several independent variables to a dependent variable [82]. It can be used when the dependent variable is quantitative, where the dependent variable is binary, logistic regression is required to be used [79]. A regression model that estimates the association between a quantitative dependent variable and two or additional independent variable using a straight line is called multiple linear regression [79, 80]. Multiple linear regression analysis is utilized in this work to determine the link between performance of safety and factors of safety management.

According to George and Mallery [80] and Norus is [83], a stepwise selection of variables is considered the highly utilized method for model development. Multiple regression makes several attempts, every time dropping the weakest related variable. Finally, the variables are retained that describe the best distribution. In this research, stepwise method followed for a variable to join the equation of regression having the p value = 0.05 and p value = 0.10 to eliminate an enrolled variable [80, 82]. The model provides a mathematical equation that comprises a constant (intercept) and coefficients of regression for the significant accomplished factors.

Two primary safety management factors obtained from factor analysis from the 23 items instrument are utilized in calculating the link with employees of performance of safety (question Q14.1). Table 3 indicates the unstandardized and standardized coefficients (β), including adjusted R^2, as well as R^2 change, t-value, and level of significance for the sample. "Management commitment, employee involvement, and safety training (Factor 1)" and "Project safety plan, safety committee, and safe use of equipment (Factor 2)" are significantly differ at $p \leq 0.001$. The β values provide the comparative effect on the variables, meaning that F1 shows the highest impact on performance of safety ($\beta = 0.349$) observed by F2 ($\beta = 0.217$), and the tendency of impact for F1 and F2 are with having positive sign. A R^2 change number of 0.166 indicates that 16.6% of the variance of performance of safety is revealed by F1 and 6.4% by F2. Accordingly, the multiple regression model of performance of safety is shown in Equation (3).

$$\text{Performance of safety management system} = 3.630 + 0.349\,(\text{F1}) + 0.217\,(\text{F2}). \quad (3)$$

4.4. Analysis of Management Interviews. In this study, eight management interviews were performed with professionals who had greater than 10 years of working experience on construction projects related to safety management. They provided rich information about safety management and how safety is implemented on construction sites in the country. The interview guide comprising 14 questions was used for conducting the interviews. All the interviews are analyzed by using the grounded theory method presented by Corbin and Strauss [77]. This theory is defined by Glaser and Strauss [84] as the finding of theory from qualitative data analytically attained from social research. It tries to discover the connotations of society's public actions, communications, and work practices. These elucidations are defined "grounded" when they are based on the contributors' individual clarifications or explanations. The approach is beneficial in evolving perspective-based narratives and descriptions [78] when same and similar answers are grouped together. Important explanations provided by interviews respondents are documented in the discussion section.

5. Discussion

The quantitative evaluation and findings of this work were described in the previous portion. This section argues the findings to deliberate safety management application in the country's construction industry. The findings show that management commitment, employee involvement, and safety training (factor 1) demonstrated important impacts to safety management on the construction sites. Project safety plan, safety committee, and safe use of equipment (factor 2) were also contributing significantly to ensure safety management on-site. The interpretation of the two-factors shows that items of both factors are loaded strongly in the SPPS analysis of the two-factor solution (Table 2). The discussion on the first factor is documented first here followed by the 2nd factor.

5.1. Management Commitment, Employee Involvement, and Safety Training—Factor 1. Numerous studies indicate that management commitment, employee involvement, and safety training are core ingredients in shaping safety management on construction projects. Zohar [20] pointed out that management commitment is a vital component of safety. Other researchers (e.g., Mohamed [21] and Dedobbeleer and Beland [50]) emphasized management commitment and workers involvement. Studies by Choudhry et al. [1] and Feng [85] indicate that

management commitment and workers participation to safety is a central element of safety management in construction. Aksorn and Hadikusumo [86] examined factors affecting safety system implementation in the Thai construction. They established that management support is an extremely important factor. Zhang et al. [87] pointed out safety training as the critical factor in construction management based on the system thinking. Interviewees revealed that the country is the leader in demonstrating safety management in the Middle East. Interviewees explained that the companies need to implement SMSs and project safety plans covering safety management for excavations, scaffolding, safe use of equipment, and electrical safety on-site. To implement a SMS, companies need to have safety organizations comprising on safety manager, safety engineers, and safety supervisors.

Workers feel uncomfortable wearing PPE during hot weather (Q11.5). During summer, the temperature sometimes rises above 48–50°C in Saudi Arabia. According to HRSD [56] regulations, workers must take a break from 12:00 to 3:00 pm. Usukhbayar and Choi [7] found that failure of wearing PPE is perceived as the most critical factor. Wilson and Koehn [32] revealed that workers usually present opposition to safety concerns, and at the same time they benefit from the enhanced safety conditions. Nonetheless, interviewees explain that workers are provided free of cost PPE, which include safety helmet, safety shoes, safety googles, safety belt or harness, safety vest, safety earmuffs, and masks as per the nature of job of workers. There exists a system of issuing, replacement, and inspection of PPE on the projects (Q11.3).

According to the responses, workers are not allowed to work under risky conditions (Q10.4). Safety engineers are responsible for analyzing the hazards and risks. The safety manager and his team maintain a register to list the hazards that happened on the site (Q10.1) for their analysis and monitoring. Cheng et al. [88] revealed that accidents happening are mainly linked to the hazardous condition. Safety managers can manage insecure actions of labor force by removing the related dangers at work situations [89].

It is mandatory for workers to receive 30 hr to 2 weeks safety training (Q3.1), especially orientation training and job specific training (Q3.3) before starting work on-site. Interviewees revealed that trainers need to explain the nature of a job to workers and associated risks. Safety booklets and printed safety materials are provided to workers upon their joining the organization (Q3.7). Workers are told to proceed with their job after obtaining relevant training [90]. An interviewee explained that he is working for a company who always provides good training to its workers. Management of the company involves employees, welcomes, and encourages safety suggestions from workers (Q4.4). They explained that the company takes good care of their employees (Q4.2). Contrary to this, Rowlinson [91] uncovered that numerous workers had a minimal level of education and have not enough training [91] in Hong Kong. These poorly educated immigrant workers cause accidents on construction sites. Mohamed [21] describes that training facilitates labor force to get the skill to execute a job safely. Wilson [92] revealed that people understand by "doing" or by following workmates or by "trial and error".

The respondents revealed that there is a health and safety committee (Q2.1) at project sites. Interviewees explained the responsibilities of site safety committee to respond to workers concerns, monitor and implement safe work procedures, investigate accidents and near miss incidents (Q5.4), and promote safety on-site. A safety engineer revealed that there are some subcontractors who do not pay serious attention to safety. The site safety committee recommends necessary measures to the project management team if noncompliance to safety rules and regulations is observed from any subcontractor. Another interviewee responded that most employees on-site promote positive safety culture and abide safety rules and regulations.

The respondents consider falling from height (Q7.1) a very risky area for accidents happening. Respondents explain that prevention from fall protection first starts with emphasis on removal of fall threats followed by averting fall from happening then arresting the fall and then following emergency procedure if a fall happens. It is always imperative to enhance a worker's awareness of fall risks and how to prevent them [92, 93].

Management instructs supervisors and workers to follow safe work procedures and practices on-site in their tasks (Q6.4). Mohamed [21] revealed that procedures are the central element of SMS. Langford et al. [38] revealed that collaboration between team participants and harmonization of safety systems is essential.

Employees are encouraged not to work with any faulty equipment (Q12.3). Usukhbayar and Choi [7] revealed that using defective equipment and machinery is the 2nd most important factor on the construction project in Mongolia.

A project manager revealed that implementation of safety management is the responsibility of management (Q2.2) on-site. Numerous studies indicated that management has the obligation for applying SMS together with planning, organizing, implementing policies, and work procedures [1, 21]. The project manager further revealed that the safety supervisors are redesignated as safety advisors to advise the project management team to ensure implementation of safe work procedures on their project.

5.2. Project Safety Plan, Safety Committee, and Safe Use of Equipment—Factor 2. Many studies indicate the importance of factor 2 including project safety plan (e.g., Gunduz and Laitinen [27]), Safety Committee [94], and safe use of equipment [5, 95].

Respondents' views that project safety plan is always implemented, monitored, and updated on the projects (Q1.5). Choudhry et al. [1] discussed a typical site plan and stressed that the implementation of the project safety plan was crucial to decrease injuries, eradicate illness and to give safe work situation.

Respondents explained that the safety committee helps the project management team to implement safety decisions on construction sites. They further revealed that the safety committee motivates workers to foster safety culture on-site (Q2.6). Safety culture is shared beliefs, opinions, and values

of personnel in the context of safety, and is very important on construction sites as members not simply consider accountable for their individual safety but are responsible for their coworker's safety [18].

Respondents explained that health and safety meetings are conducted regularly on a weekly basis at their construction projects (Q6.1). Interviewees explained that regular safety meeting are held on site to increase awareness of safety, review of any accident or incident, and prevent its future happening, give employees an opportunity to voice their concerns specially to hazards, and to facilitate compliance and cooperation for safety and health standards, rules, and safe work procedures. Hinze [4] clarified that safety meetings have two purposes; to educate about the procedure, and to persuade for following willingly the directives.

Operators always have the equipment that is required to complete the job of the projects (Q12.2). Safety equipment required for the task must be provided and their maintenance and inspection need to be ensured [33, 90]. Respondents revealed that the plant and equipment utilized on the project are appropriate for the work and their operators are well trained (Q12.1). Respondents explained that approved plant and equipment are used on construction projects after their inspection. Interviewees revealed that licensed operators know how to use equipment safely on the project site (Q7.4). In the country, each piece of equipment needs to be checked annually and inspection permits are issued by the government for their operational use on-site [52].

On-site, the workers are checked if they break the health and safety procedures (Q8.4). Safe work practices are the essential ingredient of safety management [21]. An interviewee revealed that there is no such entity in Saudi Arabia as OSHA [46] in USA, but companies need to follow rules and regulations of the Ministry of Human Resources and Social Development [52]. These standards are not in detail as compared to OSHA standards and are difficult to follow, hence, companies prefer to track OSHA safety rules and regulation to fulfill requirements of the ministry.

The organization shows its commitment to health and safety policy, rules, and regulations related to safety (Q1.2). An interviewee revealed that the safety and health policy of his company requires that the safety and health of employees and workers have utmost importance, and it is a value that cannot be compromised. The policy states that all safety laws, rules, and regulations of Saudi Arabia are followed as the minimum requirement. The policy requires the application of the project safety plan to make sure safe and sound operation on projects. The safety policy coincides with Hinze [96] that safety management is ensured by detecting and managing risks linked to activities on a project.

5.3. Safety Management Performance and Factors Affecting Safety Management. Multiple regression analysis found the link between safety performance with the safety management factors affecting safety on the projects. The findings indicate that "Management commitment, employee involvement, and safety training (Factor 1)" and "Project safety plan, safety committee, and safe use of equipment (Factor 2)" are important sponsors to safety performance on the projects. "Management commitment, employee involvement, and safety training" is the extremely crucial factor affecting safety management performance followed by "Project safety plan, safety committee, and safe use of equipment (Factor 2)" in a positive direction. This outcome was in accordance with Jaselskis et al. [39] that commitment of management, employee participation was the highly significant factor for safety management. The 2nd important factor is "Project safety plan, safety committee, and safe use of equipment" also contributing to safety management performance in a positive way in the country. The researchers noticed that the relationship between safety management performances is directly correlated to factor F1 and factor F2 for improving safety on construction sites. Regression equation supports the use of safety management measures as useful tool in exploring stakeholders' perception about site safety implementation on construction sites. Results indicate that safety can be improved on-site by paying attention to these two significant factors.

5.4. Contribution and Practical Recommendations. This study measured safety management with a proactive approach that would enhance safety and positively impact safety performance on project sites. This study explains how a survey instrument is developed, administered, and improved for measuring safety management. Safety management is measured proactively on the building construction sites before accidents happen. By means of factor analysis, two safety management factors named as "management commitment, employee involvement, and safety training" factor 1 and "project safety plan, safety committee, and safe use of equipment" factor 2, which are considered the most important result of this work.

Overall, the analysis of management interviews with the professionals provided pragmatic expertise to make up project site safer. Interviewees expressed their views on SMSs with emphasis on how safety is implemented and monitored in the construction industry. Respondents replied that the management is dedicated to safety management and employees' involvement. Organizations take good care of workers providing them with job specific training. Management and supervisors are used to investigate serious incidents and accidents. The interviewees express their views on safety training of workers and supervisors. Workers receive orientation and job specific training especially on working at height, working in confined spaces, working with machines and tools, electrical safety, and environmental safety. The interviewees explained that project safety plans are followed and implemented on the construction projects to save workers and to avoid any accident happening. Safety policy is clarified to new personnel as part of their orientation before they start their work on-site. When respondents are asked about the duties and obligations of the site committee on safety, they reply that the safety committee is responsible to apply safety system on project sites. The safety manager is responsible for conducting safety meetings regularly on construction projects. Respondents explained that workers receive free of charge PPE on their project sites. The interviewees explained that workers are provided with fall

protection equipment. They said that housekeeping is given importance on their construction sites. The interviewees explained that following construction safety laws and legislations of the Ministry of Labor and Social Development as well as the Civil Defense are compulsory requirements. They said that safety signs are used on their project sites. Hazards are identified and inspected on the construction projects. Workers are used to conducting toolbox talks before starting their work. The operatives are required to give extraordinary concentration to safe use of plants and equipment. Only trained operatives having a relevant license are allowed to operate construction equipment. When asked about how safety is helpful in developing the construction business. They replied that safety is very visible on-site. Good safety management improves the reputation of a contractor and is helpful in getting new projects.

5.5. Study Limitations and Future Work. Potential limitations of this work include that the data were collected from building construction projects in Saudi Arabia, and measured safety management proactively on those construction sites, The technique deployed might be valuable for conducting related studies before accident happening and results might be observed for comprehensive inferences. This work recommends that a separate entity may be created in Saudi Arabia such as OSHA in USA to monitor and promote safety in every occupation in the Kingdom. Challenges involved in enforcing SMSs, especially for contractors, may be investigated.

6. Conclusions

With a proactive approach, this work measured safety management before accidents happening and it would improve safety performance on projects. Safety management, as perceived by stakeholders including owners, contractors, and consultants and their employees, is measured proactively on the building construction sites. Utilizing factor analysis, two safety management factors are obtained calculating 43.35% of the variance in safety management. These factors are named as "management commitment, employee involvement, and safety training" factor 1 and "project safety plan, safety committee, and safe use of equipment" factor 2. Multiple regression analysis provided the relationship between performance of safety management and the two factors as directly correlated. The results of this research make it easy for the management to focus on two significant factors for improving on-site safety instead of dealing with many factors. The findings indicated that safety management could be applied as an applicable measure of evaluating site safety for ongoing projects. Instead of establishing safety actions on previous disasters and accidents, it is crucial to concentrate on measuring safety management in advance by leading indicators that how stakeholders perceive safety management to make-up project sites safer.

The interview results complemented the findings of the questionnaire survey and there was emphasis on the management dedication, worker participation, safety training, project safety plan, safety committee, and safe use of construction equipment. Stakeholders can further focus on the above-mentioned areas to improve construction safety and to make construction sites safer and ultimately save worker lives. The findings of this work and the methodology can be used to measure safety management in any culture or regions to make construction sites safer.

Appendix

A. Safety Management in Construction Projects

Please complete the questionnaire by ticking appropriate for which we assure the confidentiality.

General Information

(a) Project name
(b) Gender (F/M)
(c) Marital status (Single/Married)
(d) Qualification (schooling, bachelor, master/higher)
(e) You Position/Designation (Project manager, Safety manager, Engineer, Supervisor, Worker)
(f) Do you work with/as? (Client, Consultant, Contractor)
(g) Experience in the Construction Industry (<2 years, 3–5 years, 6–8 years, >10 years).

Below are presented safety and health statements on a Likert scales. Please tick only the appropriate option.

(1) Policy related to Safety
  (i) Health and safety policies are implemented to save workers and to avoid any accident at construction sites.
  (ii) The organization shows its commitment to health and safety policy, rules and regulations related to safety.
  (iii) Health and safety policy requires to assign safety supervisors for coordination and application of the safety on-site.
  (iv) Health and safety policy is clarified to new workers at the time of their orientation training before they start their work.
  (v) Project safety plan is always implemented, monitored, and updated on the project.
  (vi) The company is providing medical facilities to their workers through proper medical insurance.
(2) Safety committee and safety organization
  (i) The company has a health and safety committee to monitor safety.
  (ii) Safety is the obligation of top management, and all decisions related to safety are taken with the help of the health and safety committee.
  (iii) The safety duties of all individuals and supervisors are defined clearly.

(iv) Enough experienced safety officers and supervisors have been selected and involved for the construction project.

(v) It is necessary for the subcontractors to submit their site safety plans.

(vi) Health and safety committee motivates workers to develop safety culture among them.

(3) Education and training

(i) The safety and health training plan is updated and revised to address current needs.

(ii) The company provides induction training to workers and employees immediately after they join.

(iii) Workers get safety training related to their job on site.

(iv) The company has a computer-based training program that is used to test learned knowledge of trainees after selecting suitable tests from the data bank.

(v) First aid training is provided to each employee assuming supervisory roles on-site.

(vi) Specific training is provided in areas related to safety regulations, electrical works, plumbing works, foundation and trenching, confined space entry, fall protection, equipment operation safety, blasting, asbestos abatement, fire protection, back-injury prevention, lead abatement, crane safety & rigging, and site traffic control.

(vii) Safety booklets and manuals are provided to workers when they join the company.

(4) Management commitment and employee's involvement

(i) The top management emphasizes safety measures.

(ii) The company takes good care of their workers on site.

(iii) Top management supports the workers fully with a health and safety policy.

(iv) Top management encourages and welcomes suggestions from the workers.

(5) Accident analysis and reporting

(i) The company properly investigates every accident.

(ii) Every accident is reported to the top management.

(iii) The accident report is shared with employees and workers for their learning.

(iv) The near misses are scrutinized to avoid accidents.

(6) Health and safety meetings

(i) Health and safety meetings are conducted regularly in the company.

(ii) Hazards of the projects are discussed with workers during these meetings.

(iii) Subcontractors hold regular safety meetings.

(iv) Management instructs supervisors and workers to follow safe work practices on a daily basis.

(7) Fall protection and toolbox talks

(i) Many accidents happen at construction sites due to falling from height.

(ii) Fall protection arrangements (safety harness/safety belt, lanyard) are used during construction to ensure safety of workers.

(iii) Health and safety supervisors give toolbox talks daily before the start of work on-site.

(iv) The health and safety personnel demonstrate how to use equipment safely on the project site.

(8) Safety regulations and procedures

(i) The company has written health and safety rules for follow-up by the stakeholders.

(ii) The company practice health and safety rules in letter and spirits as per the safety manual.

(iii) Standard operating procedures (SOP) for performing construction works are clearly written and are available to perform the work safely.

(iv) The workers are made accountable if they break the health and safety procedures.

(9) Housekeeping and safety signs

(i) Housekeeping is done regularly to enhance the safety environment.

(ii) The materials are stored safely on the project site.

(iii) Wasted and scraped materials are handled in a proper way to dispose of them off.

(iv) Health and safety signboards are written in Arabic and English languages on site so that workers can understand those easily.

(10) Inspecting and supervising hazardous conditions

(i) Safety personnel maintain a register to list the hazards that happened on the site.

(ii) Safety personnel perform safety inspections at frequent intervals.

(iii) There are suitable procedures to make sure that actions are taken over safety inspections.

(iv) The workers are not allowed to work under risky conditions.

(11) Program of personal protection

(i) The legal needs for the supply of personal protective equipment (PPE) are mentioned in the safety plan of the project.

(ii) A sufficient stock of selected PPE (safety gloves, safety helmet, safety shoes, safety harness, safety goggles, earmuffs, etc.) is always obtained.

(iii) A system of issuance, replacement, and inspection of PPE is established on the project.

(iv) PPE of subcontractor's workers are checked on-site.

(v) Some workers feel uncomfortable wearing PPE during the hot weather.

(12) Supervision of equipment and plants
  (i) Plants and equipment utilized on the project is appropriate for the work and their operators are well trained.
  (ii) Operators always have the equipment that is required to complete the job of the project.
  (iii) Operative are encouraged not to work with any faulty equipment.

(13) Promotion of safety
  (i) Safety notice boards are installed so that workers can see safety material in their work time.
  (ii) Posters and safety signs are exhibited on-site.
  (iii) Safety awards (such as "best safe worker," "best safe foreman, "best safe construction site") are given to employees on annual safety performance.

(14) Performance of SMS
  (i) Please estimate the overall safety and health of your project.

B. Interview Questionnaire

Q1. Would you like to introduce yourself together with your education background, your job description, and your company construction projects.

Q2. Please explain some prominent features of the Saudi Arabia's construction industry in the context of SMS.

Q3. Would you like to explain about the health and SMS of your company. How safety systems are developed, applied, monitored, and updated periodically on your construction site?

Q4. Please express your views on the health and safety policy of your company. How is the safety policy implemented to save workers and to avoid any accidents on construction sites? Is the policy clarified to new workers during the orientation period before beginning of work on the project?

Q5. Please explain the duties and obligations of the health and safety committee. Please tell us about the difference between a safety manager, a safety engineer, and a safety advisor. Will the management show commitment to safety and take care of workers safety?

Q6. Please comment on the education and training program of workers, supervisors, and others.

Q7. Please comment on construction safety laws, legislation, and their enforcement in the industry. Are hazards identified and inspected on your project site. Does worker receive PPE free of charge on your project site?

Q8. Please shed some light on SMSs operational on construction projects in Saudi Arabia and particularly in your company. Are workers provided with fall protection equipment?

Q9. Considering your company, please explain about the safety situation on construction sites. Are weekly safety meetings conducted regularly on your project site? Please explain.

Q10. Does any procedure exist on project sites that workforce learns from incidents to avoid subsequent accidents?

Q11. How are accidents investigated on your construction site? Are those investigations shared with operatives for their learning? To what extent management is involved in investigating serious incidents and accidents.

Q12. Is there implementation of a project safety plan necessary on all projects of the company? How is the project safety plan implemented, monitored, and updated on your project? Would you like to explain please?

Q13. Is the machinery used on the project appropriate for the work on-site? Are the operatives being well trained and have license to operate the equipment? Please explain.

Q14. How is safety promoted on your construction site? Is safety helpful in developing the company's construction business? Would you like to illustrate how?

Data Availability

Data collected or analyzed during this work shall be available from the corresponding author by request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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