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Exploring the Mitigation Actions of the Epidemic Impacts on Construction Projects in the Kingdom of Saudi Arabia

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Abstract:

Background: The construction industry has an important role in the economy of countries, as the construction industry represents 6.1 percent of the gross domestic product in the Kingdom of Saudi Arabia. A global disaster such as an epidemic causes long-term damage to society, the economy, and related industries. The recent COVID-19 epidemic is one of such disasters. The construction industry was greatly affected by the epidemic globally, as well as in the Kingdom of Saudi Arabia.

Methods: This research aims to determine the impact of the epidemic on construction projects and shed light on the actions taken to mitigate the impact of the epidemic through a multiple case study of three construction projects in the Kingdom of Saudi Arabia, where a questionnaire and a semi-structured interview were conducted with professionals in these projects. Descriptive analysis and the Relative Importance Index (RII) were used.

Results: The impact was of high importance on the project time throughout all projects, especially on the project schedule; the RII value was the maximum. Secondly for material delivery within time ranged from 0.8 – 0.91 for RII value and in terms of the mitigation actions taken, communication between project management and employees witnessed maximum effectiveness reached to 83% of participants reported a very effective response, with the help of modern technologies. Most factors ranged from limited effectiveness to ineffective.

Conclusion: This research contributes to determine the effects of the epidemic and the actions taken to mitigate it, which benefits the organizations and stakeholders in the field of construction and engineering project management, to develop and improve actions, and to prepare and plan for similar circumstances in the future.

Keywords: Project management, Construction industry, Epidemic, Mitigation, Saudi Arabia, COVID-19.

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1. INTRODUCTION

Everyone around the world has been suffering from the impacts of the epidemic in terms of health, economic, and social aspects. The Kingdom of Saudi Arabia (KSA) also suffered, which led to a slowdown in the economic movement in various sectors and industries, including the construction industry. The construction sector in the Kingdom of Saudi Arabia (KSA) has a vital role in economic development, and it contributes about 6.1% of its GDP [1] . The awareness of those associated with the construction industry of the impacts of COVID-19 on the construction industry is minimal and not well-documented.

It relies primarily on the experiences of the project partners. However, the information available from these limited trials cannot be accurate. Therefore, it is essential for engineering project management to identify these potential risks in projects, make every effort to understand and accommodate them, develop strategies to address them, and adhere to the schedule, financial, and technical plans. Furthermore, the situation of construction projects was studied in-depth during the pandemic, and lessons were extracted from it to confront future outbreaks for better preparation for future epidemics. This supports the need to reevaluate the pandemic scenario and the associated impacts. This paper is a part of the thesis on the role of Engineering project management in mitigating the epidemic's impact on construction projects in (KSA) by studying three construction projects as case studies in (KSA). Moreover, the epidemic impact and the mitigation actions against the epidemic impacts on construction projects in the Kingdom of Saudi Arabia were explored.

1.1. Objective

The research is part of a master's degree thesis. This article aims to find out how the epidemic affects construction projects in Saudi Arabia and determine the role of engineering project management in mitigating the effects of the epidemic.

1.1.1. Related Studies

Whenever there is a calamity around the world, it has a long-lasting harmful impact on society and economic conditions. Moreover, the current COVID-19 outbreak is one of those calamities. Different prior studies underlined the negative repercussions of pandemics and proposed how to combat such draconian outbreaks [2]. It was determined that the influenza disease impacted the economy of the United States, and the overall cost of economic loss was 71.3 to 166.5 billion US dollars. Similarly, in the 21st century, COVID-19 is a catastrophic tragedy that affected the entire economy. The deadliest impact of coronavirus has stuck all economic and social activity in the world. As of June 22, 2021, the World Health Organization has reported nearly 180 million confirmed cases and more than 3 million deaths globally due to this epidemic. The effects of this epidemic are catastrophic and affected all economic sectors worldwide. Many construction projects in the region have been delayed due to the lockdown; some projects have been halted, and some have been rescheduled. For example, 45% of companies in Kuwait suspended operations or closed their businesses due to the pandemic. Also, 39% of architecture, engineering, and construction firms have ceased operations entirely, and 31% have seen revenues decline by more than 80% while in operation. It was also found that only 46% could cover fixed costs for approximately two months.

The potential impacts of the epidemic on the construction industry can be summarized as follows:

The Coronavirus (COVID-19) pandemic has dramatically impacted the engineering and construction industries, and client interactions are expected to result in construction projects being postponed or canceled. Global and regional supply chains are under pressure, and employee health and safety are confronting challenges. Similarly, because of the pandemic, the construction industry has experienced more difficulty in delivering projects on schedule and within budget [3].

According to the study, it was revealed that the Covid-19 epidemic had a severe influence on the supply chain in the construction industry. During the earliest phases, there was significant difficulty in procuring even vital resources due to increased demand from numerous businesses. This resulted in delays and price increases [4].

A study [5, 6] predicted a disruption in supply chains due to a shortage of subcontractors and materials, as well as the termination of contracts by clients to control costs, while another study [7] suggested that there may be a possibility of significant job losses as a result of the decline in the construction industry.

A research [8] in 2020 indicated that delays in materials delivery, changes in work breakdowns, and the project schedule owing to time delay affected the progress of the construction projects. The project was delayed because the vendors could not ship the materials [9].

A researcher [10] undertook a series of structured interviews with 34 professionals in the construction field to investigate the impact of the pandemic on their work. The study revealed various adverse effects, including disparities in the classification of construction operations as essential or non-essential across different states, delays and shortages in material deliveries, increased reliance on local suppliers and manufacturers, disruptions in inspections and permit acquisition processes, decreased productivity, project suspensions and delays, financial challenges such as price escalation, additional expenses, revenue losses, and payment delays, workplace safety concerns, remote work arrangements for certain employees, and an anticipated surge in disputes, legal actions, and claims.

Similarly, a research that was conducted [11] used interviewees and questionnaires. The research shows the impact of COVID-19 on the project schedule, and around 40% of participants addressed several delays in projects during the pandemic, which affected the project deadline. A survey indicated that the average worker worked an additional 48 minutes daily during the pandemic. This growth was driven by several causes, including the transition to remote work, higher workloads, and the necessity to take care of children or other family members at home [12].

Most importantly, many construction workers reportedly tested positive for COVID-19. A recent investigation from Los Angeles concluded that construction workersreported the highest number of positive cases compared to workers in other industries, including transportation, health care, and manufacturing.

The price of the materials was impacted by an increase in demand and a decrease in supply owing to the factory

closure [13]. The government's new traveling policy compelled construction enterprises to spend more than usual on transporting material and other equipment [14].

A study published in the journal Project Management Journal indicated that the epidemic contributed to a reduction in the quality of materials utilized in construction projects. The study also indicated that the reduction in material quality was particularly severe for projects in underdeveloped nations [15].

Most studies focused on the adverse effects of the epidemic urged project owners to take the necessary measures to mitigate the impact. They indicated the need to conduct more studies on developing effective measures to reduce the impact of the epidemic. In other words, previous works did not study the impact of COVID-19 on the construction industry in depth [16]. Relevant studies about coronavirus are abundant for further studies [17]. Previous studies have shown that there is a need for more research on the impact of the epidemic and the necessary measures to reduce or mitigate its adverse effects. Therefore, this study aims to explore the role of engineering project management in mitigating the impact of the epidemic on construction projects in the Kingdom of Saudi Arabia through multiple case studies.

2. METHOD

These case studies serve as empirical investigations that examine current occurrences within their authentic settings when it is challenging to differentiate between the environment and the phenomenon under investigation, in which the researcher focuses on a unit of study known as a finite system when the researcher wants to respond to a descriptive question (such as “What happened?”) or as an explanatory question, a common way to increase the external validity or generalizability of research in educational research is to use multiple case studies. Additionally, to answer the research questions, a semi-structured interview was conducted with three various construction projects in KSA. Three significant projects were chosen and were different due to the diversity of construction projects in the Kingdom of Saudi Arabia to shed light on these projects closely and study the recent epidemic impact on the project management elements and the actions that were taken to mitigate the effects of the epidemic and measure the effectiveness of these mitigating actions. The most common form of sampling in the case of study research is the purposeful sampling method. Furthermore, to use purposeful sampling, there are many strategies the researcher could choose from. This research adopted the Maximal Variation Sampling strategy to select the projects with criteria such as they should be residing in the Kingdom of Saudi Arabia during the pandemic period, the company’s budget is more than 10 million riyals, the number of employees is more than 100, the project manager should be PMP certified or have 10+ years of experience in project management, and should be different and not similar to each other. The selected projects have been coded to maintain their privacy as follows: Project (C1) is classified as a public facility, for a hospital in the private sector, and the budget for the project was four hundred eighty million SR, which is located in Makkah. Project (C2) is classified as an infrastructurefor a road, in the public sector, and the project budget was almost thirty million SR, which is located in Madinah. Project (C3) is a residential project in the private sector, in Makkah, and the budget for the project was about thirty-three million SR, as shown in Table **1**.

Table 1. The three projects (case studies).

Project	Type	Public/ Privet	Budget	Location
C1	**Hospital**	**Privet**	**480,000,000**	**Makkah**
C2	**Infrastructure- Road**	**public**	**30,000,000**	**Madinah**
C3	**Residential**	**Privet**	**33,350,000**	**Makkah**

2.1. Data Collection

The questionnaire was developed to collect three project data (case studies) and find out the extent of the epidemic impact on these projects, the actions taken by project management to mitigate the impact of the epidemic, and the effectiveness of these actions to mitigate the epidemic's impact on the significant elements of project management, which are five elements as follows (scope, time, cost, quality, and communication) and includes eighteen factors were identified from the literature, the eighteen most important factors were selected and classified under the five main project elements as Table **2** shows.

Table 2. The factors and categories.

Element	#	Factors
1 Scope	1.1	Scope of work modification
	1.2	Clarity of Scope of Work
	1.3	Link the scope of work to the contractor.
2 Time	2.1	Project schedule
	2.2	Number of working hours per day
	2.3	Material delivery within time
	2.4	The effect of worker shortage
	2.5	Material availability
	2.6	Worker’s productivity

(Table 2) contd.....

Element	#	Factors
3 Cost	3.2	Labor cost increase
	3.3	Material cost increase
	3.4	Equipment cost increase
4 Quality	4.1	Quality assurance
	4.2	Quality control
	4.3	Skilled labor
5 Communication	5.1	Communication between management and employees
	5.2	Worksite attendance
	5.3	Supervision

Sampling is the process of choosing a small group of people for a study so that they may assist the researcher in understanding the topic under investigation. The total number of participants reached 33 participants using purposeful sampling in the three projects under study from various parties in the project (owner, consultant, contractor). They were chosen on account of their profound experience and accessibility for interviews so that there are no less than 10 participants in each project, and the participants provide general information during the project such as duration, cost, sector, and their role, background, experience, *etc*., in the first part of the questionnaire. Then, in the second part, they will rate the epidemic impact and the effectiveness of mitigation actions on each factor on a scale (No Effect, Less Effect, Somewhat Effect, and Strong Effect).

2.2. Data Analysis

The analysis is performed through statistical analysis and descriptive statistics, and frequency and percentage are presented in the form of tables, pie charts, and bar graphs. The analysis is also performed through the Relative Importance Index (RII) and a forced 4-point Likert scale, using equations and mathematical analysis tools, such as SPSS. The relative importance index (RII) was used to detect the level of epidemiological impact of each factor in the study. RII is a quantitative measure used in research and decision-making processes to evaluate the relative importance or importance of different factors or variables within a given context. It identifies the relative contribution of each factor to a particular outcome or criterion. The RII values legend is: 0≤RII≤0.25 is Low. 0.26≤RII≤0.50 is Fair. 0.51≤RII≤0.75 is High. 0.76≤RII≤1.0 is Very High, allowing the researcher to prioritize and focus on what is most important. The relative importance index (RII) was calculated using the following formula [18]:

$$\mathrm{RII} = \frac{\sum Pi\ Ui}{N(n)}$$

where,

RII = relative importance index

Pi = participant determines the epidemic effects

Ui = number of participants placing identical weighting/ rating on the epidemic effects

N = sample size = the highest attainable score on the epidemic effects

3. RESULTS AND DISCUSSION

The following are the tabulated values of RII for the impact and frequencies of all five elements affected by the epidemic, followed by a discussion of the observed values for each of the five groups.

3.1. Comparison of the Epidemic Impact in the Three Case Studies (C1, C2, C3)

Table **3** and Fig. (**1**) show the epidemic's impact on project scope factors in the three projects through RII values. The effect on the project scope modification factor was relatively fair across the three studies. The RII values ranged from 0.250 to 0.325. Likewise, the RII values in the factor linking the scope of the project to the contractor ranged from 0.313 to 0.350. As for clarity of scope, the RII values in projects C1 and C3 were 318 and 325, respectively, while in project C2 the value was a high of 0.542. The reason may be due to the nature of the project infrastructure and the fact that it is a public project and not a private project. A study [19] stated that some project managers reduce project scopes. This strategy tries to reduce project complexity, enhance management, and adapt to adverse conditions. In addition, project managers highlighted the necessity of flexibility. Generally, these values indicate a limited impact of the epidemic on factors related to the scope of the projects.

Table 3. The epidemic impact on the project scope in the three projects.

-	C1 Study		C2 Study		C3 Study	
	RII	Importance Level	RII	Importance Level	RII	Importance Level
Scope of work modification	0.250	Low	0.313	Fair	0.325	Fair
Clarity of Scope of Work	0.318	Fair	0.542	High	0.325	Fair
Link the scope of work to the contractor	0.318	Fair	0.313	Fair	0.350	Fair

Note: 0≤RII≤0.25 is Low. 0.26≤RII≤0.50 is Fair. 0.51≤RII≤0.75 is High. 0.76≤RII≤1.0 is Very High.

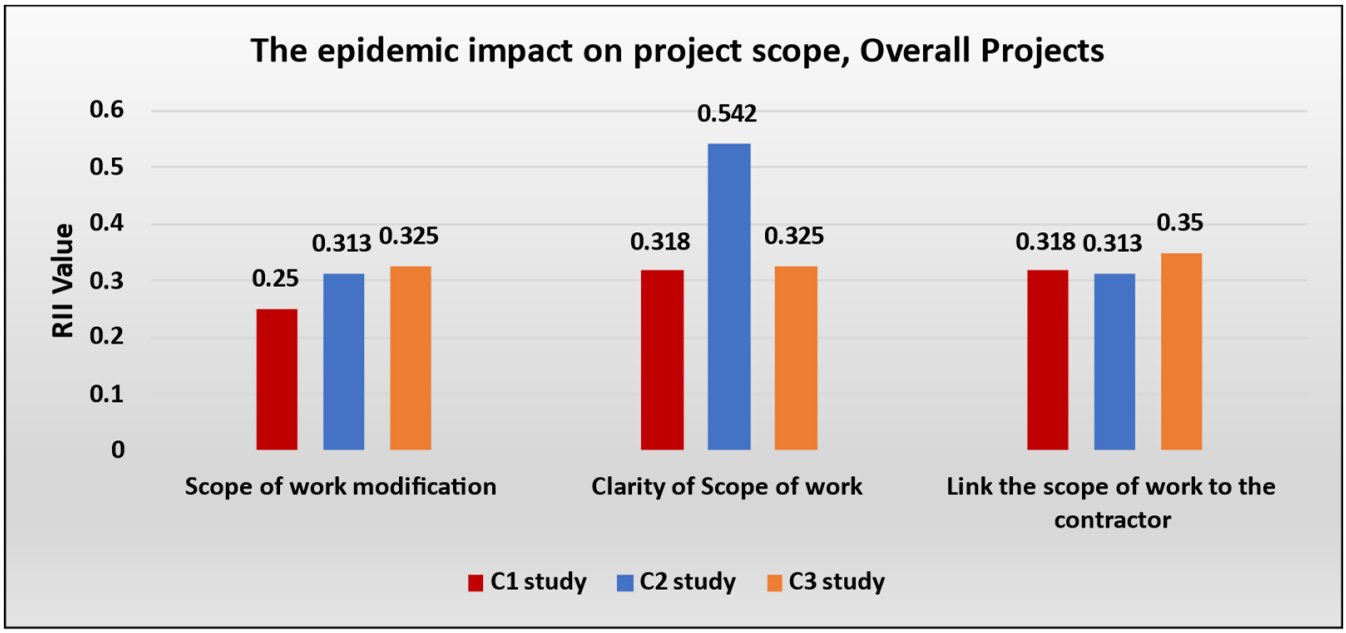

Fig. (1). RII values of the epidemic impact on project scope in the three projects.

Table 4. The epidemic impact on the project time in the three projects.

-	C1 Study		C2 Study		C3 Study	
	RII	Importance Level	RII	Importance Level	RII	Importance Level
Project schedule	1.000	Very High	1.000	Very High	1.000	Very High
Number of working hours per day	0.386	Fair	0.896	Very High	0.875	Very High
Material delivery within time	0.909	Very High	0.875	Very High	0.800	Very High
The effect of worker shortage	0.591	High	0.896	Very High	0.875	Very High
Material availability	0.841	Very High	0.792	Very High	0.950	Very High
Worker's productivity	0.568	High	0.604	High	0.925	Very High

Note: 0≤RII≤0.25 is Low. 0.26≤RII≤0.50 is Fair. 0.51≤RII≤0.75 is High. 0.76≤RII≤1.0 is Very High.

Table 4 and Fig. (2) show the importance of the strength of the epidemic's impact on the project's time factors in the three projects. The impact on the project schedule was the highest RII value of all projects. Furthermore, a high to a very high level of importance was expressed on the factors of labor shortage, availability of materials, material delivery within time, and worker's productivity as the RII values ranged from 0.591 to 0.950 in all projects, indicating the significant impact of the epidemic. There are disturbances in project time management, as supported by a researcher [20] in his study, as the epidemic had a negative impact and caused a shortage of workers and materials and closures, which hindered progress in the project or delivery of the project on time. At the same time, the factor of the number of working hours per day in the project (C1) had the lowest RII values due to the size of the project, its high budget, and the addition of additional work periods. Project managers need to address these challenges to ensure project success effectively.

Table 5 and Fig. (3) show the RII values for the impact of the epidemic on project cost in the three projects. The impact on project cost factors varied across the three studies. The RII level was high in general, while increasing labor cost and increasing material cost had a level of importance (RII) that is fair to high among the three projects. On the other hand, the factor of increasing the cost of equipment was of a varied level of importance in the three projects, and the reasons are due to the nature of the project, its budget, and the proactive measures taken by the project management. In summary, the element of project cost during the three projects had a high impact, which increased the burden on project managers to develop and study forceful procedures and methods to mitigate the effects of the epidemic.

Table 5. The epidemic impact on the project cost in the three projects.

-	C1 Study		C2 Study		C3 Study	
	RII	Importance Level	RII	Importance Level	RII	Importance Level
Labor cost increase	0.341	Fair	0.604	High	0.625	High
Material cost increase	0.659	High	0.583	High	0.425	Fair
Equipment cost increase	0.295	Fair	0.521	High	0.800	Very High

Note: 0≤RII≤0.25 is Low. 0.26≤RII≤0.50 is Fair. 0.51≤RII≤0.75 is High. 0.76≤RII≤1.0 is Very High.

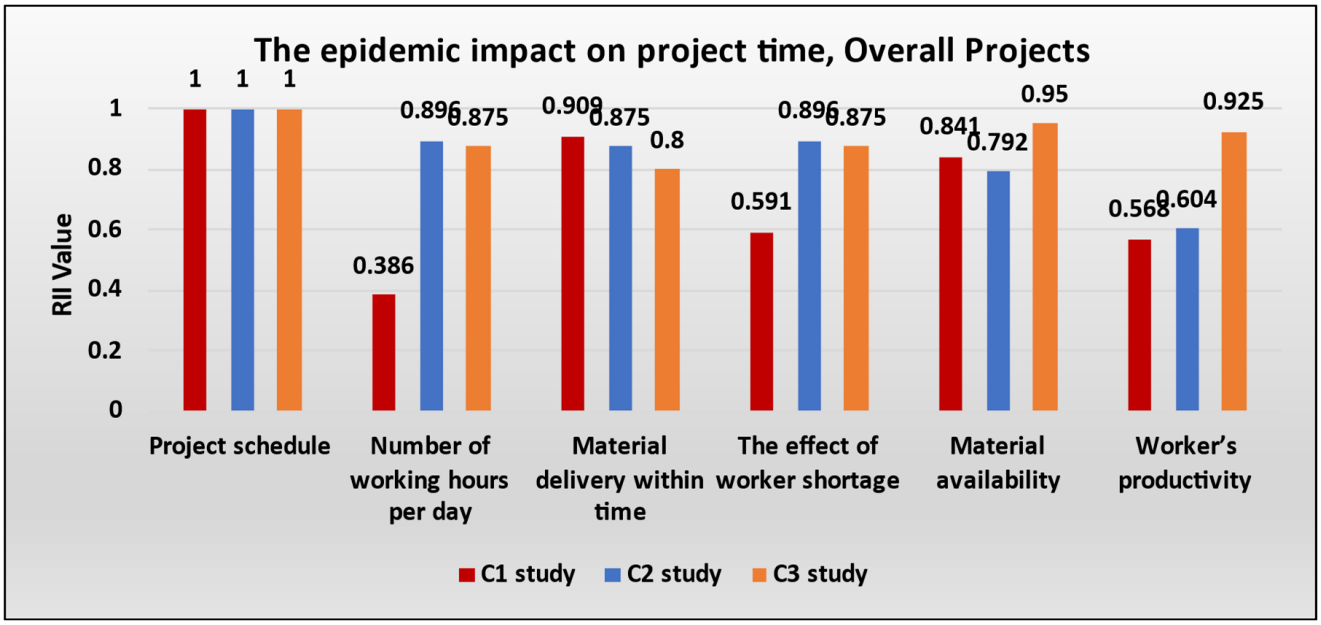

Fig. (2). RII values of the epidemic impact on project time factors in the three projects.

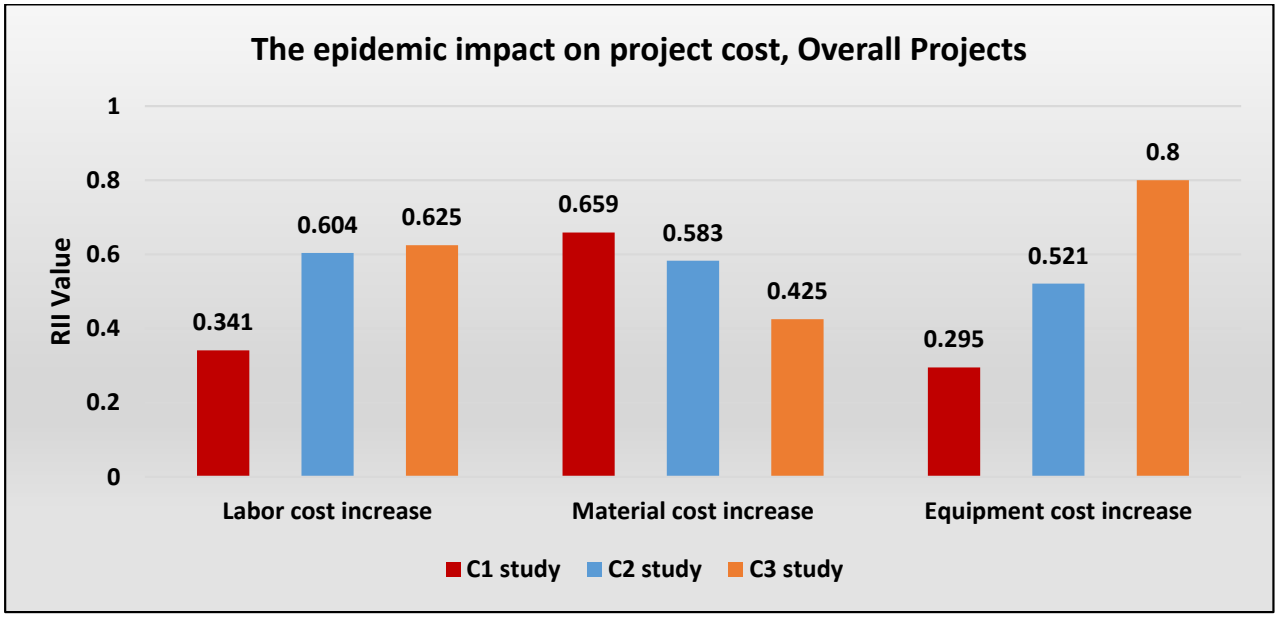

Fig. (3). RII values of the epidemic impact on project cost factors in the three projects.

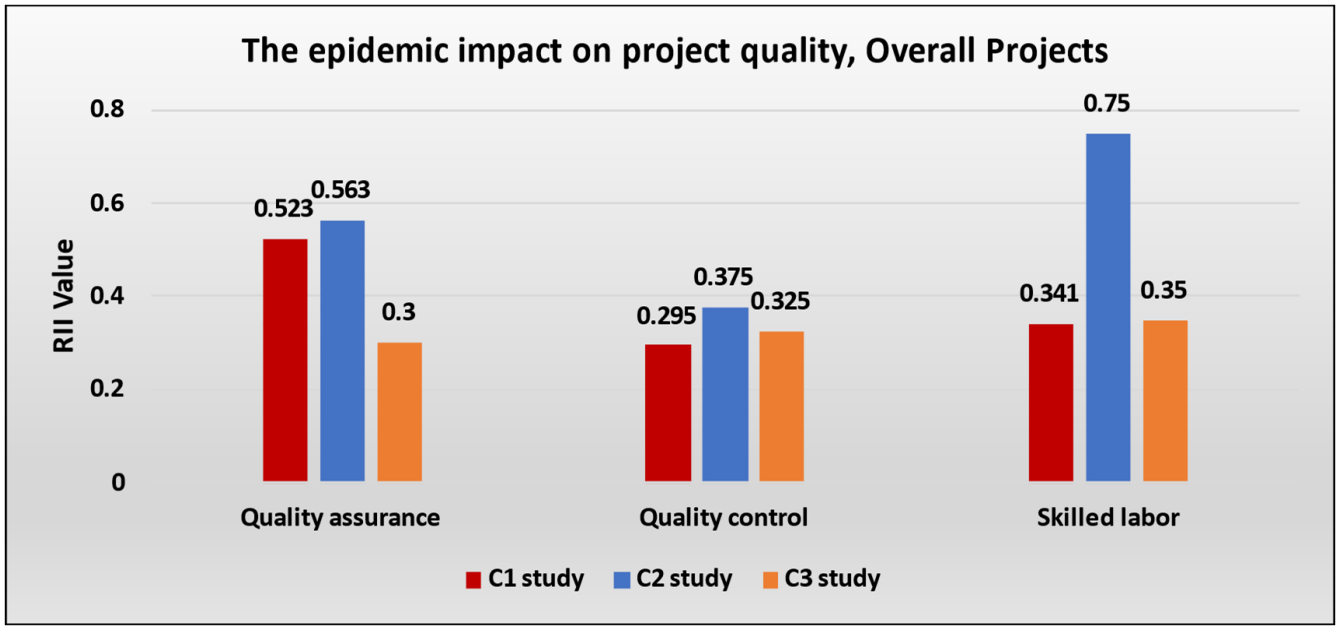

Fig. (4). RII values of the epidemic impact on project quality factors in the three projects (quality assurance, quality control, and skilled labor).

Table 6. The epidemic impact on the project quality in the three projects.

-	C1 Study		C2 Study		C3 Study	
	RII	Importance Level	RII	Importance Level	RII	Importance Level
Quality assurance	0.523	High	0.563	High	0.300	Fair
Quality control	0.295	Fair	0.375	Fair	0.325	Fair
Skilled labor	0.341	Fair	0.750	High	0.350	Fair

Note: 0≤RII≤0.25 is Low. 0.26≤RII≤0.50 is Fair. 0.51≤RII≤0.75 is High. 0.76≤RII≤1.0 is Very High.

Table 7. The epidemic impact on the project quality in the three projects.

-	C1 Study		C2 Study		C3 Study	
	RII	Importance Level	RII	Importance Level	RII	Importance Level
Communication between management and employees	0.364	Low	0.364	Low	0.425	Fair
Worksite attendance	0.864	Very high	0.917	Very high	0.875	Very high
Supervision	0.318	Low	0.583	Fair	0.575	Fair

Note: 0≤RII≤0.25 is Low. 0.26≤RII≤0.50 is Fair. 0.51≤RII≤0.75 is High. 0.76≤RII≤1.0 is Very High.

Table **6** and Fig. (**4**) show the RII values and importance level of the epidemic's impact on project quality in the three projects. The effect on the quality control factor was relatively fair across the three studies, as well as in skilled workers, except for the (C2) project, which had a high value for the relative importance index (RII). This is due to the type of project, which is considered a public project. Regarding the quality control factor, the RII values were 0.534 and 0.563 for the two projects (C1 and C2), respectively, while the RII value in the project (C3) was 0.30 due to the residential nature of the project and the availability of ready-made materials. In a study, it was reported that the quality of materials in projects decreased sharply due to the impact of the epidemic in developing countries [15]. In general, the results indicate a moderate to high impact on project quality factors in projects.

Table **7** and Fig. (**5**) show the RII values and importance level of the epidemic impact on project communications in the three projects. Worksite attendance was the most affected variable among the three projects, with RII values exceeding 0.860. On the other hand, the factor of employee communication with management was at a fair level of importance, while in

supervision, the importance level of projects (C2 and C3) was high, with RII values of 0.583 and 0.575, respectively, and the project (C1) was the least affected with a value of 0.318 due to the nature of the project and the fact that the project parties fall under one umbrella. According to a study [21], 95% of construction projects in Kuwait were unable to proceed during a lockdown, causing delays because the supervisors were unable to keep an eye on the status of the work. In conclusion, the impact of the epidemic on the element of project communications varied depending on the nature of the various factors, and this calls for more research and development and the development of procedures for each factor in particular.

3.2. Evaluating the Effectiveness of Mitigation Actions taken regarding the Impact of the Epidemic in the three Projects (C1, C2, C3)

Table **8** and Fig. (**6**) show the effectiveness of actions taken on project scope factors across the three projects. The effectiveness of mitigation and improvement was unanimously non-existent in the three projects, and this is due to the absence of procedures to a greater extent or the weakness and inefficiency of these procedures. Therefore, project management must find sustainable and effective measures, and the paper indicates that early identification of the causes of the spread of the epidemic will enable appropriate implementation techniques to manage the outbreak [22-25].

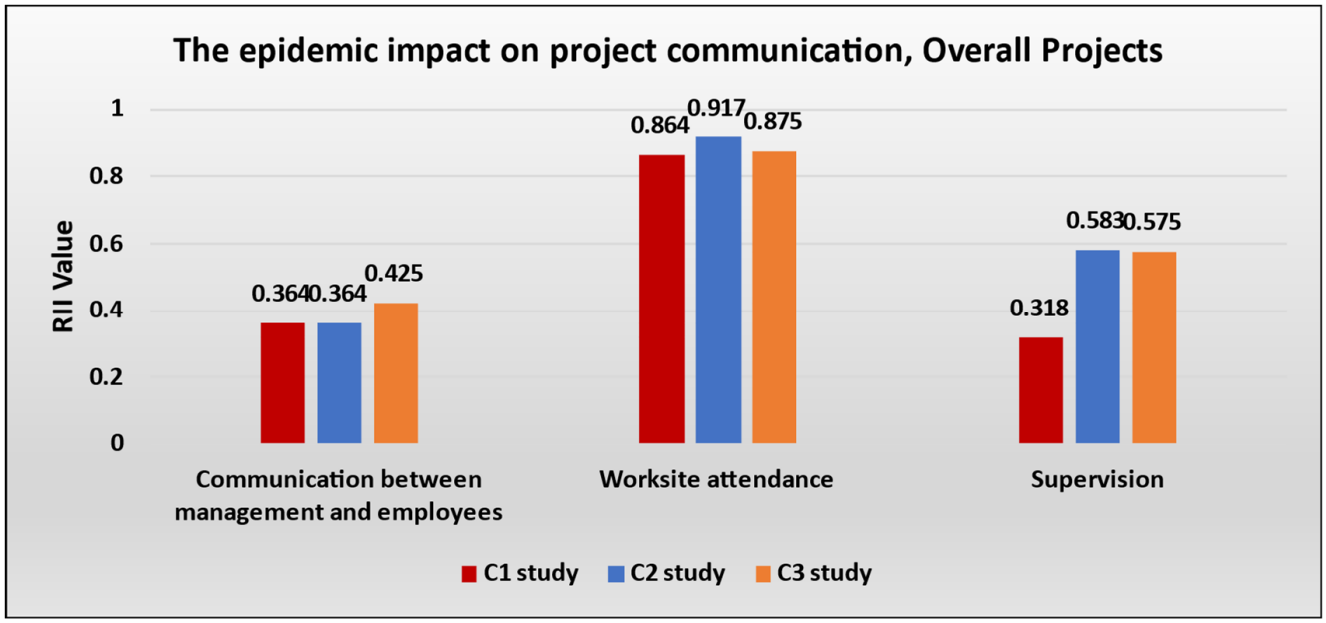

Fig. (5). RII values of the epidemic impact on project quality factors in the three projects (communication between management and employees, worksite attendance, supervision).

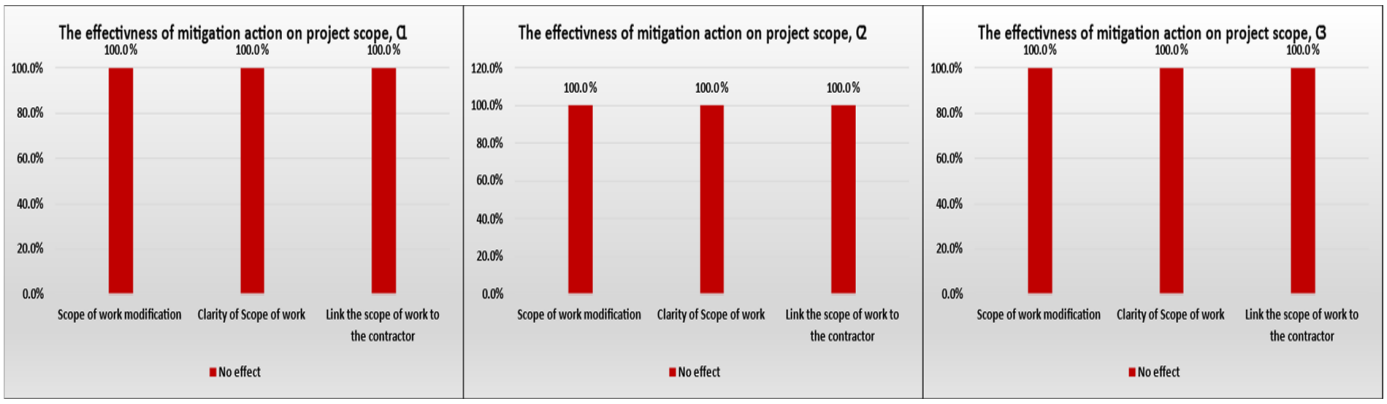

Fig. (6). The effectiveness of the mitigation action on project scope in the three projects.

Table 8. The effectiveness of the mitigation action on project scope in the three projects.

-	C1						C2						C3					
Project Scope	**No Effect**	**Less Effect**	**Somewhat Effect**	**Strong Effect**	**Perc %**	**Trend**	**No Effect**	**Less Effect**	**Somewhat Effect**	**Strong Effect**	**Perc %**	**Trend**	**No Effect**	**Less Effect**	**Somewhat Effect**	**Strong Effect**	**Perc %**	**Trend**
Scope of work modification	11	0	0	0	100	no effect	12	0	0	0	100	no effect	10	0	0	0	100	no effect
Clarity of Scope of Work	11	0	0	0	100	no effect	12	0	0	0	100	no effect	10	0	0	0	100	no effect
Link the scope of work to the contractor	11	0	0	0	100	no effect	12	0	0	0	100	no effect	10	0	0	0	100	no effect

Note: Likert scale: 1-1.75 no effect, 1.76- 2.5 less effect, 2.6- 3.25 somewhat effect, 3.26- 4 strong effect.

Table 9. The effectiveness of the mitigation action on project time in the three projects.

-	C1						C2						C3					
Project Time	**No Effect**	**Less Effect**	**Somewhat Effect**	**Strongly Effect**	**Perc %**	**Trend**	**No Effect**	**Less Effect**	**Somewhat Effect**	**Strong Effect**	**Perc %**	**Trend**	**No Effect**	**Less Effect**	**Somewhat Effect**	**Strong Effect**	**Perc %**	**Trend**
Project schedule	0	0	7	4	84.09	strong effect	8	2	2	0	50	no effect	5	5	0	0	75	no effect
Number of working hours per day	11	0	0	0	100	no effect	3	7	2	0	63.9	less effect	5	5	0	0	75	no effect
Material delivery within time	0	5	6	0	84.85	somewhat effect	1	2	8	1	68.8	somewhat effect	5	5	0	0	75	no effect
The effect of worker shortage	0	4	7	0	87.88	somewhat effect	0	10	2	0	72.2	less effect	10	0	0	0	100	no effect
Material availability	11	0	0	0	100	no effect	0	3	9	0	91.7	somewhat effect	10	0	0	0	100	no effect
Worker's productivity	3	8	0	0	86.36	no effect	12	0	0	0	100	no effect	10	0	0	0	100	no effect

Note: Likert scale: 1-1.75 no effect, 1.76- 2.5 less effect, 2.6- 3.25 somewhat effect, 3.26- 4 strong effect.

Table **9** and Fig. (**7**) demonstrate the effectiveness of the actions taken on project time factors in the three projects. It is interesting that in Project C3, 75% - 100% of participants reported the inability of the measures to mitigate the effects of the epidemic on all project time factors. In Project C1, respondents unanimously reported the inability of the actions to mitigate the effects of the epidemic on factors of material availability, the number of working hours per day, and worker's productivity, while regarding worker shortage and delivery of materials within time, 85-88% of respondents reported that there was effectiveness to some extent. At the same time, for Project C2, participants' responses differed between lack of effectiveness on the project schedule factor and less effective to somewhat effective on the rest of the factors.

Table **10** and Fig. (**8**) show the effectiveness of the actions taken on the project cost across the three projects, where it was noted that there was no effectiveness on the equipment cost increase and limited effectiveness on increasing the cost of labor and increasing the cost of materials by a rate ranging from 60% - 66.7% of the participants in Project C3. As for Projects C1 and C2, the effectiveness varied from ineffective to somewhat effective. In general, the effectiveness of the actions was low to non-existent for all projects in the element of project cost.

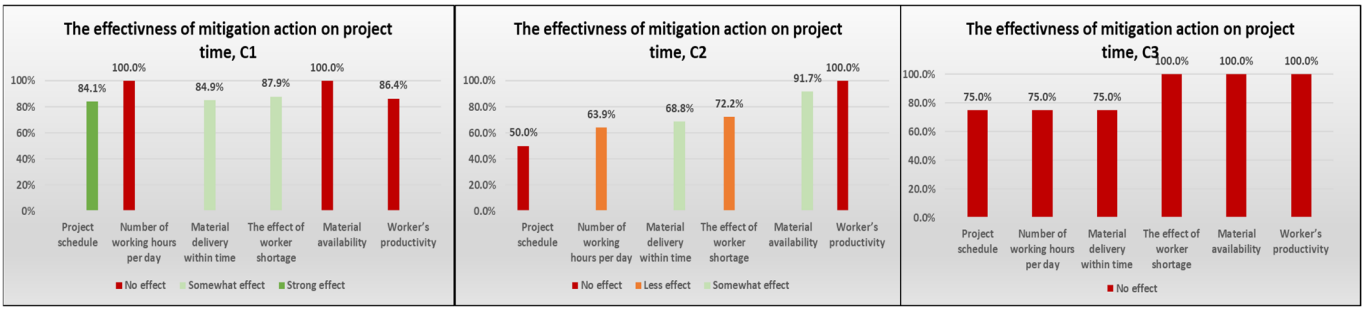

Fig. (7). The effectiveness of the mitigation action on project time in the three projects.

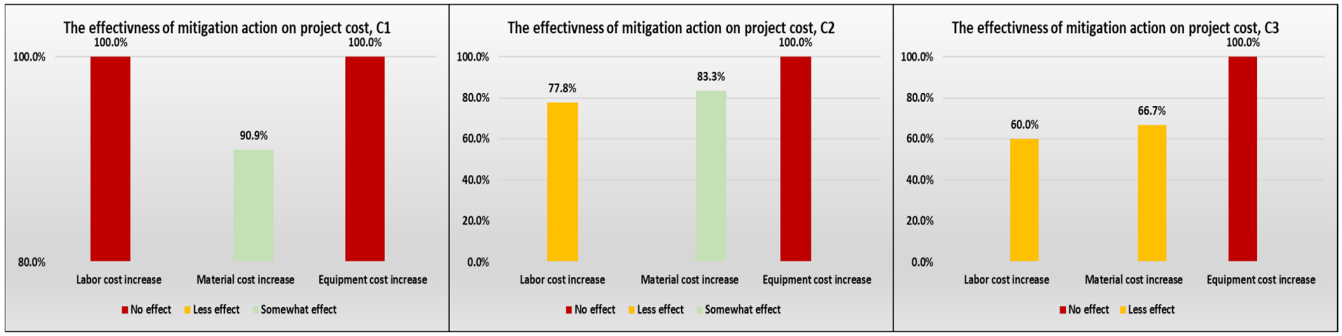

Fig. (8). The effectiveness of the mitigation action on project cost in the three projects.

Table 10. The effectiveness of the mitigation action on project cost in the three projects.

-	C1						C2						C3					
Project Cost	**No Effect**	**Less Effect**	**Somewhat Effect**	**Strongly Effect**	**Perc %**	**Trend**	**No Effect**	**Less Effect**	**Somewhat Effect**	**Strong Effect**	**Perc %**	**Trend**	**No Effect**	**Less Effect**	**Somewhat Effect**	**Strong Effect**	**Perc %**	**Trend**
Labor cost increase	11	0	0	0	100	no effect	0	8	4	0	77.8	less effect	4	4	2	0	60	less effect
Material cost increase	0	3	8	0	90.91	somewhat effect	0	6	6	0	83.3	somewhat effect	2	6	2	0	66.67	less effect
Equipment cost increase	11	0	0	0	100	no effect	12	0	0	0	100	no effect	10	0	0	0	100	no effect

Note: Likert scale: 1-1.75 no effect, 1.76- 2.5 less effect, 2.6- 3.25 somewhat effect, 3.26- 4 strong effect.

Table 11. The effectiveness of the mitigation action on project quality in the three projects.

-	C1						C2						C3					
Project Quality	**No Effect**	**Less Effect**	**Somewhat Effect**	**Strongly Effect**	**Perc %**	**Trend**	**No Effect**	**Less Effect**	**Somewhat Effect**	**Strong Effect**	**Perc %**	**Trend**	**No Effect**	**Less Effect**	**Somewhat Effect**	**Strong Effect**	**Perc %**	**Trend**
Quality assurance	9	2	0	0	59.09	no effect	0	10	2	0	72.2	less effect	8	2	0	0	60	no effect
Quality control	3	8	0	0	86.36	no effect	4	8	0	0	83.3	no effect	7	3	0	0	65	no effect
Skilled labor	0	3	8	0	90.91	somewhat effect	0	8	4	0	58.3	less effect	6	4	0	0	70	no effect

Note: Likert scale: 1-1.75 no effect, 1.76- 2.5 less effect, 2.6- 3.25 somewhat effect, 3.26- 4 strong effect.

Table **11** and Fig. (**9**) demonstrate the role of the procedures taken on the project quality factors in the three projects, where most of the participants (60% - 70% of them) indicated the ineffectiveness of the procedures on the three project quality factors in Project C3, and also in Project C1, the majority of participants reported the ineffectiveness of the actions on the factors of quality assurance and quality control, and 90.1% of them reported somewhat effectiveness on the supervision factor. In contrast, the actions were less effective than ineffective in Project C2. In general, most of the measures taken were ineffective in terms of project quality factors across the three projects.

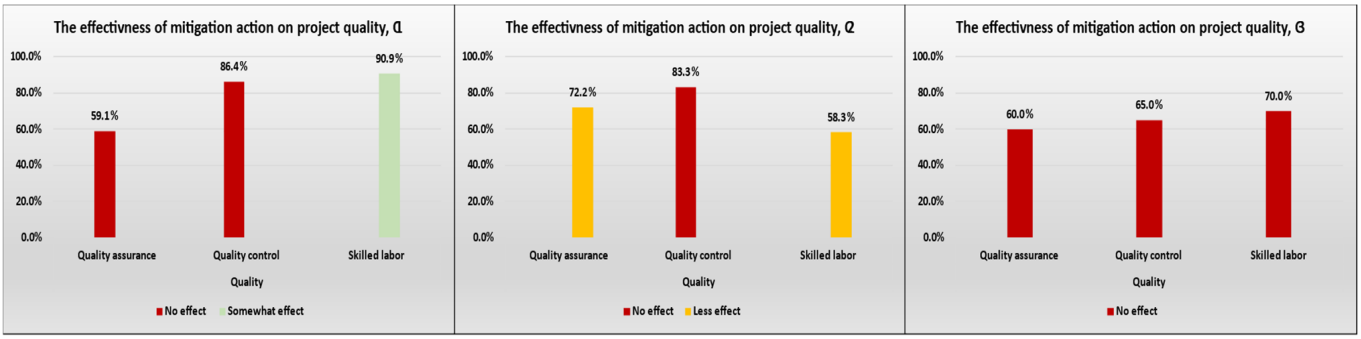

Fig. (9). The effectiveness of the mitigation action on project quality in the three projects.

Table 12. The effectiveness of the mitigation action on project communication in the three projects.

-	C1						C2						C3					
Project Communication	**No Effect**	**Less Effect**	**Somewhat Effect**	**Strongly Effect**	**Perc %**	**Trend**	**No Effect**	**Less Effect**	**Somewhat Effect**	**Strong Effect**	**Perc %**	**Trend**	**No Effect**	**Less Effect**	**Somewhat Effect**	**Strong Effect**	**Perc %**	**Trend**
Communication between management and employees	0	0	2	9	95.45	strong effect	0	0	2	10	95.8	strong effect	0	0	2	8	95	strong effect
Worksite attendance	0	8	3	0	75.76	less effect	0	9	3	0	75	less effect	6	4	0	0	70	no effect
Supervision	11	0	0	0	100	no effect	2	7	3	0	69.4	less effect	10	0	0	0	100	no effect

Note: Likert scale: 1-1.75 no effect, 1.76- 2.5 less effect, 2.6- 3.25 somewhat effect, 3.26- 4 strong effect.

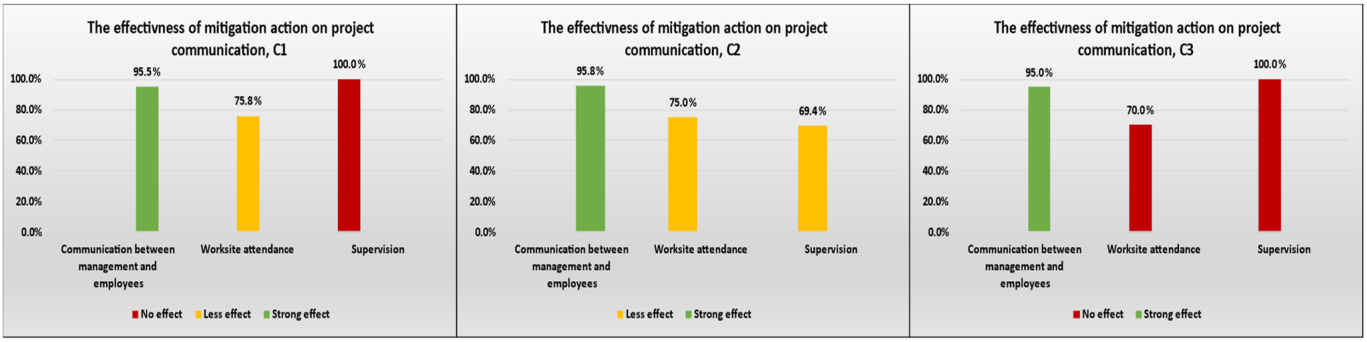

Fig. (10). The effectiveness of the mitigation action on project communication in the three projects.

Table **12** and Fig. (**10**) show the effectiveness of the actions taken regarding the communication factors in the three projects. Participants in Project C2 reported that the procedures were effective to some extent in supervision and attendance at the work site. Interestingly, the actions taken were very influential in communication between the management and employees in all projects. In Project C1, the results of the actions were of limited effectiveness on the worksite attendance, with a 100% ineffectiveness in supervision, while in Project C3, most of the actions were ineffective. In short, the actions taken were of limited effectiveness and ineffective on the project communication in the three projects. On the contrary, in the factor of communication between management and employees, the majority of participants, with a rate reach of 95.8%, reported a very high effectiveness of the actions in the three projects, thanks to the use of modern technologies such as electronic communication technologies.

CONCLUSION

The research question and objectives stated in the first chapter of the research were answered by studying three projects (C1, C2, C3) for construction projects in the Kingdom of Saudi Arabia as a multiple case study to identify the role of engineering management in reducing the impact of the epidemic on construction projects in the Kingdom of Saudi Arabia, where the study was carried out.

THE EPIDEMIC IMPACT ON THE PROJECT MANAGEMENT ELEMENTS IN THE THREE PROJECTS (CASES)

The impact of the epidemic on five project management elements was studied in the selected projects (case studies). In the study, the results based on the values of the level of importance of RII on the project scope factors were fair overall projects. In contrast, the impact on the project time factors was of very high importance level in most of the factors, and the factor of the project schedule had the highest RII value unanimously in the three projects. In general, the epedemic had a clear negative impact on project management elements in all projects, which increased the burden on project management to find effective and sustainable solutions to these challenges in similar circumstances.

EVALUATING THE EFFECTIVENESS OF THESE ACTIONS IN MITIGATING THE IMPACT OF THE EPIDEMIC

The results show that the project management in the three projects took action on some factors of the project management elements. Mitigation actions based on project scope factors were not taken in almost all projects. As for the project time factors, the results were as follows: In Projects C1 and C2, the mitigation actions taken were less effective, and for Project C3, they were ineffective. In terms of the the cost of the project, the effectiveness of the mitigation actions were less effective overall . The mitigation actions in the communication factor between management and employees were very effective, with a rate reaching 95.8% of the respondents' In short, most of the mitigation actions' effectiveness is limited due to the exceptional circumstances of the epidemic and the absence of the role of project management in preparing for such cases. Therefore, it is the responsibility of project

management to further research and pay attention to developing highly efficient actions and procedures to mitigate the impact of similar circumstances in the future.

RESEARCH LIMITATION

This research studied three selected construction projects as multiple case studies to determine the impact of the epidemic on these projects and the effectiveness of actions taken to mitigate the impact. This study was conducted in the Kingdom of Saudi Arabia, and the selected projects (case studies) were in the Makkah Al-Mukarramah region and the Medina region.

RECOMMENDATIONS FOR FUTURE RESEARCH

Through this research and study of the three projects (case studies), the need emerged to make recommendations and suggestions for future research, and they were mentioned in the following points:

- Practical actions were developed to limit and mitigate the effects of the epidemic or similar circumstances
- More research needs to be conducted through specialized centers and organizations on the impact of the epidemic and mitigating its effects
- A model needs to be developed to evaluate project management factors and related actions
- A similar future research should be conducted in other regions of the Kingdom of Saudi Arabia
- A similar research should be conducted for other project management elements

AUTHOR'S CONTRIBUTION

It is hereby acknowledged that all authors have accepted responsibility for the manuscript's content and consented to its submission. They have meticulously reviewed all results and unanimously approved the final version of the manuscript.

LIST OF ABBREVIATIONS

RII	=	Relative Importance Index
KSA	=	Kingdom of Saudi Arabia
COVID-19	=	Coronavirus Disease 2019

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

The data and supportive information are available within the article.

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None.

CONFLICT OF INTEREST

The authors declare no conflict of interest financial or otherwise.

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