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Developing an Impact Model in Construction Companies During Pandemics

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Abstract: The distinctive traits of COVID-19, which were different from other viral pathogens, quickly compelled the World Health Organization (WHO) to announce a pandemic. Many affected countries responded with different approaches to the pandemic. The disease became prevalent in the U.S. with a short delay after Asian and European regions were infected; however, the initial impacts of COVID-19 were massive, and its effects were beyond anyone's expectations. The pandemic caused new situations for various markets, including the construction industry, and demanded additional health and safety regulations. In addition, the economic effect of COVID-19 on the construction industry became another medium- and long-term challenge for construction managers and executives. In order to examine the initial perceptions of construction professionals about the COVID-19 impacts, a study was conducted during its early appearance in the U.S. during the spring of 2020. The objective of this study was to evaluate the construction professionals' perceptions of pandemics and further investigate the possibility and characteristics of an impact model during pandemics. A model was developed to highlight areas and aspects that are impacted by COVID-19 related to construction companies. The model examination was followed by a quantitative method to gather data and analyze the responses. An online survey was conducted in 2020 to verify the validity of the proposed model. The model maps out environments, domains, and factors impacting construction companies during pandemics. The implication of this paper is to realize the early perceptions of construction professionals about pandemics and the necessity of an impact model to handle the negative effects of any global disturbances. The results of this paper will help construction managers to recognize potentially affected areas and more effectively manage crisis response plans.

Keywords: Impact Model, pandemics, construction industry, financial crisis, perception, COVID-19

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1. Introduction

The emergence of COVID-19 was accompanied by doubts, negligence, disavowal, and hesitations in many countries, and soon, it became obvious that countries were globally impacted by this coronavirus, and a pandemic state was declared. The fast pace of changes and impacts left many managers and decision-makers clueless as there was no or insufficient preparation in place. In addition, many organizations and industries seemed to fall short of mechanisms to face the pandemic and its effects. The construction industry, like many other sectors, experienced a short and hard time interval in which they had to change their workflow, project structures, logistics, and operating systems to cope with the new and ever-changing status of the pandemic. Moreover, concerns and problems related to health subjects destabilized human resources in construction. In such a volatile and uncertain environment, construction project managers needed to predict their short and midterm objectives, tools, and methods while managing their projects. However, a lack of a proper framework or model decreased the maneuverability of options and forced managers and decision-makers to rely on their own experiences. Although referring to prior professional experiences helped managers to operate, a portion of construction projects could not survive or proceed normally. Encountering with the pandemic's effects was taken place in isolated frames in which a specific issue was resolved while other interrelated problems remained untouched. The lack of a holistic approach to the sustainable operation of organizations in the construction industry emanated from a dearth of pandemic impacts models. These models show a variety of factors that impact construction organizations while their interconnectivity is addressed too. A literature review of publications for impact models in construction revealed the scarcity of such models or frameworks, and, therefore, in the current study, the design, development, and validation of an impact model was defined as a primary objective for further analysis of the industry behavior during the pandemic. The proposed model can be used as a basis to further develop or use in the next global disturbance. The secondary objective of this study was to explore the initial perception of construction professionals about the different aspects of the COVID-19 impact on construction projects and organizations. This helps to compare the initial perceptions and actual or long-term perceptions of professionals. For this purpose, and after an extensive literature review, different factors, layers, and connections were determined, and an impact model was developed. The model was validated by judgment experts, and a survey was developed and distributed to obtain the perception of construction professionals. After a brief review of the background, the current study provides a succinct description of the model components. The results of the survey conducted in also explained, following the methodology used. The paper also elaborates on a few key points derived from the results in the discussions section and highlights the main findings of the study as the conclusion.

2. Literature Review

2.1. Pandemic Events

Pandemics can occur when a new virus emerges against which humans have little or no immunity, and therefore the virus can spread easily and cause significant illness or death (International SOS, 2018). The rapid escalation of the COVID-19 outbreak surprised many states, organizations, and companies. It is assumed that the cause of the COVID-19 outbreak was the SARS-CoV-2 virus (McKibbin and Fernando, 2020). It is uncertain how this disease evolved and what effects the economy suffered; therefore, planning response models were hard for decision-makers to formulate. The alarming levels of spread and severity made the World Health Organization (WHO) declare a pandemic status in March 2020 to coordinate international responses to the disease (WHO, 2020a). Although this was the first modern pandemic caused by a coronavirus, its impacts, and the responding systems were not new. Throughout history, many diseases have caused similar situations, and their impacts lasted longer than what was initially expected. From 1918 to 1919 Spanish Influenza killed at least 50 million people worldwide, including approximately 675,000 in the United States (CDC, 2018). There were three different waves of disease during the Spanish Influenza pandemic, lasting from the spring of 1918 to the summer of 1919, during which the pandemic peaked in the course of the second wave in the U.S. During this pandemic, one-third of the world's population was infected. The second influenza-caused pandemic happened in 1957 when a new influenza A (H2N2) virus appeared in the eastern part of Asia. H2N2 became prevalent in the U.S. in the summer of 1957. It is estimated that, as a result, 1.1 million worldwide and 116,000 in the U.S. died (CDC, 2019). The next pandemic arose in 1968, in which an influenza A (H3N2) virus affected 1 million worldwide and caused about 100,000 deaths in the U.S. (CDC, 2019). The next similar pandemic occurred in the spring of 2009 when a novel influenza A (H1N1) virus emerged. (Terry, 2020). The pandemic list is not limited to those discussed. The Sixth Cholera Pandemic originated in India, where 800,000 died during 1910-1911. The disease then spread to the Middle East, North Africa, Eastern Europe, and Russia (MPH, 2020). The severe acute respiratory syndrome (SARS) outbreak was the first pandemic of the 21st century that rapidly spread globally and infected 8,098 people during its outbreak (LeDuc and Barry, 2004). Another pandemic-prone disease was the Middle East Respiratory Syndrome (MERS) which caused 866 associated deaths (case-fatality rate: 34.3%) globally since 2012. Cases have been seen in most of the countries on the Arabian Peninsula (WHO, 2020b).

2.2. Economic Impacts of Pandemics

Pandemics generally impose direct and indirect economic impacts. The direct impacts are relatively small in which negative economic growth results from labor force fluctuation and affects local and regional trade intensity. The indirect impacts are even greater in scope. According to the World Bank, a severe pandemic could reduce world gross domestic product (GDP) by roughly 5 percent (Madhav, et al., 2017). Similarly, Jonung and Roeger (2006) modeled the macroeconomic effects of a pandemic in Europe and stated that a pandemic results in an estimated 2 and 4% of loss in GDP for the EU-25, which is consistent with the macroeconomic effects of a pandemic for other countries and regions. Meltzer, Cox, and Fukuda (1999) estimated the possible effects of an influenza pandemic as well as the economic impact of vaccine-based interventions in the United States and concluded that economic impact would be US$71.3 to $166.5 billion, excluding disruptions to commerce and society. In a report on long-term economic consequences of pandemics, Jordà, Singh, and Taylor (2020) addressed labor scarcity and a change in precautionary savings and concluded that major macroeconomic impacts of post-pandemic remain for decades with depressed investment opportunities. While health and safety have been the greatest concerns for many people in the United States and around the globe during the pandemics, the economic consequences of such events are inevitable. Although economic data from the beginning of the twentieth century are somewhat inaccessible, it is estimated that numerous businesses, particularly service- and entertainment-oriented businesses, suffered double-digit losses in their revenue during the Spanish Flu (Kurt, 2020). In another study, Correia, Luck, and Verner (2020) explored the variation in the severity and speed of the pandemic and duration of non-pharmaceutical interventions (NPIs), such as social distancing, implemented to prevent or decrease contagion during the Spanish Flu pandemic. They showed that cities that implemented NPIs for longer terms suffered lower mortality while those in the shorter, medium-term experienced a higher infection rate. Although not all ripple effects of the COVID-19 pandemic are known and calculated, it has impacted the United States with unprecedented speed and severity. Within three weeks of pandemic declaration, about 10 million employees in the U.S. applied for unemployment benefits. The exponential staggering increase in unemployment has never been experienced before, not even at the pinnacle of the global 2009 financial crisis (Bluedorn et al., 2020).

The impacts of COVID-19 did not limit to the economy. Several researchers have explored various effects of COVID-19 on various segments of construction organizations and projects in different countries. Nigeria and showed that small-size companies are affected more by COVID-19 safety risks.

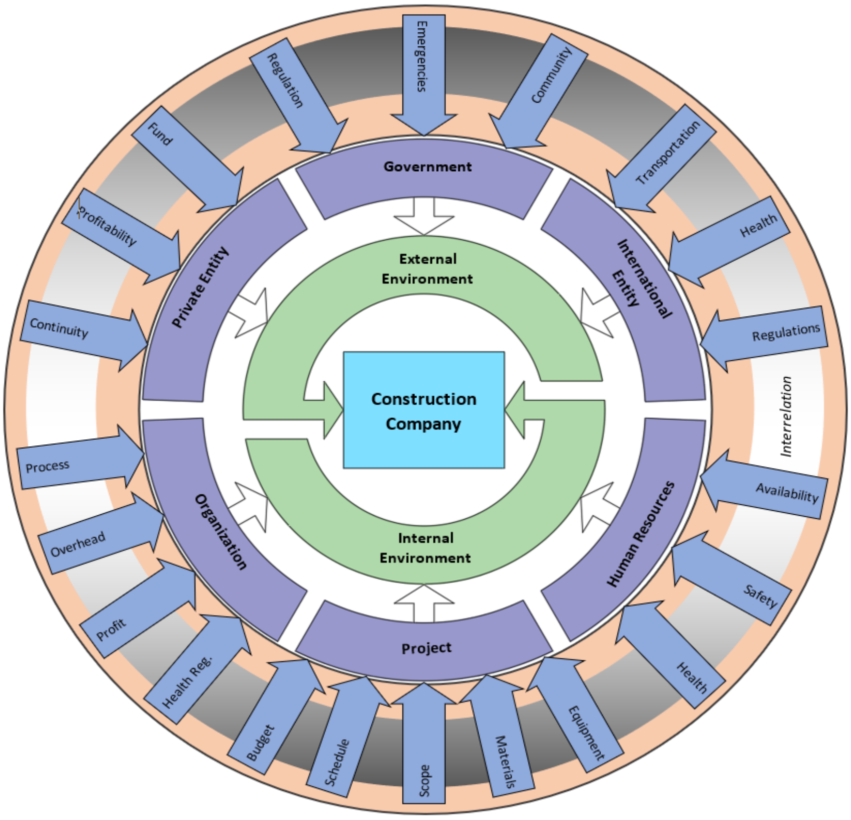

Fig. 1. Impact Model for Construction Companies During Pandemics

Omatule Onubi et al. (2021) explored the determinants of COVID-19-related safety behavior on construction projects in Pirzadeh and Lingard (2021) explored health and well-being experiences in a sample of remote construction professionals and showed a significant relationship between work–life satisfaction and mental well-being during COVID-19. Al-Mhdawi et al. captured the impact of COVID-19 on construction projects in developing countries and concluded that contractual implications, construction financial market, supply chain operations, and safety and risk management were four areas mainly impacted by COVID-19. Kim et al. (2021) analyzed the feasibility of COVID-19 response guidelines for construction sites and provided a method to estimate construction cost and time before and after the COVID-19 pandemic and proactively recognize and respond to pandemic-related events. Ling et al. (2021) the impact of the COVID-19 pandemic on Singapore's construction industry in the areas of supplies, output, prices, and project performance and suggested indexes to estimate the risk and markup to be added to the base construction cost. Jeon et al. (2021) reviewed different factors impacting the construction industry in the U.S. using the Purdue Index for Construction (Pi-C) as an indicator based on the five dimensions of Economy, Stability, Social, Development, and Quality and showed that the impacts of the pandemic were visible in economy and stability dimensions. Raoufi and Robinson Fayek (2022) surveyed construction organizations in North America and identified the most effective mitigation actions and showed "accelerate the uptake of digitalization," "create shorter, more flexible supply chains (e.g., localizing supply chains)," and "stagger shifts for workers" were among the actions that gained attention from early to mid-pandemic. Chih et al. (2021) reviewed the resilience of organizations in the construction industry against COVID-19 and urged construction organizations to plan their response strategies for short-term and long-term performance.

3. The Impact Model

Several models and criteria have been put forth to advance an operational model for construction companies. Lidelöw and Simu (2015) presented a model to show the linkage between business strategy and operations strategy in construction companies that included three levels which are strategic, tactical, and operational. They specified four decision categories of an operations strategy, including 1. organization, quality, human resources, and planning; 2. capacity and vertical integration; 3. process technology, product development, and performance measurement; and 4. facilities. Berg et al. (2019) mapped out archetypical business models in construction in which value proposition, profit formula, resources, and processes were addressed for different construction individuals, including architects, engineers, contractors, and suppliers. Carbon Pricing Leadership Coalition (CPLC) and International Finance Corporation (IFC) (2018) produced a construction value chain model, with actors and interactions that consisted of local authorities, financiers, developers, owners, users, architects and engineers, contractors, material and equipment suppliers, manufactured products, and raw materials. These entities are categorized into regulations, services, and inputs. Kudryavtsev and Arzumanyan (2016) provided an operations architecture of the construction company in which marketing and sales, design and engineering, construction, material procurement and subcontracting, logistics, finance, order management, and general administration were integrated into the vision and strategy, learning and innovation, oversight and management, and execution levels. Jang et al. (2019) designed a business model framework for construction companies to quantitatively analyze the relationship between business models and the performance of international construction companies. In this framework, three dimensions of 'who,' 'what,' and 'how' are assumed. These dimensions depict who the target customer is, what is offered to the target customer, how to create the offering, and how to make money.

Mokhlesian and Holmen (2012) reviewed nine business model elements, including value proposition, target customer, customer handling/ distribution channel, customer interfaces/ relationship, value configuration, capability/core competency, partner network, cost structure, and revenue model for green construction companies and concluded that value configuration and cost structure elements were the most emphasized items among various existing models. In summary, while these models exhibit some aspects of construction processes or businesses, none has holistically presented impacting factors during a disruptive situation.

The Impact Model for construction companies presented in this paper builds on and adds to previous models by more fully addressing factors found in the literature which affect construction companies during pandemics. The components of this model are derived from the literature and previous models. The model is configured as a group of circles to illustrate that no one section of the model is prioritized over another, and items located in each circle have relative interactions. The inner circle serves as a platform for all the other circles. Also, all other elements in the model can have equal influence, allowing construction managers and decision-makers to initiate work to prepare a response during pandemics. While there is no direct relationship between this model and the other models developed for various purposes in construction, the components of this model are derived from other instances along with factors specified through the literature review. The model consists of three main layers: Enterprise Environment, Operational Domain, and Impact Factor, as shown in Fig. 1. These three layers are described as follows:

- Enterprise Environment

The Enterprise Environment layer includes two major categories:

  - External

The external environment includes components or stakeholders that are external to the company, and construction managers do not typically have any control over their impacts. Construction companies are the recipients of potential actions or behaviors of the external environment.

  - Internal

Unlike external factors, the internal environment includes items that are under the company's control. These factors have continuous interactions with decisions made by the company and therefore are more flexible.

- Operational Domain

The operational domain layer is the next layer after the Enterprise Environment, which is the result of individual factors and collectively create an impacting environment surrounding the construction company. The six major operational domains of this layer include the following items:

  - International Entity

This domain includes factors that originated from abroad and impact the construction company through different ways such as imports, travels, and health regulations. Construction companies have the least impact or interaction with this domain. This domain includes regulations, health, and transportation.

  - Government

This domain corresponds to all governmental organizations that impact construction companies and include federal, state, and local authorities. These organizations can change their funding routine due to unforeseen circumstances. Also, they may impose short and mid-term regulations that impact the construction flow. The government domain includes community, emergency, and regulation factors.

  - Private Entity

This domain includes all individuals that are run by private sectors. One main stakeholder in this domain is the owner, who can enormously alter the construction workflow through funding or changing the project's specifications. Another main party in this domain is subcontractor, supplier, or vendor, which their continuity and profitability can considerably impact construction companies. In this domain, funds, profitability, and continuity are impacting factors.

  - Organization

As an internal domain, the organization includes all items that are continuously decided upon, controlled, and revised by managers to achieve the optimized objectives of the company. The state of this domain is balanced among projects and products produced by construction companies. In this domain, the impacting factors are processes, overheads, and profits.

  - Project

This domain consists of factors that are limited to the boundaries of particular projects at a given time. Unlike the organization domain, this domain typically deals with the maximization of objectives (i.e., budget, schedule, scope) instead of optimization of them. This domain includes budget, schedule, scope, materials, and equipment.

  - Human Resources

This domain encompasses factors interacting with people in construction companies. This domain is the most susceptible group to unusual situations with immediate impacts on construction flows. The human resources domain consists of health, safety, and availability factors.

To explore the applicability of this model, a survey was administered with construction professionals, and the obtained data were analyzed against different components of this model.

4. Methodology

The pandemic events impact on the construction industry is an evolving situation in which both known and unknown factors and their intensity are difficult and time-consuming to determine (Shibani et al., 2020; Brown, 2020). While in some parts, passing time reveals the extent of impacting factors, agile organizations strive to obtain further data and shape their subject knowledge. Exploring the conditions and acquiring additional information provides two outcomes: first, a clear understanding of the status quo to make required decisions to handle existing pandemic effects, and second, fostering the ability to predict the future. The sooner construction managers recognize the different aspects of a pandemic event, the fewer risks they will encounter in the short and long term. For this purpose, a study was performed to explore construction managers' perceptions toward COVID-19 in early stages of the pandemic. The overarching research question in the study was "how do construction professionals perceive COVID-19's impacts on different aspects of their professional life?".

The first phase of this research was initiated in March 2020, focusing on construction professionals' perceptions. To collect quantitative data, a survey was developed and distributed to the sample group. The survey was designed as an instrument to collect data regarding the population sample. A cross-sectional procedure was employed to accumulate information from the sample group at a certain date (Setia, 2016). The population in this study included professionals in the construction industry with full-time positions. The survey consisted of four sections: demographic information, COVID-19 impacts, professional concerns, and professional preparedness. The surveys were administered in the first two weeks of April to capture the time-based professionals' perceptions. To obtain a random sampling of the population, two invitation emails were dispatched (March 30th and April 9th, 2020), and then the survey was closed on April 12th, 2020. A priori analysis was used to estimate the number of responses required by using the population proportion and determining the sample size (Singh and Masuku, 2014). The confidence interval of 95% ($Z\alpha/2$ = 1.96) and the margin of error of 10% (ε = .10) were assumed. The amount of information regarding the resulting data distribution was limited, therefore, the maximum proportion of respondents was considered (p = 50%). As a result, the required sample size for the study was 97 subjects. A total of 130 out of 138 responses from obtained surveys were deemed suitable for analysis based on their completeness. To facilitate the data collection and increase the rate of response, a digital mode of response acquisition was selected in which the Qualtrics online survey platform (Qualtrics, 2020) was employed to develop and administer surveys.

Participants received their access to the survey through a URL that linked the participants directly to the survey. The survey link was distributed to the Mississippi University's Building Construction Science program advisory board and construction companies affiliated with Associated General Contractors (AGC) and Associated Builders and Contractors (ABC) in the state of Mississippi. The obtained quantitative data were cleaned and coded, and then they were compiled, modeled, and analyzed with statistical software such as Excel and SPSS. To perform frequency analysis, descriptive statistical methods were used. In addition to the descriptive analysis, Kruskal-Wallis and Spearman's Rho tests, as non-parametric tests, were used to measure the strength of association between variables. To ensure the applicability and suitability of the non-parametric tests, their assumptions were first checked to be true (Murray, 2017; Maache and Lepage, 2003). The study was not intended to explore the cause-effect or causal relationships (Bae et al., 2017). However, to measure the internal reliability and consistency of sections in the survey, Cronbach's alpha measurement (Gliem and Gliem, 2003) was utilized to examine the reliability of the measurements. A Cronbach's alpha of .86 was gained overall from the data analysis, which classifies the internal consistency of the survey as "high" (Taber, 2017). The results of the reliability analysis indicate a high internal consistency between the items.

5. Results

A data model was created by integrating all data gathered. Redundant or incomplete responses were omitted from the model to ensure the data quality. The following sections summarize the main results of the responses:

5.1. Descriptive Analysis

To describe the basic features of the data model in this study, descriptive statistics were employed to provide simple summaries of the sample and the measures (Trochim, 2020). The following sections are the results of the quantitative analysis of data that were gathered through the survey. Like other areas in construction, females formed the minority of participants, as only 18% of participants were female. Participants reported different positions as their current title, among which "project manager" with 38% had the highest percentage. In addition, participants specified their work experience at various intervals. More than half of the participants (51%) had +25 years of experience, following the 15-25 years group with 23%.

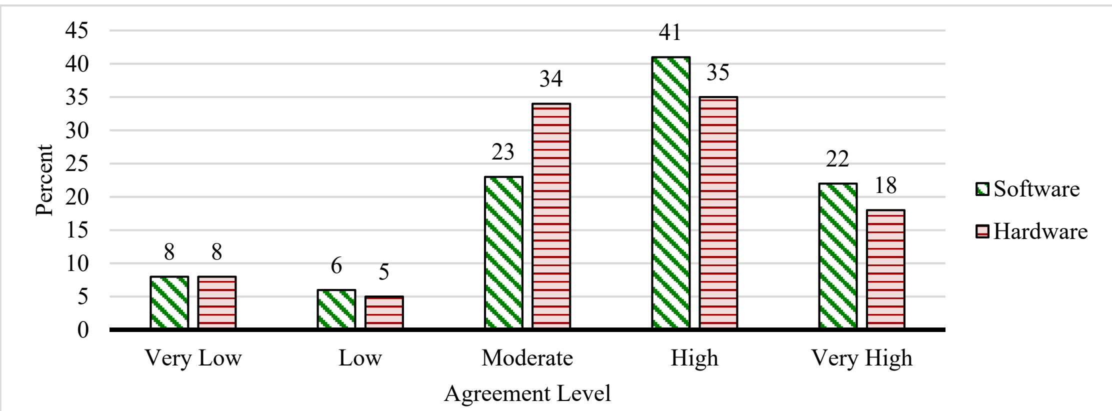

Fig. 2. Access to proper software and hardware

Participants were asked to report how their working time has been impacted by COVID-19 so far in the second part. Possible options were "No change," "Decreased," and "Increased" in time, and their percentages were 55%, 36%, and 9%, respectively. The majority of the professional working time in the construction industry is not affected by COVID-19. This trend might be a result of the nature of the construction industry to work in high-risk work conditions.

In the next question, participants rated to what extent their jobs or activities can be virtually or remotely performed. The percentages of five agreement levels from Very Low to Very High were 13%, 8%, 41%, 25%, and 13%, respectively. Only 21% (Low and Very Low) reported that their jobs could not be performed remotely. Despite the physically-intensive nature of many construction jobs, a considerable portion of the job could be performed remotely. Participants also reported the degree to which they have access to proper Software, Procedures, or Guidelines as well as Hardware/Equipment that were required to perform their job remotely. As shown in Figure 2, the majority of participants stated that they had sufficient access to both hardware and software. High access to the proper software and hardware represents the construction industry's prepared structure to cope with the critical condition.

Participants were also asked to estimate the significance of the impact of COVID-19 on construction as a large industry. A 5-Level Likert scale (Very Low to Very High) was used to rate the level. The percentages for these five levels were 0%, 5%, 43%, 34%, and 18%, respectively. More than half of the participants estimated a significant (High and Very High) impact on construction caused by COVID-19.

In the next part, participants were asked to assess the effect of COVID-19 on various procedures, segments, and features of construction organizations and projects. Similarly, a 5-Level Likert scale (1: Very Low, 5: Very High) was used for rating. The following items were required to be rated:

Q1. Proficient employee availability
Q2. Construction materials scarcity
Q3. Construction equipment availability
Q4. Safety and health of employees
Q5. Productivity rate
Q6. Overhead cost of projects
Q7. Company's profit
Q8. Safety guidelines and instructions
Q9. Maintaining client's relationship
Q10. Local government shutdown
Q11. International projects/imports/travels
Q12. Delivering projects on time
Q13. Delivering projects on budget

The weighted average (out of 5) was calculated for each item, as shown in Table 1. The range of averages varies from 2.16 (International projects/imports/travels) to 3.88 (Company safety regulations and guidelines). Proficient employee availability, construction materials shortage, construction equipment availability, international projects or imports or travels, and on-budget project delivery were weighted below the mid-point. High score rating in the safety regulations and guidelines demonstrates the company's proportionate reaction to the new condition to alleviate the negative impacts.

To explore the relationship between the items impacting construction companies during pandemics, the factorability of items stated above was evaluated and shared criteria for the factorability of possible correlation were investigated. The relationships among items were explored, which resulted in a correlation of .3 or above with at least another item for all items. Also, it was determined that the Kaiser-Meyer-Olkin measure of sampling adequacy for this set was .775, which is above the commonly accepted threshold of .5. Also, Bartlett's test of sphericity was significant ($\chi2$ (113) = 462.72, $p < .05$). The anti-image matrices showed that the diagonals of the correlation matrix, with three exceptions, were also 0.5 or above. The extraction values in the Communalities matrix were all, except one, above 0.3, indicating that each item shared some common variance with other items. The only value below 0.3 was Q11. International projects/imports/travels were omitted from the model. A principal components analysis was employed to assess factors impacting construction companies during pandemics. The first three components had Eigenvalues above 1, explaining 32%, 13%, and 9% of the variance, respectively. In the final step, using varimax rotation and employing a primary factor loading of 0.4 or above, the three dimensions of Project Continuity, Workforce Normality, and Resource Availability were labeled, as shown in

In the third section, the main aim was to investigate the perceptions of construction professionals about the level of preparedness of different entities in coping with or adjusting to COVID-19's impact. Eight items were presented in a matrix to be rated by participants using a 5-Level Likert scale (1: Very Low, 5: Very High). These items are denoted by R1-R8 as follows:

R1. Personal life
R2. Professional career
R3. Division/group/department
R4. The company's organizational system
R5. The company's technical and procedures
R6. Subcontractors
R7. Clients
R8. The construction industry in general

Table 3 illustrates the weighted average of score of each item (out of 5), perceived by participants. A similar factor analysis test was performed to explore the factorability of a correlation of the eight items regarding the preparedness of construction companies during pandemics. The examination of correlations between items showed that all items correlated with at least one other item at 0.3 or above. Also, it was shown that the Kaiser-Meyer-Olkin test of sampling adequacy for this group was .857, which is above the commonly accepted threshold of 0.5. Also, Bartlett's test of sphericity was significant ($\chi2$ (113) = 558.60, $p < .05$).

Table 1. Weighted average of COVID-19 impacts on project/organization aspects

Aspects	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
Weighted Average	2.6	2.55	2.18	3.69	3.06	3.12	3.05	3.88	3.11	3.24	2.16	3.21	2.93

Table 2. Factor analysis for items impacting construction companies

Items	Component			Dimension
	1	2	3	
Q13	.811			Project Continuity
Q12	.796			
Q7	.728			
Q6	.695			
Q11	.443			
Q10	.418			
Q8		.883		Workforce Normality
Q4		.735		
Q9		.562		
Q5		.513		
Q3			.845	Resource Availability
Q1			.646	
Q2	.426		.594	

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

Table 3. Preparedness average score for different entities

Aspects	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**
Weighted Average	3.4	3.24	3.29	3.26	3.27	3	3.13	3.16

The extraction values in the Communalities matrix were all above 0.5, indicating that each item shared some common variance with other items. A principal components test was utilized to investigate factors impacting construction companies' preparedness during pandemics. The first two components had Eigenvalues above 1, explaining 60% and 14% of the variance, respectively. Finally, using varimax rotation solution and using a primary factor loading of 0.4 or higher, two dimensions of Internal Environment and External Environment were specified and labeled, as shown in Table 4.

Table 4. Factor analysis for items impacting construction companies' preparedness

Items	Component		Dimension
	1	2	
R3	.858		Internal Environment
R4	.852		
R2	.826		
R5	.781		
R1	.636		
R8		.879	External Environment
R7		.838	
R6		.766	

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 3 iterations.

The objective of the next section was to obtain the intensity level of construction professionals' concern during the pandemic era toward important factors, including the following items:

a. Family-related issue handling
b. Availability of PPE
c. Health concerns
d. Job stability
e. Changing the job routine (e.g., online work)
f. Projects' time/cost/scope-related changes.

The intensity level was rated employing a 5-Level Likert scale (1: Very Low, 5: Very High). Table 5 shows the weighted average of these items. Overall, all items show an above-average level of concern among construction professionals.

In the next question, participants expressed how soon they had believed the effects of COVID-19 on their companies or projects would be entirely eliminated. In other words, they evaluated when they predict the status of their projects would turn back to the before the COVID-19 time. The intervals provided were "within one month," "within three months," "within six months," "within one year," and "more than one year." Fig. 3 shows the percentage of each interval among which "within three months" gained the highest percentage (about one-third).

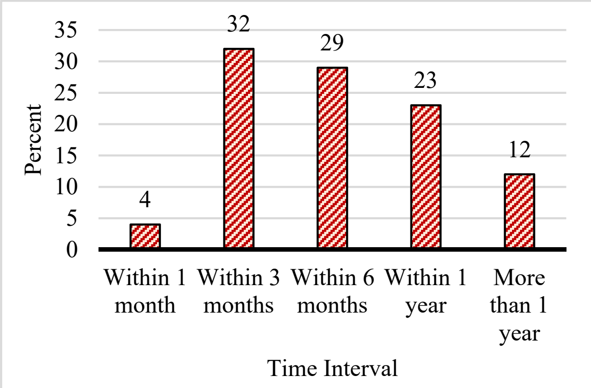

Fig. 3. Percentage of time intervals to remove COVID-19 impact

In another question, participants stated if they believed the effect of COVID-19 on the construction industry would last more than any other industry. As shown in Fig. 4, half of the participants did not think the inertia in construction would cause the COVID-19 effects to stay longer in the construction industry than in other industries.

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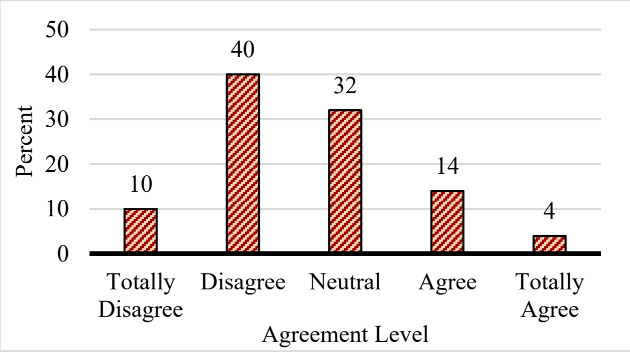

Fig. 4. Agreement levels on the longevity of COVID-19 effects in construction

Table 5. Weighted average score for different concern areas

Area	a	b	c	d	e	f
Weighted Average	3.7	3.7	3.96	3.65	3.5	3.66

And finally, participants rated to what extent they thought the post-COVID-19 era would be similar to the 2008 economic crisis. Similar to previous sections, a 5-Level Likert scale (1: Very Low, 5: Very High) was used to quantify the rates. While there is a normal distribution for the levels of similarity, responses leaned to the disagreement side. Figure 5 shows the percentage of each similarity level.

5.2. Correlation Analysis

Correlation analyses were also utilized to evaluate the strength of relationship between quantified variables. These analyses help to extract more information and depict the relationship between responses. More notable results were found through the correlation analysis:

- Various Kruskal-Wallis H tests failed to show any statistically significant correlation between the gender and any other variable pertaining to the effect or concerns of COVID-19. This means participants' gender did not correlate with the perceptions toward COVID-19 and its impacts.
- A Kruskal-Wallis H test indicated that there was a statistically significant difference in estimated effect levels of COVID-19 between the different positions of participants, KWH = 4.683, $p = 0.030$, with a mean rank position score of 57.02 for Project Manager and 70.80 for Non-Project Manager groups. Similarly, a statistically significant difference in similarity to 2008 financial crisis levels between the different positions of participants was shown, KWH = 3.855, $p = 0.050$, with a mean rank position score of 49.73 for Project Manager and 61.64 for Non-Project Manager groups.
- To explore the association between the levels of preparedness among different entities, a Spearman's rank-order correlation test was conducted for each pair of items. Eight items examined in this test are found in Table 3.
- To run the test, required assumptions were examined to ensure there was a monotonic relationship between each pair measured on an ordinal scale. A Spearman's rank-order correlation was conducted to determine the relationship between participants' perceptions toward the preparedness of different items in response to COVID-19. A series of Spearman's rank-order correlation tests for levels of preparedness among different entities showed that there was a positive correlation between all eight entities rated by participants.
- Similarly, the relationship between six possible major concerns of professionals was explored. The relationships examined are included in Table 5.
- A Spearman's rank-order correlation was used to determine the relationship between participants' perceptions toward the possible concerns as an effect of COVID-19. The correlation test showed that there was a positive correlation between all six concerns perceived by participants.

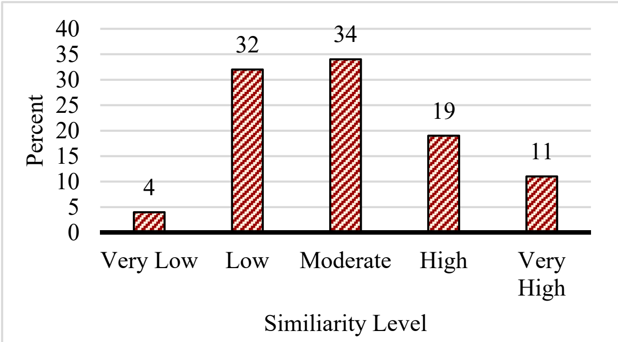

Fig. 5. Percentage of similarity levels

6. Discussion

Pandemics have short-term and long-term effects on society and include economic, political, cultural, and health aspects. Many industries suffer from the unpredictable, and most likely unprepared, situation after pandemics and experience hardship that in some cases may result in going out of business. The construction industry, unlike some other fast-paced businesses, such as healthcare, food, and hospitality, has higher business endurance. This economic resilience emanates from the nature of the construction industry's size and workflow. However, because of these characteristics, any momentum in construction has longer-lasting effects. One of the factors that impacts construction organizations' behaviors and responses to an unusual situation, like a pandemic, is the perception of individuals involved. While the perceptions of individuals evolve over time as more and more information becomes available, having a clear understanding of an impacting event in a project-based industry such as construction is crucial. This study reveals several notable points derived from construction professionals' perceptions of COVID-19 impacts. The majority of participants in this study have more than 25 years of experience, which means they were familiar enough with previous public health concerns as well as the 2008 financial crisis. Changing the working style from in-office to online necessitates a time adjustment. This time change may not be applied to those construction professionals who are partially or entirely on project sites. In addition, the working time for professionals in the online system may be summarized as essential activities and therefore result in a decrease in working time. However, there was still a group of participants who reported an increased working time which might be due to the communication settings, coordination, and efficiency. This is consistent with the next point reported by participants regarding the possibility of performing remotely/online, as over one-fifth of participants stated they were not able to comfortably accomplish their responsibilities remotely. Another factor that affects the possibility and quality of remote performance is the accessibility of required soft (procedures, workflows, software) and hard (equipment, infrastructure, hardware consistency) systems. The majority of participants reported satisfactory access to adequate software and hardware.

The next observable point from the data is the reported estimate of the significance level of COVID-19's effects on construction. Participants overwhelmingly believed that COVID-19 has a high level of effect on construction, and only 5% estimated it negligible. This impact on a granular scale has a diverse variance. As shown in Table 1, the levels of impacts (Very Low to Very High) exhibit distinct patterns among the potential subjects. In contrast, the levels of preparedness (Very Low to Very High), illustrated in Table 3, show a uniform variability. These two sets together indicate the similarity of perceptions toward different individuals/roles' preparedness against COVID-19 which is inconsistent with the perceptions on possible impacted areas. Another detectable feature is the heterogeneity in estimated durability of COVID-19 in which one-third of participants expected to resume the routine within three months while another one-third estimated this interval as one year or more. Similarly, the resemblance of the COVID-19 era to the 2008 financial crisis has a wide range of frequencies.

An additional output, extracted from the data, is the impact of gender and position on responses variability. It was shown that participants' gender did not correlate statistically with their responses. Inversely, participants' positions showed a significant correlation with the estimated impact of COVID-19 as well as its similarity to the 2008 financial crisis. Finally, positive associations were detected between the preparedness levels of different individuals. In addition, positive associations existed among the concerned subjects. These two sets of correlations indicate uniform perceptions toward factors impacting construction professionals' preparedness and concern at different levels.

7. Conclusion

This paper addressed preliminary results of construction professionals' perceptions toward COVID-19 impacts in its earliest phase in the U.S. While the medium and long-term effects of COVID-19 are evolving, the initial understanding of such an event is a key factor in managing future pandemic consequences. The first phase of this study was designed and conducted in a relatively short interval to portray a cross-sectional image of construction professionals' perceptions. In addition to the overall weight of construction in national GDP, the comprehensive effect of construction activities on public well-being highlights the importance of the construction industry's response to unusual events such as the COVID-19 pandemic. The results indicated uniform approaches toward various factors while some divergence was reported on a few subjects. For example, the majority of participants reported a congruent perspective toward the impact intensity of COVID-19. On the other hand, there was not a dominant prediction on the longevity of COVID-19.

In general, the responses in different sections did not reveal a surprising pattern, which can be interpreted as a relatively well-prepared and confident response of construction professionals in handling the COVID-19 effects on their business. In developing the impact model, it was aimed to define general terms and factors that provide the most inclusiveness, but it should be noted that construction per se is a very broad industry with a multitude of subsections and, therefore, cannot always be considered as one entity. Although the number of professionals who participated in this study exceeded the required sample size, the generalization of results is not guaranteed. The data collection was performed during a limited time interval when the number of people with COVID-19 was increasing, and new information was revealed almost daily. A larger and more heterogeneous sample can increase the conclusions' reliability in the following studies. Moreover, inter-industry studies of operations and perceptions will better define the characteristics of the construction industry during the COVID-19 pandemic. In addition, a longitudinal study will highlight the evolution of professional perceptions over time.

Author Contributions

Saeed Rokooei contributed to conceptualization, methodology, software, validation, analysis, investigation, data collection, draft preparation, manuscript editing, visualization, and supervision. Amin Alvanchi, Alireza Shojaei, and George Ford contributed to project administration, data collection, survey development, draft preparation, and manuscript editing.

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Institutional Review Board Statement

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