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The effects of COVID-19 on safety practices in construction projects
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Abstract

The coronavirus (COVID-19) pandemic was recognized as a worldwide epidemic and classed as a high risk in early 2020, affecting people’s health, economies, and business sectors considerably. This pandemic has had an impact on people’s lifestyles and work processes in a multitude of sectors. The construction industry is one such industry that has had a substantial influence on it. However, this influence needs to be measured in different areas. This study aims to measure the effects of the COVID-19 on the 7 core safety elements and their 24 procedures that are derived from the recommended practices for safety and health programs in construction that is issued by OSHA to see whether their priorities have been changed or not. The data were collected and then analyzed using Relative Importance Index (RII) to study the changes in their priorities; and using t-test to study the significance of the changes before and after COVID-19 pandemic.

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1. Introduction

Construction projects have persisted in recent months because they were deemed necessary, and they were exempt from government laws that required all firms to close. Therefore, during the next stage of the COVID-19, construction sites become different than to what they were before the pandemic.

Usually, organizations have certain obligations when it comes to employee’s health and safety. Therefore, minimizing the virus spread has become a highest priority. This was a challenging in construction projects since workers are not able to work from home and it was necessary to work very close proximity to others. Construction projects has been facing a unique challenge as usual, however, governments and organizations tried to minimize the risks of spreading the virus by issuing new requirements or guidelines on how to perform construction activities as the business begins to reopen.

COVID-19 pandemic has affected different countries, and the effects were on individuals and businesses. As a result, a huge scope for involvements and assessment of recommendations in many areas were conducted and provided. In term of safety science, a study was carried out which acknowledged major scopes of safety have involved in the community such as medicine, treatment, and vaccine safety which follows an undiscovered way, pleasing oriented system for intelligence and the classification of higher order patterns with relevant interdisciplinary [1]. A study provided the need to analyze the negative effects of the pandemic on the world economy; and it indicates that there is no traditional to measure of COVID-19 in a method that adapts all the relevant factors such as related cases, deaths, and rescues into a particular indicator [2]. Several evaluations of the cost of the COVID-19 occurrence in seven various scenarios of how the virus could grow were studied [3]. At that time, the probability of these scenarios and the range of possible options are unclear. In the case where COVID-19 establish as a pandemic, therefore, the result was recommended that the cost could be escalated quickly.

In construction industry, some studies showed that COVID-19 affected the progress and the contractual agreements of construction projects. In Kuwait, 17 factors were identified as they affected the progress construction projects. In Kuwait, 17 factors were identified as they affected the progress and the contractual agreements of construction projects. Some of those factors were causing essential issues due to the complex relationship between the employers, the architects and engineers, and the contractors, while others considered as a issues that were out of management control such as the weather, floods, earthquakes, and COVID-19 [4]. Government restrictions during COVID-19 Pandemic resulted...
in significant delays in construction projects as employees were unable to work in normal working times [5]. This led owners along with contractors to reschedule and reallocate resources in construction projects to reduce the delays and to finish projects within an acceptable time. The contractual requirements were affected in different aspects [6]. These effects were identified as termination of projects, changes in notice requirements, forced majeure clauses, privilege for additional time, requests for changes effect of refused additional time, cost increase, resources availability, and safety measures. As the situation continued to be fluctuating, it was difficult for owners to predict the effects on construction projects to allow them to take some courses of actions which would help in managing projects more effectively. So, it was recommended that contractors needed to evaluate the contractual commitments and the expected effects to support and confirm nonperformance as per agreed scope and milestones.

In terms of safety performance management and practices in construction projects, which is a serious problem in construction industry [7], different studies provided different strategies and procedures to be used boost the performance and to mitigate the effects of COVID-19 pandemic. A study identified issues that might affect the performance of safety on construction project by implementing different identified factors which could have a positive impact and reduce the number of accidents in construction project [8]. That would result in increasing the productivity as well as projects would be more expected to finish on time. The active safety performance implementation in the project might lead to enhancement of project performance. Another study indicated that the construction sites should integrate the indorsed safety rules in their daily operations that may take additional time to adapt to the new safety guidelines in construction [9]. Safety management system and safety responsibility reduced risk level and enhance safety performance in projects as the relationship between them could affect safety responsibility positively [10]. According to the result of Critical Success Factors (CSF) analysis, which classified it into four elements: involvement of workers, prevention of safety, system control and management responsibility, one of the most important element to ensure the beneficial implementation of safety in construction projects is the support that is needed by organization management [11]. To validate the involvement of these factors to the safety measures, three studies have been organized and the result demonstrated that safety performance implementations was measure as high.

The management should revisit safety roles to recognize the changes that need to be adapted as a reaction to the COVID-19 pandemic and any accepted new roles might be announced on construction sites for any activities [12]. It was recommended that some safety actions that might be required prior to start construction activities [13]. Other precautions suggestions were provided to ensure worker is preforming in safely manner [14]. A safe environment for workers was created by developing a positive relation between management and worker to accelerate the worker response to the new procedures of the work during the pandemic [15]. The risk of COVID-19 has been studied and to provide some options for upcoming study; and it was emphasizing that the importance of safety and other practice and suggested some factors to be developed to promote any further issues [16].

Some studies were conducted to show the different strategies that were adopted by different organizations to merge the impact of COVID-19 on the practices of safety performance and management in construction projects. However, there is a lack in studies that investigated how COVID-19 pandemic has affected the safety practices in construction projects. This paper aims to explore the changes on the existing safety practices in construction projects as well as to identify any new procedures that has been resulted due to the COVID-19 pandemic. This is because of the fact that introducing new strategies of safety practices in some studies were expected to have some effects on the existing safety producers and safety elements. So, these effects need to be investigated to study the significance of any change occurred on safety elements. In addition, new safety and health measures emerged which need to also to investigated and studied.

2. Research methods

As shown in Fig. 1, the stated study statement was investigated by collecting data into two phases. Phase one was about identifying the safety elements in construction, so recommended safety practices in construction projects by OSHA [17] were used to examine how they were affected by COVID-19 pandemic. Then, 40 highly experienced construction professionals in safety in the construction industry of Saudi Arabia such as safety engineer, project engineer, project manager and others who were involved in safety matters in construction projects were asked to judge the importance of those safety elements through a survey. The questions in the survey were firstly structured to prioritize the importance the 7 core elements before and after COVID-19 pandemic to quantify the changes and to measure the significance of any change. The 7 core safety elements were: Hazard prevention and control, Hazard identification and assessment, Worker participation, Management leadership, Communication, and Coordination for employers on multiemployer worksites, Education and training, Program evaluation and improvement. Then, the experts were also asked to prioritize the importance the 24 safety producers for each core safety element before and after COVID-19 in construction projects to quantify the changes and to measure the significance of any change. Finally, experts were asked to identify the new safety producers that had been results due to COVID-19 pandemic to see if there were any new common safety procedures and then to measure the importance of these new measures.

2.1. Relative importance index

To quantify the results of the changes in the core safety elements and their procedures in construction projects, Relative Importance Index (RII) has been used to analyze the data followed by Likert Scale pattern. RII is a method that is a mean that is related to the weight anticipations of participants on a Likert Scale [18]. RII is commonly used to rate different variables in a survey [19]. The ranking of the factors that are considered in RII are ranked from highest to lowest starting from 1, which represents the highest RII value equals or close to 1. The RII is calculated as in Eq. (1):

\[
\text{RII} = \frac{\sum W_n}{(A \times N_r)} = \frac{nX_5 \cdot 5n_5 + 4n_4 + 3n_3 + 2n_2 + n_1}{5 \times N_r}
\]

where RII = relative importance index; \( W_n \) is weighting given to each core element and each safety procedure by participants ranging from 1 to 5, where 1 is considered as the very low important safety procedure and 5 is considered as the very important procedure. The number of participants is represented by the \( nXn \), where \( n_5 \) stands for the number of participants who rated any core element or safety procedure as low importance. The \( n_4 \) stands for the number of participants who rated any core element or safety procedure as important, the \( n_3 \) stands for the number of participants who rated any core element or safety procedure as very high importance, the \( n_2 \) stands for the number of participants who rated any core element or safety procedure as high importance, the \( n_1 \) stands for the number of participants who rated any core element or safety procedure as medium importance, and \( n_0 \) stands for the number of participants who rated any core element or safety procedure as low importance. The variable \( A \) is the highest weight which is 5 in this study and \( N_r \) is total number of participants which is 40 in this study. The RII value is ranging from 0 to
where 0 not inclusive; the higher the RII result is after COVID-19 pandemic, the more important was the change on safety procedures in construction projects. The RII results were then ranked, and the results are shown in Table 1 and Table 2. The average RII results for the core elements and their safety procedures give the RII results of the mean groups.

2.2. T-test analysis

Then t-test will be used to test the significance of the changes in core safety elements and for each safety procedure. The t-test will be calculated as follows:

\[
t = \frac{(m_c - m_t)}{\sqrt{\frac{s_c^2}{n_c} + \frac{s_t^2}{n_t}}}\]

(2)

Where, \(m_c\) and \(m_t\) represent the empirical means and \(s_c^2\) and \(s_t^2\) are used to compute the normalization of the distance between the two samples population.

Noted that \(m\) for each population is equal to \(\frac{\sum x_i}{n}\) and \(s^2 = \frac{\sum (x_i - m)^2}{(n - 1)}\) are the well-known estimates for both the mean (m) and standard deviation. [20]. As known, the t is almost following a student distribution using:

![Fig. 1. Study and Data Collection Methods.](image-url)
### Table 2
RII Results of Safety Procedures Before and After COVID-19.

| Core Safety Elements | No | Safety Producers | Before COVID-19 | After COVID-19 | Core Safety Elements | No | Safety Producers | Before COVID-19 | After COVID-19 |
|----------------------|----|------------------|----------------|----------------|----------------------|----|------------------|----------------|----------------|
|                      |    |                  | RII  Rank      | RII  Rank      |                      |    |                  | RII  Rank      | RII  Rank      |
| 1.0 MANAGEMENT       | 1.1| Expect performance | 0.81  4        | 0.84  4        | 4.0 EDUCATION AND TRAINING | 4.1| Identify control options | 0.83  2        | 0.85  3        |
| LEADERSHIP           | 1.2| Communicate your commitment to a safety and health program | 0.83  2        | 0.89  1        | 4.2 Develop and update a hazard control plan | 0.85  1        | 0.86  2        |
|                      | 1.3| Allocate resources | 0.83  2        | 0.86  2        | 4.3 Select controls to protect workers during nonroutine tasks and emergencies | 0.79  4        | 0.84  4        |
|                      | 1.4| Define program goals | 0.85  1        | 0.86  3        | 4.4 Implement selected controls on the job site | 0.82  3        | 0.87  1        |
| 2.0 WORKER           | 2.1| Encourage workers to participate in safety program | 0.83  4        | 0.87  1        | 5.0 HAZARD PREVENTION AND CONTROL | 5.1| Follow up to confirm that controls are effective | 0.85  2        | 0.87  4        |
| PARTICIPATION        | 2.2| Encourage workers to report safety and health concerns | 0.81  5        | 0.87  1        | 5.2 Provide program awareness training | 0.83  4        | 0.88  2        |
|                      | 2.3| Give workers access to safety and health information | 0.84  2        | 0.86  4        | 5.3 Train employers, managers, and supervisors on their roles in the program | 0.81  5        | 0.88  1        |
|                      | 2.4| Involve workers in all aspects of the program | 0.85  1        | 0.87  1        | 5.4 Train workers on their specific roles in the safety and health program | 0.86  1        | 0.84  5        |
|                      | 2.5| Remove barriers to participation | 0.84  2        | 0.81  5        | 5.5 Train workers on hazard identification and controls | 0.85  2        | 0.88  2        |
| 3.0 HAZARD           | 3.1| Collect existing information about job site hazards | 0.83  4        | 0.86  5        | 6.0 PROGRAM EVALUATION AND IMPROVEMENT | 6.1| Monitor performance and progress | 0.84  3        | 0.87  2        |
| IDENTIFICATION       | 3.2| Inspect the job site for safety hazards | 0.88  2        | 0.87  2        | 6.2 Verify that the program is implemented and is operating | 0.85  2        | 0.89  1        |
| AND ASSESSMENT       | 3.3| Identify health hazards | 0.85  3        | 0.87  4        | 6.3 Correct program shortcomings and identify opportunities to improve | 0.85  1        | 0.84  3        |
|                      | 3.4| Conduct incident investigations | 0.88  1        | 0.88  1        | 7.0 COMMUNICATION AND COORDINATION FOR EMPLOYERS ON MULTIEmployer WORKSITES | 7.1| Establish effective communication | 0.85  1        | 0.85  2        |
|                      | 3.5| Identify hazards associated with emergency and nonroutine situations | 0.80  6        | 0.87  2        | 7.2 Establish effective coordination | 0.84  2        | 0.87  1        |
|                      | 3.6| Characterize the nature of identified hazards, identify interim control measures, and prioritize the hazards for control | 0.82  5        | 0.86  6        | | | | | |

The RII calculations details for safety procedures are attached in Appendix A.
The results of the core elements of safety using Relative Importance Index (RII) analysis are shown in Table 1. The results show that there were changes occurred on their importance due to COVID-19 Pandemic. Table 1 shows that the importance from 1, which is very low, to 5, which is high, where some safety procedures had not been changed where there were some dramatic changes in some other procedures. The first noticeable result is that hazard prevention and control had become the most important factor where it was ranked as the fourth before COVID-19. Also, program evaluation and improvement that was the sixth important factor before, had become the second most important factor after COVID-19 pandemic. The reason of these two procedures becoming the most important two procedures is due to the governmental instructions and restrictions in Saudi Arabia as there were measures that were enforced for around two years which must be followed by all sectors as there were high penalties for those who were not complying with the COVID-19 restrictions and instructions. The other noticeable result is that the management leadership and the communication and coordination have been ranked as the lowest two after COVID-19 pandemic. The importance score for these lowest two procedures has not actually been significantly less than what they have been before COVID-19 pandemic; however, there were other safety measure that have become more important after COVID-19 pandemic compared to their status before.

Table 2 shows the results of safety procedures using RII analysis. Looking at the safety procedures of the core elements, which also changed during COVID-19 pandemic, the results are discussed as follows:

3.1. RII results of hazard prevention and control

By looking at the results of the RII analysis of the safety procedures of this core safety element, which has become the most important one, it can be seen that all of them became higher after COVID-19 pandemic compared to their results before except one which is train workers on their specific roles in the safety and health program which has been ranked as the lowest one. However, the rankings of the safety procedures of this core element have also been changed where some become more important and some has become less important where there was only one that stayed in the same statues before and after COVID-19 Pandemic, which is training workers on hazard identification and controls. The reason that this safety factor stayed in the same statues before COVID-19 pandemic could be because of the importance of identifying and controlling hazards that may result of COVID-19 pandemic. The discussed results of these safety procedures of the Hazard Prevention and Control could justify the reason that why it has become the most important core safety element as the safety performance needs to be improved by redesigning the prevention system to meet specific cases and needs and also to be adaptable to emerging risks such as COVID-19 [21].

3.2. RII results of program evaluation and improvement

The results of the procedures of this second core safety element have the same trend as the most important core safety element. This is because of the fact that there was a need for more collaborations between different parties to tackle COVID-19 crisis [22], which means that all existing programs need to be re-assessed to adopt the new instructions by WHO and local governments to control the spread of this disease. The RII analysis results showed that all safety procedures have become higher after COVID-19 pandemic compared to their statues before except one which is the correcting program shortcomings and identify opportunities to improve which was ranked as the most important safety procedures for this core safety element but then become the less important one. However, the RII score of this safety procedure after COVID-19 pandemic is not significantly different to its score before. So, it is ranked the lowest as the others have become more important after the pandemic as more monitoring of performance and progress was required and more verification on implementing and operating the programs was required too. In addition, it is always recommended to keep regularly monitoring and reviewing safety programs [23] to report any updates that may affect the existing programs and to adapt the need and emerging risks.

3.3. RII results of communication and coordination for employers on multiemployer worksites

The effective communication has a crucial importance in identifying hazards in construction sites [24]. However, this safety procedures as discussed earlier in the results of the core safety element has become less important after COVID-19 compared to its status before. By looking at the RII results of its safety procedures there were no significant changes as the two safety procedures did not score less after COVID-19 pandemic compared to their scores before as one stayed the same statues where the other one scored higher RII after COVID-19 pandemic. It means that the practitioners are looking to the safety procedures in isolation to their core safety elements.

3.4. RII results of management leadership

Recent studies claim that management should encourage and regularly assess the effectiveness of the leadership and attitudes and also to develop motivations among all different participants in projects to enhance the safety performance [25]. In contrast, this core safety element as discussed earlier in the results became the lowest important one after COVID-19 compared to its status before. It did not mean that it less important compared to the others but due to the need to more prevention controls and re-evaluating the existing safety programs it became less important compared to them. The RII results of its safety procedures are that there were no significant changes as the four safety procedures did not score less after COVID-19 pandemic compared to their scores before as all of them have scored higher RII after COVID-19 pandemic. The reasons of ranking the safety procedures after COVID-19 pandemic were not that different to their status before. It means that the practitioners are again looking to the safety procedures in isolation to their core safety element, which is the same trend occurred in their scores to the Communication and Coordination for Employers on Multiemployer Worksites, where it is also ranked lower after COVID-19 pandemic, but its safety procedures have scored higher after the pandemic.
3.5. RII results of workers participation

As a core safety element, the RII result of workers participation did not show a significant difference to its importance after COVID-19 pandemic compared to its status before. However, the results of its safety procedures showed that they all scored higher RII after COVID-19 pandemic where three of them became the most important ones. These three safety procedures are about encouraging workers to participate in safety program; and to report safety and health concerns and being involved in all aspects of the program. This derived from the fact that construction workers have crucial importance in maintain the safety performance in construction projects as they high levels of stress would affect their performance [26] which means that the risks of COVID-19 would increase the stress level more than usual. This leads to involve them more in the design and assessment of safety programs. This is also could be justified due to the enforced measures and restrictions of COVID-19 in Saudi Arabia where workers play a significant role in controlling the spread of this pandemic as well as reporting any symptoms of infections. There is also another safety procedures that has ranked the fourth important one but with no that significant difference compared to the first important ones which was giving access to workers to safety and health information. The importance of this safety procedure in COVID-19 pandemic was derived from the fact that sharing the information of safety program and health status would help workers in being updated with any new safety measures and to control the possibility of being infected in construction sites which may lead to affect the progress of the work. As noted earlier, the results of the safety procedures showed that the practitioners evaluated their importance in isolation to the evaluation of their core safety elements. However, the result of their core safety elements has scored higher RII after COVID-19 pandemic compared to its status before but not with that significant difference.

3.6. RII results of hazard identification assessment

The RII result of this core safety element after COVID-19 pandemic was higher compared to its score before, however, it was less than the most important two core safety elements. Looking at the RII result of its safety procedures most of them scored higher after the pandemic compared to their scores before but with not that significant difference except one which scored significantly higher RII after the pandemic which is identifying hazards associated with emergency and nonroutine situations. This result of this safety procedure is acceptable as the restriction and instruction to be followed by Saudi government in COVID-19 pandemic encourage the project management team and safety practitioners beside workers to be more alerted of any emergency cases or nonroutine situations that may affect the progress of the project, as they all play a key role in managing hazards in construction sites [27].

3.7. RII results of Education and training

The RII result of this core safety element was higher after the COVID-19 pandemic compared to its score before. All safety procedures of this core safety element scored higher RII after the pandemic compared to their scores before. There is one safety procedure could be considered scoring higher RII after the pandemic which is about implementing the selected controls on the job site. The training of the employees has a crucial importance to ensure adequate safety awareness levels is achieved and to improve safety performance in construction projects [28]. So, the increased importance of this core safety element and its safety procedures is justified and also validate that it was more required and important to ensure the implementation of the safety controls to maintain the safety of the worker and safety performance in construction sites.

3.8. Significance of the changes on safety core elements and procedures

To examine the significance of the changes of core safety elements and their procedures, T-test analysis has been conducted and the results are shown in Table 3 and Table 4. The main result derived from the core safety elements is that priorities of two procedures are significantly increased after COVID-19, which are Hazard Prevention and Controls and Program Evaluation and Improvement. This is different to the results of the safety procedures as the findings show that the significant increased occurred in safety procedures that are different to the changes in the core safety elements. The reason is that in general there was more focus on these two core safety elements as COVID-19 required reviewing the existing practice and more control to prevent its spread and possibilities of infection according to the local instructions and regulations enforced by the government.

The RII results of safety procedures in Table 4 show some changes in the ranking of core safety element and their procedures after COVID-19 pandemic, however, the significance of those changes is limited to three safety procedure which are: Encouraging workers to report safety concerns, which is related to the core element of Worker Participation, Identifying hazards associated with emergency and nonroutine situations, which is related to the core element of Hazard Identification and Assessment, Train employers, managers, and supervisors on their roles in the program.

These results of the above three safety procedures means that their importance have been significantly increased after COVID-19 Pandemic compared to the other changes on the importance of safety procedures where the changes were not significant. The main reason for these significant changes was to control the spread of the COVID-19 and its infection on individuals as well as the workflow of the construction projects as that expected to lead to some changes of the project plans and time. So, the focus on more detailed assessment and identification of hazards, and engaging workers on different levels to report any hazard was justified as

Table 3
The Significance of Changes in the Core Safety Elements in Construction Projects during COVID-19 Pandemic.

| No. | Core Safety Elements                                    | t-test one tail | t-test two tail | Significance |
|-----|--------------------------------------------------------|----------------|----------------|--------------|
| 1.0 | Management Leadership                                  | 0.147          | 0.293          | N            |
| 2.0 | Workers Participation                                  | 0.399          | 0.799          | N            |
| 3.0 | Hazard Identification and Assessment                   | 0.398          | 0.795          | N            |
| 4.0 | Hazard Prevention and Control                          | 0.013          | 0.027          | Y - BOTH     |
| 5.0 | Education and Training                                 | 0.194          | 0.388          | N            |
| 6.0 | Program Evaluation and Improvement                     | 0.015          | 0.030          | Y - BOTH     |
| 7.0 | Communication and coordination for Employers on multiple worksites | 0.251          | 0.502          | N            |
Table 4
The Significance of Changes in the Safety Procedures in Construction Projects during COVID-19 Pandemic.

| Core Safety Elements | No | Safety Producers | t-test two tail | t-test one tail | Significance | Core Safety Elements | No | Safety Producers | t-test two tail | t-test one tail | Significance |
|----------------------|----|------------------|-----------------|----------------|--------------|----------------------|----|------------------|-----------------|----------------|--------------|
| 1.0 MANAGEMENT LEADERSHIP | 1.1 | Expect performance | 0.550 | 0.275 | N | 4.0 EDUCATION AND TRAINING | 4.1 | Identify control options | 0.670 | 0.335 | N |
| | 1.2 | Communicate your commitment to a safety and health program | 0.109 | 0.054 | N | | 4.2 | Develop and update a hazard control plan | 0.783 | 0.391 | N |
| | 1.3 | Allocate resources | 0.412 | 0.206 | N | | 4.3 | Select controls to protect workers during nonroutine tasks and emergencies | 0.207 | 0.104 | N |
| | 1.4 | Define program goals | 0.783 | 0.391 | N | | 4.4 | Implement selected controls on the job site | 0.128 | 0.064 | N |
| 2.0 WORKER PARTICIPATION | 2.1 | Encourage workers to participate in safety program | 0.245 | 0.122 | N | 5.0 HAZARD PREVENTION AND CONTROL | 5.1 | Follow up to confirm that controls are effective | 0.479 | 0.239 | N |
| | 2.2 | Encourage workers to report safety and health concerns | 0.095 | 0.047 | Y - ONE TAIL | | 5.2 | Provide program awareness training | 0.198 | 0.099 | N |
| | 2.3 | Give workers access to safety and health information | 0.488 | 0.244 | N | | 5.3 | Train employers, managers, and supervisors on their roles in the program | 0.053 | 0.027 | Y - ONE TAIL |
| | 2.4 | Involve workers in all aspects of the program | 0.595 | 0.297 | N | | 5.4 | Train workers on their specific roles in the safety and health program | 0.595 | 0.298 | N |
| | 2.5 | Remove barriers to participation | 0.532 | 0.266 | N | | 5.5 | Train workers on hazard identification and controls | 0.366 | 0.183 | N |
| 3.0 HAZARD IDENTIFICATION AND ASSESSMENT | 3.1 | Collect existing information about job site hazards | 0.325 | 0.163 | N | 6.0 PROGRAM EVALUATION AND IMPROVEMENT | 6.1 | Monitor performance and progress | 0.393 | 0.196 | N |
| | 3.2 | Inspect the job site for safety hazards | 0.877 | 0.439 | N | | 6.2 | Verify that the program is implemented and is operating | 0.169 | 0.084 | N |
| | 3.3 | Identify health hazards | 0.683 | 0.342 | N | | 6.3 | Correct program shortcomings and identify opportunities to improve | 0.789 | 0.394 | N |
| | 3.4 | Conduct incident investigations | 0.886 | 0.443 | N | 7.0 COMMUNICATION AND COORDINATION FOR EMPLOYERS ON MULTIEmployer WORKSITES | 7.1 | Establish effective communication | 0.888 | 0.444 | N |
| | 3.5 | Identify hazards associated with emergency and nonroutine situations | 0.062 | 0.031 | Y - ONE TAIL | | 7.2 | Establish effective coordination | 0.670 | 0.335 | N |
| | 3.6 | Characterize the nature of identified hazards, identify interim control measures, and prioritize the hazards for control | 0.251 | 0.126 | N | | | | | | | |

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COVID-19 has been classified as the high hazard that needs to review the existing measures to control it as possible as they can.

3.9. New safety measures emerged during COVID-19 pandemic

There were five new safety measures that had been identified during the COVID-19 pandemic in construction projects in Saudi Arabia, which are: social distancing, wearing mask, wearing gloves, virtual meeting and COVID-19 quarantine protocol, see Table 5. These new safety measures were resulted from the new regulations enforced by Saudi government to control the spread of COVID-19. Similar measures were enforced in other different countries all workplaces such as social distancing which was difficult to implemented in some areas like urban spaces unless it is considered in early stages of urban design [29]. The other thing that needs to be reconsidered about these new safety measures is the reviewing the existing guidelines and standard with the aid of digital transformation [30], however, in construction projects it is required to see how social distancing could be controlled where the work environment needs on physical attendance and the possibility of social distancing is difficult. The other positive impact of these new safety measures in construction projects is that the health condition of workers has become more important than what it was before [31,32]. These new measures are expected not to last for a long time, so they are considered as temporary safety procedures.

4. Conclusion

This study explored the changes of the importance of safety practices in construction industry due to COVID-19 pandemic. The safety practices were divided into core elements and different number of procedures for each core safety element. The results showed that the importance of some core safety elements remain the same where are some others have been significantly increased to identify, assess, and control COVID-19 effects on workers in construction projects. There were two core safety elements that had been significantly changed. One core safety element that have been significantly increased was about the fact that there has been more need to prevent and control the infection of the workers to maintain the work in construction projects. The other core safety element was about re-evaluating the existing safety programs and improve them to adapt the new safety measures and to ensure that they were appropriate to control the effects of the pandemic on the safety of the workers in construction projects which would result in maintaining the required progress and productivity of the projects. Regarding the changes of the safety procedures, the results showed that there were dramatic changes in the importance for most of them but there were three that were significantly increased to report and control COVID-19 effects and also to ensure that everyone understood his role to maintain the work during this pandemic. There were also five new safety measure have been added where there is only two that have been identified as very important. However, these new safety measures were considered temporary as they are expected not to be considered after the pandemic. The findings of this study showed how COVID-19 positively affected the safety procedures in construction projects as more attention was paid from all different levels of workers in construction projects. This study is limited to the construction industry in Saudi Arabia.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. The RII results of the safety procedures:

| Core Safety Elements | No | Safety Producers | Participants Importance Scores Before Covid-19 | Core Safety Elements | No | Safety Producers | Participants Importance Scores After Covid-19 |
|----------------------|----|------------------|-----------------------------------------------|----------------------|----|------------------|-----------------------------------------------|
|                      |    |                  | 1    2  3  4  5  RII Rank |                      |    |                  | 1    2  3  4  5  RII Rank |
| 1.0 MANAGEMENT       |    |                  |                                | 2.0 WORKER PARTICIPATION |    |                  |                                |
| LEADERSHIP           | 1.1| Expect performance | 1    0  9  16 14 0.81 4  | 1.3| Allocate resources | 0    1  8  15 16 0.83 2  |
|                      | 1.2| Communicate your commitment to a safety and health program | 0    0  8  18 14 0.83 2  | 1.4| Define program goals | 0    0  8  15 17 0.85 1  |
|                      |    |                  |                                | 2.1| Encourage workers to participate in safety program | 0    2  7  15 16 0.83 4  |
|                      |    |                  |                                | 2.2| Encourage workers to report safety and health concerns | 0    2  7  18 13 0.81 5  |
|                      |    |                  |                                | 2.3| |                       |
|                      |    |                  |                                |                      |    |                  |                                |
|                      |    |                  |                                |                      |    |                  |                                |

Table 5
New Safety Measures resulted from COVID-19.
The RII results of the safety procedures: (continued)

| Core Safety Elements | No | Safety Producers | Participants Importance Scores Before Covid-19 | Participants Importance Scores After Covid-19 |
|-----------------------|----|------------------|-----------------------------------------------|-----------------------------------------------|
|                       |    |                  | 1 2 3 4 5 RII Rank | 1 2 3 4 5 RII Rank |
| 2.3 Give workers access to safety and health information | 0 2 23 13 0.84 2 | 0 2 23 13 0.86 4 |
| 2.4 Involve workers in all aspects of the program | 0 2 6 20 12 0.85 1 | 0 2 6 20 12 0.87 1 |
| 2.5 Remove barriers to participation | 0 0 9 15 16 0.84 2 | 0 0 9 15 16 0.81 5 |
| 3.0 HAZARD IDENTIFICATION AND ASSESSMENT |    |                  |                                            |                                            |
| 3.1 Collect existing information about job site hazards | 0 2 5 19 14 0.83 4 | 0 2 5 19 14 0.86 5 |
| 3.2 Inspect the job site for safety hazards | 0 0 3 19 18 0.88 2 | 0 0 3 19 18 0.87 2 |
| 3.3 Identify health hazards | 0 1 8 11 20 0.85 3 | 0 1 8 11 20 0.87 4 |
| 3.4 Conduct incident investigations | 0 0 4 16 20 0.88 1 | 0 0 4 16 20 0.88 1 |
| 3.5 Identify hazards associated with emergency and nonroutine situations | 0 2 9 16 13 0.80 6 | 0 2 9 16 13 0.87 2 |
| 3.6 Characterize the nature of identified hazards, identify interim control measures, and prioritize the hazards for control | 0 1 7 20 12 0.82 5 | 0 1 7 20 12 0.86 6 |
| 4.0 EDUCATION AND TRAINING |    |                  |                                            |                                            |
| 4.1 Identify control options | 0 1 5 21 13 0.83 2 | 0 1 5 21 13 0.85 3 |
| 4.2 Develop and update a hazard control plan | 0 1 6 16 17 0.85 1 | 0 1 6 16 17 0.86 2 |
| 4.3 Select controls to protect workers during nonroutine tasks and emergencies | 1 1 10 15 13 0.79 4 | 1 1 10 15 13 0.84 4 |
| 4.4 Implement selected controls on the job site | 0 0 12 13 15 0.82 3 | 0 0 12 13 15 0.87 1 |
| 5.0 HAZARD PREVENTION AND CONTROL |    |                  |                                            |                                            |
| 5.1 Follow up to confirm that controls are effective | 0 0 8 15 17 0.85 2 | 0 0 8 15 17 0.87 4 |
| 5.2 Provide program awareness training | 0 2 7 15 16 0.83 4 | 0 2 7 15 16 0.88 2 |
| 5.3 Train employers, managers, and supervisors on their roles in the program | 0 2 9 14 15 0.81 5 | 0 2 9 14 15 0.88 1 |
| 5.4 Train workers on their specific roles in the safety and health program | 0 0 8 12 20 0.86 1 | 0 0 8 12 20 0.84 5 |
| 5.5 Train workers on hazard identification and controls | 0 0 9 13 18 0.85 2 | 0 0 9 13 18 0.88 2 |
| 6.0 PROGRAM EVALUATION AND IMPROVEMENT |    |                  |                                            |                                            |
| 6.1 Monitor performance and progress | 0 0 9 14 17 0.84 3 | 0 0 9 14 17 0.87 2 |
| 6.2 Verify that the program is implemented and is operating | 0 0 8 15 17 0.85 2 | 0 0 8 15 17 0.89 1 |
| 6.3 Correct program shortcomings and identify opportunities to improve | 0 1 6 15 18 0.85 1 | 0 1 6 15 18 0.84 3 |
| 7.0 COMMUNICATION AND COORDINATION FOR EMPLOYERS ON MULTIEMPLOYER WORKSITES |    |                  |                                            |                                            |
| 7.1 Establish effective communication | 0 0 6 18 16 0.85 1 | 0 0 6 18 16 0.85 2 |
| 7.2 Establish effective coordination | 0 1 7 16 16 0.84 2 | 0 1 7 16 16 0.87 1 |
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