

Research Article

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Studying pandemic effects and mitigation measures on management of construction projects: Najaf City as a case study

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Abstract: The corona virus pandemic greatly affected Al-Najaf construction sector and its economy. This study examines the impact of pandemic on the sector and assesses the mitigation measures used. A questionnaire was given to 66 construction industry experts, covering 38 variables related to contracts, finance, chain supply, risks, and safety. Results, analyzed using the relative importance index, ranked finance as the top priority, followed by safety, risk, and other factors. Operational aspects, supply chain, and contracts were of lesser concern. Key variables included safety concerns, contractor payment delays, risk management, communication, and health projects. Mitigation measures revealed the importance of management actions and health and safety initiatives. Financial and communication measures were significant, while environmental measures ranked lower. Vaccination and emergency loans were highly valued. Evaluation, communication strategy, and cash support were also important. In conclusion, this study underscores the significance of risk management and safety in mitigating the impact of pandemic on the construction sector. Updating Iraqi legal documentation, particularly for crisis management, is crucial. Adopting a modern management approach is necessary to overcome pandemic-related challenges. The study provides recommendations for further investigation, offering valuable insights for decision-makers and future research in the field.

Keywords: pandemic, Al-Najaf construction projects, effected and response categories, relative importance index, mitigation measures

1 Introduction

1.1 General

At the beginning of 2020, the world faced a pandemic phenomenon represented by corona virus (COVID-19), which severely affected the world economy, especially in developed countries [1,2]. Several countries tried to identify the impact of COVID-19 on construction sectors, including the United States, China, and Korea [3]. The statistics provided by the International Air Transport Association indicated that more than 1.7 million jobs in the Middle East were lost because of border closure due to COVID-19 [4]. As a developing country, Iraq has several obstacles and features that might exacerbate the effect of pandemic on the construction sector [5]. The crisis led to deteriorating economic growth [6], increased unemployment, and loss of investment, disturbing the supply chain of construction materials [7]. The construction sector differs from other sectors because it often demands the on-site participation of all project members [8]. No response strategy or guidelines were created to address all steps required to deal with the pandemic's consequences on construction companies [9]. The unexpected pandemic creates a new focus on prioritizing issues related to the health and safety of construction sector cadres. The new priorities include challenges to the supply chain, communication, contract commitments, and providing alternatives urgent. The topic of health and safety management has dominated the construction industry's concerns since February 2020 [10]. In addition, it has also disrupted the transportation system and supply of materials [11]. Consequently, the mode of communication for many companies has shifted to video conferencing for regular meetings instead of

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face-to-face meetings [12]. Changes in contracts anticipating the emergence of risk are very effective on project performance and the cumulative impacts on the process, particularly time delays, additional charges, and contractual provisions of force majeure [13,14]. Different techniques are required to address challenges depending on the size of the company. Similarly, challenges' impact on construction projects may vary based on infrastructure project types [15]. Previous studies have investigated the effect of COVID-19 on different construction projects and engineering management approaches. To complement this significant research topic, this study aimed to evaluate the impact of COVID-19 on construction projects and measures of response adopted to mitigate these effects on the Al-Najaf construction sector.

2 Literature review

This study investigated the previous studies on the impact of COVID-19 on construction project performance and measures adopted in response.

2.1 General

The effect of COVID-19 has been extensively studied in different industry sectors such as health care, trade, agriculture, food, and business. The concept of redefining work-site safety and developing technology that improves project productivity and maintains the safety of workers was investigated by Pamidimukkala and Kermanshachi [2], who identified 17 safety issues categorized into 5 groups and recommended 11 management strategies.

Al-Mhdawi *et al.* [3] surveyed 388 Iraqi industry professionals from the construction sector. They identified 16 construction factors grouped into 4 construction themes: contractual implications, construction financial market and supply chain operations, safety, and risk management. Furthermore, Nguyen *et al.* [16] used basic analysis and relative importance index (RII) techniques to survey 129 respondents in Vietnam using an online questionnaire survey. Three principal facets of the construction industry were considered: firms' business activities, project performance, and workforce demand. They highlighted the multi-level and dimensional nature of the effects of pandemic on the construction industry, particularly revenue and profitability. Rehman *et al.* [5] studied the effect of COVID-19 on the project construction industry performance in the United Arab Emirates. The aspects of project

management include cost, resources, schedule, and contracts. Significant challenges were observed, including schedule delays, disrupted cashflows, delayed permits, approvals, and inspections, travel restrictions, serious health and safety concerns, and material and equipment shortages that hindered the timely delivery of construction projects. The main responses were economic support programs, digitization of processes, fee and fine waivers, and health facilities.

However, Raoufi and Fayek [17] listed 177 possible actions to control and mitigate the pandemic effects within 16 categories. The top five categories of actions were health and public health directives, other issues (assessing the impact of the global economy on the construction market), workforce, communication, suppliers, and subcontractors. Bou Hatoum *et al.* [10] compiled a list of 100 preferable practices that let employers mitigate the workforce's concerns and provide insights into construction site safety and health trends. The practices were divided into 11 themes: access points, communication and awareness, compliance, daily tasks and activities, engineering controls, exposure response plan, human interactions, hygiene and sanitization, management of deliveries, physical and mental health, and safety wearables and carry-ons. Zamani *et al.* [15] interviewed 20 contractors' companies and presented that COVID-19 caused operational and financial issues, while financial aid and complete information must overcome those impacts. However, Alsharef *et al.* [18] demonstrated a new opportunity to create construction projects involving the fast-track construction of medical facilities and recruiting skilled workers, construction of residential buildings, and transportation-related work. They also examined new safety measures and other project hazards that had been implemented.

Furthermore, AlSamarraie and Ghazali [19] classified pandemic consequences in Iraq and recommended mitigation strategies consisting of four categories. These include measures of maintaining a stay-at-home policy for unhealthy employees, wearing a face-covering mask, establishing wash stations or cleaning products at various locations, maintaining an attendance log for all employees and visitors, providing safety equipment like personal protection equipment (PPE) for workers, and expanding welfare amenities on-site to ensure laborers feel comfortable reporting to work. Also, Araya and Sierra [20] identified 15 categories and 6 construction stakeholders of COVID-19 impacts. But Timilsina *et al.* [21] reported three impact levels: financial, operational, and institutional in the construction sectors. However, Umar [22] identified four impacts from the analysis review, health, safety, workforce management, and legal issues. All the previous studies recommended how to organize construction projects during and after the COVID-19 pandemic.

2.1.1 Knowledge gap

Current literature identifies a comprehensive list of construction themes and factors to show the impact of the outbreak of COVID-19, and all responses must be based on quantitatively assessing the impact of the pandemic on Iraq's construction sector/Al-Najaf Province. In addition, this study aimed to cover the knowledge gap and understand the impact and respondents' expectations for the preferable response measures to the construction sector recovery course.

2.2 Iraqi construction sector and pandemic

Iraq's construction sector has the characteristics of developing countries and faced similar challenges with massive disruptions and difficulties due to a curfew in March 2020 because of COVID-19. Accordingly, more than 36,000 contracting companies were witnessing the loss of profits and challenges, such as a 52% employment reduction and a 68% production reduction, as stated by the Ministry of Planning's statistics [8]. The payment rate in the construction sector also decreased by 25%, while 65% of workers were subjected to a reduction in the number of working days, and 2% of workers were completely laid off. Hence, project completion was harder, the supply chain was interrupted, and labor shortage cases emerged – Iraq's current legislation, such as the Iraqi Civil Code [3]. Based on the presented reviews related to this topic, several factors were selected to investigate the impact of the pandemic on the performance of construction projects in Al-Najaf Province, as suggested by Alraie [23]. These factors were categorized based on their common characteristics: contractual, financial, operations and risks, safety, etc. The list of factors with a brief description is presented in Table A1. The review of previous studies identified many suggested responses grouped into distinct categories, namely, health and safety, finance, management, communication, and environment, as shown in Table A2.

3 Methodology

In this study, an online questionnaire consisting of three parts was developed. Based on the literature review results and interviews/consultations with construction sector professionals who added valuable inputs to the original questionnaire version, samples were prepared by distributing the online questionnaire linked with the construction professionals' communication groups, engineers, managers, and all sector stakeholders, ranging from academia to components of the services supply chain through emails, social media, and contracts. The collected data were analyzed, and the results were calculated using the RII method and then discussed. Recommendations for further research were made regarding how to build up the management approaches.

The questionnaire was designed based on three parts: the first part related to respondents' information such as education, position, experience, and infection cases (65%) and vaccination received (only 3%) as the vaccination campaign was just rolled out in the Province. The second part is related to capturing the impact of the pandemic on the construction sector through 38 questions categorized, including contractual, financial, operations and supply chain, risk management, and safety using the Likert scale format of impact through the five-point system (very high = 5, high = 4, moderate = 3, low = 2, and very low = 1).

However, the third part required respondents to prioritize and suggest mitigation measures into five categories: health and safety, financial, management, communication, and environment, according to the pandemic requirements. The online questionnaire was received and answered by 75 respondents, and only 66 respondents were observed to be complete. Then, the collected data were analyzed using the SPSS software. The sample size of 66 respondents was associated with investigating the impact of four category/group levels variables and five response measures groups. The α value of survey reliability Cronbach's was 0.95, more than the accepted limit (0.7) that revealed a reliable and valid

Table 1: Demographic analysis of respondents

Education	No.	%	Position	No.	%	Experience	No.	%	Sector	No.	%
Ph.D.	2	3	Consultant	8	12	0–10	11	17	Private	41	62
M.Sc.	4	6	Academic	6	9	11–15	19	29	Public	25	38
B.Sc.	22	33	Site Eng.	17	26	16–20	17	26			
Diploma	17	26	PM	11	17	21–25	10	15			
Certificate	13	20	Supplier	10	15	25	9	14			
Other	8	12	Contractor	14	21						
Total	66	100		66	100		66	100		66	100

distribution [24]. The analysis data of the 66 respondents according to their education, position (job), experience, and sector are indicated in Table 1.

4 Results and discussions

The circumstances and underlying operations of the particular organizations cause a considerable impact on the breadth of the consequences. Furthermore, the shifting conditions impact each part of the construction process.

But it was noted that contract or project defaults, time management, revisions, project suspensions, terminations, and reinstatements stand out. Also, effective individuals and teams with pertinent industry knowledge and technical skill competence are required to create practical decisions in that novel and distinctive setting.

4.1 Impact on project performance

The RII was used to determine the total impact of each factor, where the ranking of each item according to its

Table 2: RII ranking, means, and importance levels result for 38 factors in four categories with averages

Category	Factor no.	Descriptive	Mean	RII	Rank	Importance level	Average impact by category
Contractual	1	Planning	3.273	0.655	20	⁴ H-M	0.596
	2	Feasibility study	3.030	0.606	31	H-M	
	3	Design	2.636	0.527	37	⁵ M	
	4	Bidding	3.000	0.600	32	H-M	
	5	Handover	2.773	0.555	36	M	
	6	Mobilization	2.909	0.582	35	M	
	7	Contract types	2.955	0.591	34	M	
	8	Staff contracts	3.086	0.617	30	H-M	
	9	Overhead/contractor	3.136	0.627	28	H-M	
Financial	10	Tax, etc.	3.000	0.600	32	H-M	0.689
	11	Land prices	3.333	0.667	19	H-M	
	12	Profit/developer	3.500	0.700	12	H-M	
	13	Bank loans	3.682	0.736	6	H-M	
	14	Project budget	3.485	0.697	15	H-M	
	15	Gross cost	3.364	0.673	17	H-M	
	16	Contractor payments	3.121	0.624	29	H-M	
	17	¹ Contractor P.D	3.788	0.758	2	H-M	
	18	Labor P.D	3.636	0.727	8	H-M	
Operation/Technical	19	Cost on-track	3.545	0.709	9	H-M	0.675
	20	Maintenance	3.455	0.691	16	H-M	
	21	Local/for gain labor	3.231	0.646	23	H-M	
	22	Foreign services	3.545	0.709	9	H-M	
	23	Machine/equipment	3.364	0.673	17	H-M	
	24	Local/for gain materials	3.489	0.698	14	H-M	
	25	Supervision	3.273	0.655	20	H-M	
	26	Laboratory tests	3.273	0.655	20	H-M	
	27	Warehousing	3.152	0.630	27	H-M	
	28	Operation stage	3.182	0.636	25	H-M	
	29	Power supply	3.500	0.700	12	H-M	
	30	Claim/ ² CO/disputes	3.197	0.639	24	H-M	
Risks management, safety, and others	31	Productivity	3.682	0.736	6	H-M	0.683
	32	Time on-track	3.545	0.709	9	H-M	
	33	Safety measures	3.818	0.764	1	H-M	
	34	Risk management	3.727	0.745	3	H-M	
	35	³ GoI response	2.379	0.476	38	M	
	36	Companies compliance	3.182	0.636	25	H-M	
	37	Communication	3.697	0.739	4	H-M	
	38	Health projects	3.697	0.739	4	H-M	

¹Payment delay, ²change orders, ³government of Iraq, ⁴high impact and ⁵indicated medium impact.

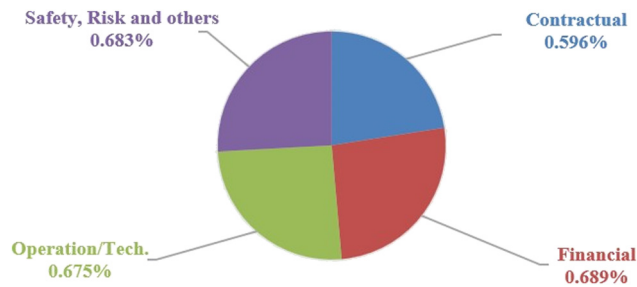


Figure 1: Average impact of the pandemic per category.

relative importance was determined by respondents. All factors were addressed and coded from the questionnaire to demonstrate their significance and effect in the order of priority. Their values were calculated using equation (1), and the results of the analysis are summarized in Table 2 [24]

$$RII = \sum W / (A \times N), \quad (1)$$

where W is the weight of each variable presented to the participants with the range from 1 to 5; A : Highest weight (equal to 5), and N is the total number of participants.

As more impacts of the pandemic on the construction industry members, an initiative-taking approach to search for substantial and practical legal assistance should be crucial for making cost-effective decisions. The direct effects of the pandemic on the construction sector are indicated in Figure 1. The main categories of COVID-19 impact on the construction sector include contractual from factors 1 to 9, financial from factors 10 to 19, operation and supply chain from factors 20 to 32, and risk management, safety, and others from factors 33 to 38.

According to the category analysis, the average impact by RII revealed that the financial value was the greatest with an average impact of 0.689 with the corresponding mean value of 3.445, followed by safety, risk and others, operations, and supply chain and contractual aspects with values of 0.683 (3.417), 0.675 (3.376), and 0.596 (2.978), respectively.

Safety concerns greatly impacted individual factors, followed by contractors' payment delays, risk management, communication, and health projects. Sub-contractors represented the most pandemic effects on the construction industry in Najaf Province because they are more vulnerable to bankruptcy due to the huge disruptions in the supply chain. In addition, the relationship between the labor and suppliers had a significant impact because they survive on daily demands to cover their basic requirements. The results of this study agreed with Al-Mhdawi et al. and Alsamarraie and Ghazali [3,19] regarding categories/groups identification although only 16 factors on the country level were used, while in this study, 38 factors emerged at the province level were used.

In terms of financial and operational categories, the results of this study were similar to those of Gamil and Alhagar [9], although they used 14 factors. From the specific elements/factors side, the results of the impact on contracts were similar to Larasati et al. [13]. Furthermore, regarding risk management, the result of the current study was similar to that of Salami et al. [14]. This study had a similar trend (three categories) as Timilsina et al. [21], although they did not categorize contractual issues separately. Also, the results agreed with the nine categories of

Table 3: Analysis of 15 responses divided into 5 categories

Category	Overall impact %	Response description	Item impact %
1. Health and safety	32	1. Vaccination HC ¹	21
		2. Social distancing	6
		3. PPE ²	5
2. Finance	26	4. Cash support	8
		5. Emergency loans	14
		6. Flexible cost control	4
3. Management	28	7. Agile management	4
		8. Flexible time control	7
		9. New technology adaptation	3
		10. Varieties in supply management	7
		11. Emergency teams formation	7
		12. Contracts updates	6
4. Communication	12	13. Diverse communication and collaboration strategies	9
		14. Adopting decision-making	3
5. Environment	2	15. Environmental control	2

¹Health care and ²personal protection equipment.

impact on construction projects (productivity, using local suppliers, stoppage and delay, etc.) as detailed by Araya and Sierra [20]. In addition, cost, time, environment, and communication factors had a signed agreement with Nguyen *et al.*'s [16] results.

4.2 Response measures

The third part of questionnaire's results are related to the pandemic response measures and respondents' evaluation of these measures, whether the public or private sector responded to them. The response results include 5 categories and 15 individual response measures illustrated in Table 3. The category analysis results indicated that the priority for health and management actions was essential to mitigate the impact of the pandemic. They were followed by financial and communication, then environmental actions. The greatest individual score was for the vaccination, followed by emergency loans. At the same time, the communication strategy and cash support were next, according to the evaluation of respondents. These results agreed with Alsamraie and Ghazali [19] and Iqbal *et al.* [7] regarding finance. Raoufi and Fayek [17] observed similar results in the health and finance categories. In addition, the communication results of this research agreed with the coping strategies of international organization for migration [8].

The need for an agile management approach, as surveyed in this research, was recommended by Bou Hatoum *et al.* [10] as the best practice to be implemented as an exposure response plan. Furthermore, the survey results regarding impact and response exhibit that an emerging innovative management approach was evolving, as reported by Assaad and El-Adaway [25]. A modern approach used new communication strategies and features in project management. The results clarified a gap in the legal environment of Iraqi documentation to address such abnormal situations, which did not cover by the force majeure section.

5 Conclusion

The pandemic outbreak significantly affected public health, economic growth, and social life, including the construction industry worldwide. Also, the lockdown caused a great change in organizations' patterns, delays in construction projects, a decline in workforce capacity, and economic growth. Accordingly, different safety practices were adopted, such as maintaining social distancing among employees, let one task for each worker, monitoring through innovative technologies, and disinfecting all tools and equipment after

work. To evaluate the impact of the pandemic on the construction sector in Al-Najaf Province, a survey was conducted on four categories: contractual categories, operation and supply chain, and financial and safety risks. Also, the respondents identified and prioritized response actions to mitigate the effects of the pandemic on this sector.

Regarding the impact ranking, the results identified domination of risk management, safety factors over other factors, and a gap in the legal sphere of Iraqi documentation. It was concluded that a new management approach that used modern communications strategies and management features is required to address such irregular situations as pandemic situations.

Furthermore, reviewing the current management approaches is a suitable entry into the post-pandemic construction sector. The urgency toward rearranging mitigation priorities should be with the health and management, followed by financial and communication.

6 Recommendations

It is essential to highlight the impact of health and safety concerns, management, communications, health projects, off-site construction methods, etc. Furthermore, to ensure construction activities and long-term sustainability in case the COVID-19 pandemic exists, the following recommendations were suggested:

1. Restructuring the management system should render a more flexible framework.
2. It created various scenarios for construction work that yielded fewer interruptions in a future outbreak and analysis results, such as using the factor analysis method.
3. Encourage digital transformation in business processes to decline contacts and maintain distance, which could be implemented at all levels, including enterprise, management, and implementation on-site.
4. Ensure a sustainable supply chain that includes vendors, backups, alternative partners, contract terms, and insurance policies.
5. Ensure financial safety, including re-assessing interruption scenarios that affect capital in terms of breach of contract, compensation, and coverage for complicated developments.

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Appendix

Table A1: Description of the 38 factors used in this research

Category	Factor no.	Factor name	Description
Contractual	1	Planning	Lack of information to conduct proper planning
	2	Feasibility study	Difficult to gather data for the study
	3	Design	Reducing alternatives
	4	Bidding	Process restrained
	5	Handover	Delay and overdue
	6	Mobilization	Administrative start-up hindered
	7	Contract types	Preference for lump sum/turnkey affects the quality
	8	Staff contracts	Released and shrink staff
	9	Overhead/contractor	Unrealistic and exaggerated
Financial	10	Tax, etc.	Government is unable to collect proper taxes
	11	Land prices	Unstable and unpredictable
	12	Profit/developer	Decreased sharply/discouraging new projects/losses for suppliers
	13	Bank loans	It decreased and became harder to get
	14	Project budget	Increase and overstep planned
	15	Gross cost	Unclear and unpredictable
	16	Contractor payments	Untimely and challenging
	17	¹ Contractor P.D	Disturbed cash flow
	18	Labor P.D	Poor control and commitment
Operation/Technical	19	Cost on-track	Deviation and overstep planned
	20	Maintenance	Loss of contingency control
	21	Local/foreign labor	Workers are unable to reach their workplaces
	22	Foreign services	Stoppage and missing
	23	Machine/equipment	Limited access and supply
	24	Local/foreign materials	Less available and costly
	25	Supervision	Limited offers and quality
	26	Laboratory tests	Acute shortage with lockdown
	27	Warehousing	Discouraged and limited
	28	Operation stage	The supply chain has been disrupted
	29	Power supply	Shortage and costly
	30	Claim/ ² CO/disputes	Increased and nested
	31	Productivity	Lowered and quality challenged
	32	Time on-track	Delay and poor scheduling
Risks management, safety, and others	33	Safety measures	Increase and dominate
	34	Risk management	Shortage of alternatives
	35	³ GoI response	Overdue and limited
	36	Companies compliance	Arbitrary and limited awareness
	37	Communication	Difficulties and system inadequacy
	38	Health projects	Prioritized and funded

¹Payment delay, ²change orders and ³Government of Iraq.

Table A2: Response measures analyzed in this research

Category	Response	Description
1. Health and safety	1. ¹ Vaccination H.C.	Encourage restoring activities
	2. Social distancing	Provide basic protection
	3. ² PPE	Masks & gloves provide additional protection
2. Finance	4. Cash support	Quick recovery
	5. Emergency loans	Support work resumption
	6. Flexible cost control	Encourage speedy restart
3. Management	7. Agile management	Quick and cost-effective in uncertain conditions
	8. Flexible time control	Better time management
	9. New technology adaptation	Reduce deviation
	10. Varieties in supply management	Quality choices
	11. Emergency teams formation	Control unpredictable events
	12. Contracts updates	Flexible adaptation for emergency
4. Communication	13. Diverse communication and collaboration strategies	Reduce contact and increase productivity
	14. Adopting decision-making	Making right choices
5. Environment	15. Environmental control	Improve access to sustainable tools

Note: ¹Health care and ²Personal protection equipment.