Journal of Construction Engineering, Management & Innovation
2023 6(4):340-353
DOI 10.31462/jcemi.2023.04340353

RESEARCH ARTICLE

Impact of COVID-19 on inspection of Turkish public construction works and recommendations for the post-pandemic era

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Article History

Received 27 November 2023
Accepted 21 December 2023

Keywords

Building inspection
COVID-19 pandemic
Public construction projects
Questionnaire survey
Turkey

Abstract

Although the COVID-19 pandemic has profoundly disrupted construction projects worldwide, studies on its impacts on building inspection services remain limited. Ensuring adequate quality and safety through inspections is particularly important for projects delivering critical public assets. Thus, this study aims to investigate Turkish building inspectors' perspectives regarding the effects of the pandemic on public construction works between 2020 and 2022. For this purpose, a survey was conducted with 66 professionals involved in public inspection services. The findings revealed the established problems in the building inspection system, independent of the pandemic period, as well as the additional impediments caused by COVID-19, such as changing work routines, site operation issues, and quality problems. Furthermore, the agreement analysis verified the high level of consensus on the impacts of the pandemic among different participant groups, except that more experienced inspectors considered their tasks more challenging during this period. Implementing a balanced set of incentives and accountability measures, adopting remote inspection technologies, promoting modular construction applications, providing support programs for inspectors, and establishing long-term policies were presented as the key recommendations to build more resilient inspection mechanisms for the post-pandemic era. This research is believed to provide valuable insights into the theory and practice by exploring the diverse pandemic disruptions and response mechanisms.

1. Introduction

Public construction projects deliver vital community services like hospitals, transportation hubs, and infrastructure facilities. Ensuring effective quality and safety inspection regimes for such assets is thus essential, considering the critical functions they provide to the general public [1]. Routine inspections by qualified engineers are imperative to avoid catastrophic structural or system failures endangering the public. Building inspection activities play an indispensable governance role in this regard by verifying that contractor work complies with the standards dictated by codes or the owner requirements stipulated in contract documents [2]. However, despite the importance of building surveillance, studies have revealed specific problems in inspection mechanisms worldwide [3-5].

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eISSN 2630-5771

The COVID-19 pandemic has introduced additional pressures that have profoundly disrupted the execution of public construction projects [6]. "Significant delays on projects," "inability to secure materials on time," "reduction in productivity rates," and "material price escalations" have been among the significant adverse effects of the pandemic on the construction industry [7]. According to Olanrewaju et al. [8], the COVID-19 pandemic has increased disputes and claims by approximately 80% and project costs by more than 40%. Additional risks introduced during this period have interrupted building inspection services, as well [9]. For instance, remote work requirements and quarantines frequently hampered on-site audit activities, while transportation barriers delayed material checks. Although the disruptions are evident, academic studies exploring building inspectors' perspectives on the pandemic's impediments remain scarce. Context-specific evidence is needed to inform policies, particularly for public construction works, which are vital for socioeconomic functioning amidst recovery efforts.

Thus, this study aims to investigate the perceptions of Turkish building inspectors regarding the effects of the COVID-19 pandemic on public construction works between 2020-2022. The motivation lies in the need to understand these unprecedented impacts on inspection for developing tailored policy solutions that enhance resilience against future disruptions. The research employed a survey methodology incorporating literature analysis and interviews with senior inspectors to create exploratory pandemic-focused questions. Data was collected from 66 building inspectors involved in Turkish public construction projects to assess the influence on various aspects. Based on the statistical analyses of the results and the insights from the existing literature, recommendations were provided for the post-pandemic era.

The remainder of the paper is organized as follows. Section 2 reviews the literature on enhancing the existing building inspection practices and the pandemic impact on the construction industry. Section 3 outlines the methodology utilized in the research. Next, the results and discussion are presented in Section 4. Section 5 provides several recommendations to increase the resilience of the building inspection mechanisms against possible future impediments. Finally, Section 6 concludes the paper with a general summary and discussion of the contributions, limitations, and new research potentials.

2. Literature Review

2.1. Studies on improving building inspection practices

Although building inspection plays a vital role in ensuring construction quality, safety, compliance, and performance over a facility's lifespan, several studies reveal gaps and limitations in current inspection practices. For example, Erol and Dede [5] critically reviewed the building inspection system in Turkey and suggested remedies, such as strengthening the penal provisions stipulated in the law. Regarding building codes and regulations, Bortolini and Forcada [3] highlighted the variability in technical building inspection requirements across different countries and devised a standardized building inspection system to improve accuracy and reliability. Analyzing Hong Kong regulations, Chan [4] recommended establishing detailed guidelines and clear standards in the mandatory building inspection scheme to facilitate compliance. There are also many researchers who suggested optimizing inspection resources, often using risk assessments. Yuan et al. [10] prioritized inspection checklist items to optimize the resources based on the likelihood and severity of the failure. Kim et al. [11] developed a stepwise regression model to determine the appropriate number of inspection staff. Mohamad and Tran [12] proposed a risk-based prioritization approach to optimize construction inspections based on their criticality. Furthermore, several studies highlight the use of technology to improve inspection productivity, quality, and data management. Hamledari et al. [13] designed a drone-based automated inspection system using 4D Building Information Modelling (BIM). Yuan et al. [14] developed a mobile

application to facilitate construction inspections using digital as-built data in asset management systems. Finally, May et al. [15] proposed a BIM-based Augmented Reality (AR) defect management system for construction inspections.

Despite the aforementioned efforts, only a limited number of studies, such as Tekin [9] and Lu et al. [16], focused on the consequences of the COVID-19 pandemic on inspection practices. Thus, there is a need for more research to understand the impact of the pandemic on building inspection services and propose action plans for the post-pandemic era.

2.2. Studies on the pandemic within the construction industry

The COVID-19 pandemic has profoundly disrupted the global construction industry, leading to numerous studies investigating its impacts on various aspects of construction projects, firms, and professionals. Many papers examined the pandemic's repercussions on economic development and the general performance of the construction industry across different parts of the world. Ahmed et al. [17] focused on identifying the top pandemic factors in Bangladesh's construction sector, affecting the national economy and development. Wang et al. [18] revealed various difficulties encountered in China's construction industry via a survey of civil engineers. There have also been studies focusing on the project performance. Sami Ur Rehman et al. [19] highlighted factors affecting general project performance in the UAE construction sector, including delays, cashflow problems, traveling restrictions, health and safety issues, and material and equipment availability. Badawy et al. [20] analyzed the data of projects in Egypt before and after COVID-19 to identify the main risk factors caused by the pandemic. Kisi and Sulbaran [21] used a survey to show how supply chain disruptions affected costs and schedules in the US construction industry. Chigara and Moyo [22] identified factors affecting health and safety in Zimbabwe through construction professional surveys and factor analysis. Olanrewaju et al. [8] found that factors such as materials shortages, pandemic measures, and labor issues increased disputes in Nigeria via an open-ended questionnaire. Some researchers also concentrated on human-related aspects. Oo et al. [23] used surveys to examine individual perceptions of the Australian construction consultants of remote working. Soliman et al. [24] revealed the main motivational and demotivational factors for Kuwaiti construction workers during the pandemic based on interviews and factor analysis. Tan and Abdul-Samad [25] collected survey data from Malaysian project managers to find factors reducing labor productivity.

In addition, many studies have focused on the impact of the pandemic on the built environment, specifically in Turkey. Gumusburun Ayalp and Çivici [26] identified increased material costs and cash flow issues as major pandemic impacts through a construction industry survey. Aslan and Türkakin [27] utilized optimization techniques to determine minimum infection risk scheduling options for a construction project. Tekin [28] compared man-hour values before and after the pandemic to identify the most affected construction activities, as well as the root causes of the productivity declines. Aladag et al. [29] used structural equation modeling to reveal the main dispute factors arising from the pandemic in Turkey. İlter [30] uncovered differences between Turkish and international architects' pandemic reactions through social media content analysis.

Regarding building inspections in Turkey, Tekin [9] focused on assessing individual risk factors threatening inspection services during and after the pandemic through expert surveys. However, there remains a gap in understanding Turkish inspectors' perspectives on the pandemic's diverse effects on public construction projects. In order to address this gap, this study conducts a questionnaire-based survey of inspectors involved in public construction works. The results provide updated insights from the post-lockdown recovery period and unique evidence to inform policies for enhancing inspection, which is critical for quality and safety in public construction projects.

3. Methodology

This study employed a research methodology consisting of four main steps to investigate the issues around building inspection of public construction works in Turkey during the COVID-19 pandemic, as shown in Fig. 1.

First of all, a review of existing literature on building inspection activities and the impacts of COVID-19 was undertaken to gain background knowledge and identify the key issues to be explored through a survey. Moreover, interviews were conducted with three experts who had over 50 years of combined experience in inspecting public buildings to elicit perspectives on specific challenges and changes caused by the pandemic in Turkey. Information from the literature and expert interviews was used to formulate topics and questions for an original survey questionnaire.

Then, a survey composed of 3 parts was developed to collect empirical data. The survey went through an iterative development process and was pre-tested with the same experts for feedback on question clarity and validity. The first part involved seven questions related to age, gender, education, profession, professional experience, current role, and experience in the current institution of the participants to obtain their demographic information. The second part sought the general opinions of the inspectors regarding their jobs and building inspection services without considering the pandemic period. This part aimed to verify the existing problems in building inspection practices reported by several researchers, as presented in Section 2.1, rather than a comprehensive exploration. Four questions answered on a dichotomous scale in this part are presented below:

- Q8: Are you pleased with your current job in terms of professional satisfaction?
- Q9: Do you consider the building inspector position the most suitable field for you? If you had the chance to choose, would you still like to be in the inspector position?
- Q10: Are you satisfied with your current salary and working conditions in return for your labor, responsibilities, and working hours?

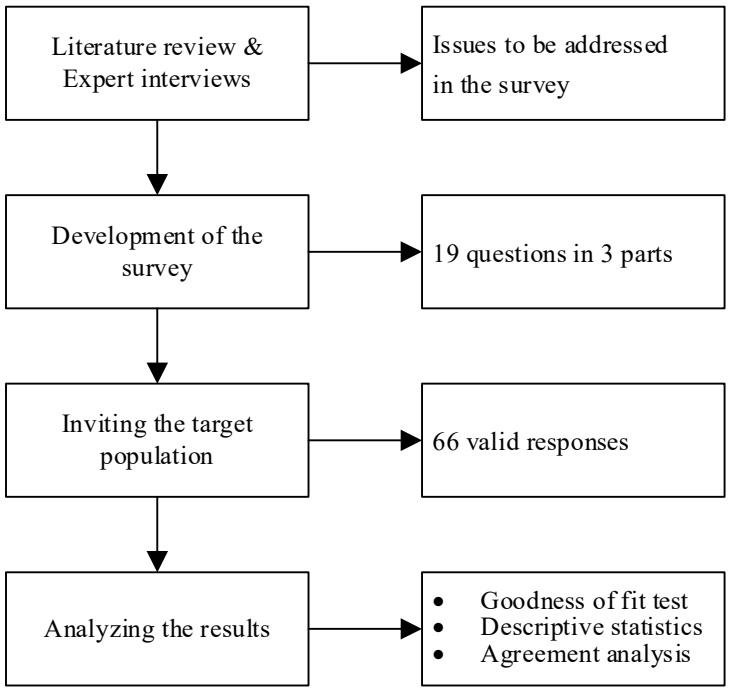

Fig. 1. Research methodology

- Q11: Do you agree with the proposition that the site visits and inspections conducted by building inspection engineers are sufficient in general for the appropriate progress of construction works, regardless of the pandemic period between 2020 and 2022?

In the third part, the participants were asked to rate their level of agreement with a given proposition using a five-point Likert scale. The questions focused on the challenges and impacts of the pandemic on the building inspection services of public construction works between 2020 and 2022, as well as solution mechanisms. The eight propositions included in this part are listed as follows:

- Q12: Various disruptions occurred in the construction site inspections and visits as well as office work due to quarantine, restrictions, measures, remote work, or coming to the office on certain days of the week.
- Q13: Various disruptions occurred in site works due to production and transportation problems caused by finding specification-compliant materials or a sufficient number of workers/craftsmen.
- Q14: One of the reasons for the problems experienced in the manufacturing stages on construction sites has been the low quality of materials or labor chosen by contractors due to economic reasons.
- Q15: There have been changes in the attitudes of employers during this period compared to previous periods.
- Q16: The additional disruptions and problems experienced at construction sites significantly affected the overall quality of the construction work and the comfort of the end user.
- Q17: It has been more challenging to do building inspection engineering during this period compared to previous periods.
- Q18: The sanctions imposed on contractors who fail to fulfill their obligations by the contract and specifications have been deterrent and sufficient.
- Q19: The legislative amendments made (such as the extension of time right, additional price difference, incremental price difference, termination right, contract transfer, issuance of new unit price books in 2022, etc.) have had a positive impact on the progress of construction works.

Following the development of the survey, it was distributed to approximately 200 professionals who had engineer, chief, or supervisor roles in building inspection services related to public construction works in Turkey. The online questionnaire created in Google Forms was sent to respondents with an introductory email explaining the research purpose and compliance with ethical requirements. A total of 66 valid responses were obtained for analysis over a data collection period of one month, resulting in a satisfactory response rate of 33.7%. Table 1 demonstrates the profile of the participants representing different groups.

The final step involved the analysis of the collected survey data. For the questions in the second part, the chi-square goodness of fit test was used to determine if there were significant differences in the participants' responses [4]. On the other hand, the Likert scale questions in the third part were analyzed with descriptive statistics, including means and standard deviations. Furthermore, agreement analysis was conducted on these questions to identify areas of consensus or divergence among different groups of participants [6]. Accordingly, the Mann-Whitney and Kruskal-Wallis tests were employed to assess the statistical significance of observed differences among two or multiple independent groups, respectively. These non-parametric tests were chosen for their robustness in handling non-normally distributed data [2, 4]. All data analysis was performed using the IBM SPSS statistics version 23. The results are presented in the next section.

4. Results and Discussion

4.1. General questions

The general questions in the second part of the survey were analyzed using the chi-square goodness of fit test to determine if the proportion of "Yes/No" responses significantly differed from an expected 50/50 split. The results are summarized in Table 2.

Table 1. Participant profile

Category	Group	Frequency (%)
Age (AG)	AG1: 20-29 years	9 (13.6)
	AG2: 30-39 years	25 (37.9)
	AG3: 40-49 years	23 (34.8)
	AG4: > 50 years	9 (13.6)
Gender (GE)	GE1: Male	57 (86.4)
	GE2: Female	9 (13.6)
Education (ED)	ED1: Undergraduate degree	52 (78.8)
	ED2: Postgraduate degree	14 (21.2)
Profession (PR)	PR1: Civil engineer	25 (37.9)
	PR2: Electrical/electronic engineer	16 (24.2)
	PR3: Mechanical engineer	10 (15.2)
	PR4: Architect	9 (13.6)
	PR5: Other	6 (9.1)
Professional experience (PX)	PX1: 1-10 years	14 (21.2)
	PX2: 11-20 years	36 (54.5)
	PX3: > 20 years	16 (24.2)
Current role (CR)	CR1: Building inspection engineer	52 (78.8)
	CR2: Building inspection chief	8 (12.1)
	CR3: Building inspection supervisor	6 (9.1)
Experience in the current institution (XI)	XI1: 1-2 years	12 (18.2)
	XI2: 3-10 years	12 (18.2)
	XI3: Over 10 years	42 (63.6)

Table 2. Chi-square goodness of fit test results for the general questions

Question	Answers (Yes-No)	Chi-square	*p*-value
Q8	23-43	6.061	0.014*
Q9	30-36	0.545	0.460
Q10	1-65	62.061	<0.001**
Q11	25-41	3.879	0.049*

* $p < 0.05$ (Significant at the confidence level of 95%)
** $p < 0.01$ (Significant at the confidence level of 99%)

For Q8 regarding job satisfaction, 43 respondents (65.2%) answered "No" compared to only 23 (34.8%) answering "Yes". The chi-square test confirmed that this distribution was significantly different from 50/50 ($\chi2 = 6.061$, $p = 0.014$), suggesting most participants were not satisfied with their jobs. In contrast, the responses for Q9 on the suitability of the inspector position were nearly equally split between "Yes" (n = 30, 45.5%) and "No" (n = 36, 54.5%), showing no significant deviation from 50/50 ($\chi2 = 0.545$, $p = 0.460$). On the other hand, an overwhelming majority of participants (n = 65, 98.5%) answered "No" to Q10 about their satisfaction with salary and working conditions. The chi-square test revealed that this imbalance was highly significant ($\chi2 = 62.061$, $p < 0.001$). Lastly, for Q11 on the general sufficiency of building inspections, there were more

disagreed (n = 41, 62.1%) than agreed (n = 25, 37.9%), with the difference being marginally significant ($\chi 2 = 3.879$, $p = 0.049$).

In summary, the responses indicated that most participants were dissatisfied with their jobs, especially the compensation and working conditions. However, opinions were split regarding the suitability of the inspector position as a career. Many also believed the site inspections conducted were inadequate. The results largely coincide with the findings of the previous studies on the building inspection system in Turkey, such as Erol and Dede [5], and reveal the established problems of the system, independent of the pandemic period.

4.2. Pandemic-related questions

Eight 5-point Likert scale questions in the third part of the survey focused on the building inspectors' perspectives regarding the impacts of the COVID-19 pandemic on public construction projects. While Fig. 2 displays the responses ranging from "Strongly Disagree" (1) to "Strongly Agree" (5), Table 3 presents mean and standard deviation values for each question across different groups.

For Q12 on disruptions to inspection routines, the overall mean response was 3.47, with a standard deviation of 1.099. This indicates respondents generally agreed that the pandemic caused disruptions through remote work, quarantines, and changing office schedules. Regarding Q13 about disorders to site work, the mean response of 3.98 (SD=0.794) shows respondents clearly agreed that production and transportation issues made materials and workers unavailable, slowing construction progress. For Q14 on using low-quality material/labor due to economic reasons, overall agreement was also high, with a mean of 3.89 (SD=0.825). The results for Q15 show that employer attitude changes caused relatively fewer negative impacts during the pandemic, with a mean of 2.82 and SD of 0.943. Regarding the effect on overall construction quality (Q16), the mean response of 3.29 (SD=0.973) indicates moderate agreement that pandemic-related disruptions and problems negatively impacted quality and user comfort. However, about a quarter of respondents (25.8%) selected "Neither agree nor disagree," expressing a neutral opinion on this issue. For Q17 on increased inspection difficulty, the overall mean was 3.33 (SD=1.086), confirming that many inspectors found their jobs more challenging throughout the pandemic period. Q18 on the sufficiency of the sanctions for non-compliant contractors had the lowest overall mean score, with 2.30 (SD=1.123). About 70% of the participants disagreed or strongly disagreed that penalties have been adequate.

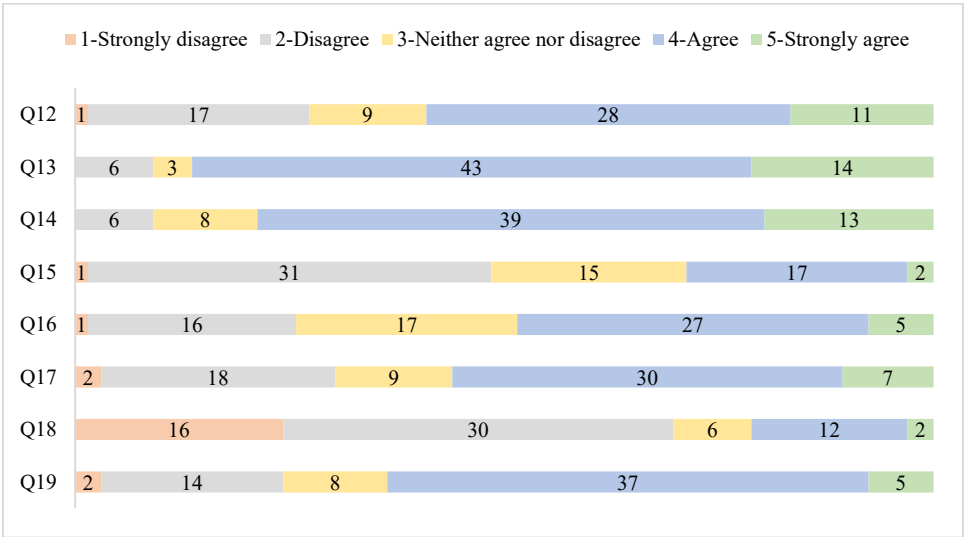

Fig. 2. Distribution of the answers for the pandemic-related questions

Table 3. Descriptive statistics for the pandemic-related questions across different groups

Category	Group	Q12		Q13		Q14		Q15		Q16		Q17		Q18		Q19	
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
AG	AG1	3.67	1.118	4.11	0.928	3.78	0.667	2.78	0.667	3.56	0.527	3.11	0.782	2.44	1.014	3.56	0.882
	AG2	3.48	1.122	3.96	0.790	3.96	0.935	3.00	1.041	3.28	1.173	3.20	1.291	2.32	1.249	3.44	1.044
	AG3	3.43	1.037	3.96	0.767	4.00	0.674	2.61	0.839	3.30	0.876	3.35	0.982	2.17	1.029	3.35	1.112
	AG4	3.33	1.323	4.00	0.866	3.56	1.014	2.89	1.167	3.00	1.000	3.89	0.928	2.44	1.236	3.56	0.882
GE	GE1	3.42	1.051	3.95	0.833	3.91	0.786	2.74	0.897	3.33	0.913	3.26	1.078	2.26	1.110	3.40	0.997
	GE2	3.78	1.394	4.22	0.441	3.78	1.093	3.33	1.118	3.00	1.323	3.78	1.093	2.56	1.236	3.67	1.118
ED	ED1	3.56	1.018	3.96	0.816	3.94	0.777	2.79	0.893	3.25	0.905	3.33	1.061	2.27	1.069	3.44	1.018
	ED2	3.14	1.351	4.07	0.730	3.71	0.994	2.93	1.141	3.43	1.222	3.36	1.216	2.43	1.342	3.43	1.016
PR	PR1	3.44	1.083	3.92	0.954	3.76	1.012	2.84	1.028	3.48	0.872	3.00	1.080	2.32	1.180	3.48	0.918
	PR2	3.75	1.000	3.88	0.719	4.19	0.544	3.13	0.806	3.44	0.964	3.50	0.966	2.19	1.109	3.38	1.088
	PR3	3.20	1.033	4.10	0.316	4.10	0.568	2.30	0.675	3.10	0.994	3.50	0.850	2.50	0.972	3.10	1.197
	PR4	3.67	1.323	4.33	0.707	3.78	0.833	3.00	1.118	2.89	1.167	3.78	1.394	2.44	1.333	3.78	1.093
	PR5	3.00	1.265	3.83	0.983	3.50	0.837	2.50	0.837	3.00	1.095	3.33	1.211	2.00	1.095	3.50	0.837
PX	PX1	3.64	1.008	4.14	0.770	4.00	0.784	2.79	0.802	3.43	1.016	2.93	0.997	2.00	0.784	3.57	0.852
	PX2	3.47	1.082	4.00	0.717	3.94	0.791	2.83	0.971	3.42	0.937	3.25	1.131	2.50	1.254	3.28	1.111
	PX3	3.31	1.250	3.81	0.981	3.69	0.946	2.81	1.047	2.88	0.957	3.88	0.885	2.13	1.025	3.69	0.873
CR	CR1	3.54	1.111	4.00	0.767	3.96	0.816	2.87	0.971	3.29	0.977	3.31	1.112	2.19	1.067	3.44	1.018
	CR2	2.75	0.886	3.88	0.835	3.38	1.061	2.25	0.463	3.25	0.886	2.88	0.991	3.13	1.356	3.38	0.916
	CR3	3.83	0.983	4.00	1.095	4.00	0.000	3.17	0.983	3.33	1.211	4.17	0.408	2.17	0.983	3.50	1.225
XI	XI1	3.75	1.055	4.17	0.835	3.67	0.778	3.08	0.996	3.58	0.669	3.42	0.900	2.08	0.793	3.58	0.900
	XI2	3.50	1.168	3.92	0.996	4.17	0.937	3.00	0.953	3.33	1.073	3.17	1.267	2.17	1.030	3.83	0.718
	XI3	3.38	1.103	3.95	0.731	3.88	0.803	2.69	0.924	3.19	1.018	3.36	1.100	2.40	1.231	3.29	1.088
Overall		3.47	1.099	3.98	0.794	3.89	0.825	2.82	0.943	3.29	0.973	3.33	1.086	2.30	1.123	3.44	1.010

M = Mean, SD = Standard Deviation

Finally, for Q19 regarding the positive impacts of legislative amendments, the mean of 3.44 (SD=1.010) indicates a general agreement that these changes helped improve construction progress.

In summary, the COVID-19 crisis appears to have affected Turkish public construction works negatively from the viewpoint of building inspectors. The descriptive statistics show that the pandemic caused disruptions to work routines, site operations, and quality, while the impact of employer attitude changes was relatively limited. It has been determined that these disruptions were at a level that both affected the comfort of the end-user and made the building inspection task more challenging. Regarding solution mechanisms, penalties were found to be insufficient, whereas incentives were considered more effective.

Although the above results reflect the overall perspective of all participants, Table 3 reveals the differences between different groups, too. In order to determine whether these differences are statistically significant, the Mann-Whitney and Kruskal-Wallis tests were conducted (Table 4).

Table 4. Agreement analysis for the pandemic-related questions

Question	*p*-value						
	AG*	GE**	ED**	PR*	PX*	CR*	XI*
Q12	0.935	0.249	0.286	0.498	0.767	0.101	0.590
Q13	0.874	0.445	0.669	0.579	0.586	0.858	0.520
Q14	0.496	0.924	0.410	0.391	0.649	0.222	0.189
Q15	0.552	0.064	0.655	0.147	0.976	0.143	0.335
Q16	0.719	0.454	0.404	0.506	0.167	0.991	0.452
Q17	0.352	0.164	0.867	0.264	0.040***	0.073	0.910
Q18	0.891	0.450	0.828	0.841	0.424	0.146	0.808
Q19	0.970	0.431	0.965	0.710	0.373	0.931	0.258

* Kruskal Wallis Test
** Mann-Whitney Test
*** $p < 0.05$ (Significant at the confidence level of 95%)

According to Table 4, a significant result was found for Q17 on the increase of inspection challenges during the pandemic across different professional experience groups (p = 0.040). The participants with over 20 years of experience (M = 3.88) agreed more strongly than those with experience of 10-20 years (M = 3.25) and 1-10 years (M = 2.93) about the negative impact of the pandemic on the building inspection services. This implies that more experienced inspectors have had more difficulties during the pandemic. For other questions, there were no statistically significant differences based on age, gender, education, profession, experience, or current role. In terms of areas of consensus, the highest level of agreement was for Q13, where close mean scores across different groups and a small overall standard deviation of 0.794 indicate most respondents strongly believed that the pandemic caused problems with the availability of materials and workers. There was also a strong consensus around Q14, showing that quality problems arising from economic reasons during the pandemic have been considered important by different groups.

Consequently, while some group differences existed, the building inspectors who participated in this survey largely agreed on the diverse impacts of the pandemic across most aspects of public construction projects. The results of the study, showing pandemic disruptions to work routines, site operations, and quality, align with the findings of Tekin [9]. Similarly, the opinion proposed by Lu et al. [16] that the difficulties experienced by inspectors have increased during this period was also confirmed with further evidence showing the perception changes with different experience levels. In addition to the measures suggested by Tekin [9] to deal with inspection-related risk factors and the technological solutions of Lu et al. [16] to improve the reliability of inspection workflows, this study recommends more generic actions to enhance the resilient capacity of building inspection in the post-pandemic era, as detailed in the following section.

5. Recommendations

The COVID-19 pandemic has profoundly disrupted construction projects and building inspection activities worldwide, including in Turkey. As the findings of this study reveal, public construction works and their inspection in Turkey have faced various challenges like changing work routines, site operation issues, and quality problems. It is, therefore, imperative to take certain actions focused on increasing the resilience of the building inspection mechanisms against future crises and uncertainties. This section provides some recommendations for the post-pandemic era based

on the existing literature and empirical evidence from this research.

To begin with, an overwhelming majority of the inspectors surveyed believe the current sanctions for contractors failing inspection requirements during the pandemic have been inadequate. Thus, the legal provisions need to be strengthened to ensure accountability, fairness, and adherence to quality standards by all stakeholders, even during turbulent times. The penalties could be enhanced by incorporating additional liabilities for rework, infrastructure failures, and time/cost overruns arising due to violations, as pointed out by Erol and Dede [5]. On the other hand, recent legislative amendments allowing compensation for pandemic impacts appear to have facilitated construction progress in Turkey based on the findings of this study. Along with stricter sanctions, positive incentives like monetary rewards, certifications, and recognition programs can also be implemented to motivate contractors and suppliers who consistently deliver high-quality work and compliance. As Wang et al. [18] noted, government assistance is instrumental for the construction industry to handle challenges caused by the pandemic. Carefully designed incentives and accountability measures can drive the behavioral changes needed to prioritize quality and safety at all stages.

The research findings also supported that shifting to remote work and changing on-site routines during the pandemic restrictions frequently disrupted inspection activities. As Lu et al. [16] emphasized, technology solutions are essential to facilitate remote inspections when physical visits are difficult. Emerging digital tools based on BIM, AR, Virtual Reality (VR), or the Internet of Things (IoT) can enable inspectors to monitor project progress and detect defects remotely. For instance, inspectors can obtain on-site data through real-time BIM models to virtually identify deviations from the design [31]. Adopting drones and automated camera systems would also help collect site visual data for remote digital inspection [13, 32]. However, specialized training programs are imperative to build the capability of inspection staff to use new technologies. The government can also provide funding support to procure advanced technologies needed for high-quality digital inspections. Gradually transitioning from traditional manual procedures to integrated digital inspection workflows would significantly enhance the functioning of remote inspection practices.

According to the survey, the pandemic caused shortages of materials and craftsmen in Turkish public projects, indicating the vulnerability of the conventional construction model relying heavily on on-site manual work. Shifting towards offsite manufacturing and assembly can increase construction supply chain resilience even if pandemics recur. Prefabrication and modular building techniques allow work to continue during infected site closures and minimize infection transmission risks through reduced on-site labor [33]. As Assaad et al. [34] explained, offsite construction provides a more controlled environment, which may also facilitate easier inspection of modular units before final site installation. In addition to offsite construction, other modern methods of construction can enhance quality and resilience against disruptions. For example, the use of lean construction techniques offers possibilities to counter uncertainties in material deliveries and labor availability during an outbreak [35]. Similarly, robotic construction can ensure the continuity of critical tasks, even with restrictions on worker numbers, while enabling video feeds for remote inspection [36]. Hence, financial incentives, partnerships, and training programs can be introduced to encourage greater usage of such methods in public construction projects.

The survey results revealed that inspectors with over 20 years of experience faced more difficulties during the pandemic, likely due to lower adaptability. The findings also showed the lack of satisfaction among inspectors with compensation and working conditions coupled with the heavy psychological stresses and safety risks imposed by the pandemic. Targeted support is essential to enhance the motivation, capacity, and well-being of inspection staff. Training programs focusing on

veteran inspectors can help them use contemporary technologies and comply with special inspection requirements imposed by disasters. Providing these upskilling opportunities as well as arrangements towards balancing their work-life satisfaction would be impactful retention measures for employees [23, 37]. Besides, performance-based financial incentives and reward schemes may improve satisfaction levels [24].

Most participants (nearly two-thirds) of this study considered the site inspections conducted as insufficient in general, even before the pandemic. Thus, long-term inspection policies are required to ensure construction quality and safety. Since inspection departments were often understaffed to handle growing workloads efficiently with the added complexities of pandemic-related procedures, public agencies could consider increasing the number of their full-time professional inspector positions over the next few years. Furthermore, devising risk-based prioritization frameworks could be helpful in dealing with staffing shortages, especially during extraordinary situations such as pandemics [12]. As the lack of preparedness exacerbated the challenges of COVID-19, developing contingency plans to be enacted during different disaster scenarios could be another useful policy [38]. For instance, protocols could cover remote inspection workflows, virtual communication methods, changes in on-site audit schedules, and exceptions in document submission rules during lockdown periods.

Consequently, this section has put forward a range of recommendations to contribute to the resilience of building inspection mechanisms, including enhancing the effectiveness of penalties and incentives, improving remote and digital inspection capabilities using emerging technologies, promoting offsite construction and other modern construction methods, providing support to inspectors, and establishing long-term inspection policies. Implementing these actions can significantly bolster the functioning of public construction inspection in Turkey, even amidst turbulent events.

6. Conclusions

This study has investigated the perspectives of Turkish building inspectors regarding the impacts of the COVID-19 pandemic on public construction projects between 2020-2022. A survey was conducted with 66 professionals involved in inspection services for public buildings. The results provide valuable insights into the diverse pandemic disruptions and response mechanisms.

The findings demonstrated the dissatisfaction of the inspectors in terms of their work conditions and general sufficiency of building inspections, independent of the pandemic period. The pandemic-related questions, on the other hand, reveal that remote work requirements, quarantines, and changing office schedules hampered routine inspection activities. Additionally, production and transportation issues made materials and workers unavailable, causing significant disruptions to site operations. Using low-quality materials or labor for economic reasons during this period has been another critical area of concern. However, changes in the attitudes of employers were not considered a major issue by the inspectors. There was an agreement among the participants that the pandemic has negatively impacted overall construction quality and user comfort to a certain extent. Many participants, especially experienced ones, also confirmed that the pandemic has increased the challenges associated with their building inspection tasks. While the penalties for contractors failing inspection requirements were found inadequate, recent legislative amendments to provide relief appear to have facilitated general construction progress.

Regarding recommendations for the post-pandemic era, a balanced set of financial incentives and legal penalties can strongly motivate contractors to maintain quality standards even amidst disruptions. Adopting advanced technology solutions can enable remote inspection in case of infected site closures. Modular and offsite construction techniques can allow for continuity of work and facilitate easier inspections through a more controlled environment. Providing upskilling and well-being support programs for inspectors is

another proposed measure. Moreover, the efficiency of these suggestions can be reinforced by establishing long-term inspection policies.

Overall, the research presents clear empirical evidence that Turkish public construction projects and their inspection regimes have faced serious impediments due to the COVID-19 pandemic. It contributes to the body of knowledge by uncovering the impacts of the global crisis on public inspection functions, which have received limited focus in construction management literature so far. In terms of practical contributions, the recommendations can guide policymakers in Turkey and worldwide in devising tailored regulations and action plans for the construction sector to recover from pandemic effects and enhance resilience and preparedness for future uncertainties.

However, the research also has some limitations. Since only the participants with inspector duties were surveyed, perspectives from other stakeholders involved in public construction may differ. In addition, the findings reflect the subjective view of 66 participants involved in this study. More comprehensive conclusions could be reached through wider industry surveys in future studies. Regarding research methods, longitudinal case studies tracking inspection practices can validate the reported disruptions and the effectiveness of the recommended measures in a real-life setting. In conclusion, this study paves the way for devising more resilient inspection mechanisms in future research efforts to withstand uncertainties of the post-pandemic reality in the construction industry.

Declaration

Funding

This research received no external funding.

Author Contributions

H. Erol: Conceptualization, Methodology, Formal Analysis, Writing-Original Draft, Writing-Review & Editing, Supervision; G. Gül: Conceptualization, Methodology, Data Collection, Writing-Review & Editing.

Acknowledgments

The authors would like to thank all the experts and survey participants for their contributions to this study.

Data Availability Statement

The data presented in this study are available on request from the corresponding author.

Ethics Committee Permission

The authors acquired ethics committee permission for surveys implemented in this paper from the Hacettepe University Ethics Commission (Date: 16/05/2023; No: E-35853172-900-00002846786).

Conflict of Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

[1] Ko CH, Li SC (2014) Enhancing submittal review and construction inspection in public projects. Automation in Construction 44: 33–46.

[2] Zalejska-Jonsson A, Muyingo H (2019) Building inspection in multi-dwelling housing and the perception of building quality. Construction Economics and Building 19(2): 144–159.

[3] Bortolini R, Forcada N (2018) Building inspection system for evaluating the technical performance of existing buildings. Journal of Performance of Constructed Facilities 32(5): 04018073.

[4] Chan DWM (2019) Sustainable building maintenance for safer and healthier cities: Effective strategies for implementing the Mandatory

Building Inspection Scheme (MBIS) in Hong Kong. Journal of Building Engineering 24: 100737.

[5] Erol H, Dede MS (2022) A stakeholder-based review of the building inspection system in Turkey: The case of Yalova. Journal of Construction Engineering, Management & Innovation 5(2): 95-106.

[6] Rani HA, Farouk AM, Anandh KS, Almutairi S, Rahman RA (2022) Impact of COVID-19 on construction projects: The case of India. Buildings 12(6): 762.

[7] Alsharef A, Banerjee S, Uddin SMJ, Albert A, Jaselskis E (2021) Early impacts of the COVID-19 pandemic on the United States construction industry. International Journal of Environmental Research and Public Health 18(4): 1559.

[8] Olanrewaju A, Anavhe PJ, Chu HC (2023) Disputes and claim management during the COVID-19 crisis: The lessons learned. Journal of Legal Affairs and Dispute Resolution in Engineering and Construction 15(1): 04522054.

[9] Tekin H (2022) Assessment of risks in building inspection services during and post-COVID-19 pandemic. ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part A: Civil Engineering 8(2): 04022003.

[10] Yuan C, Park J, Xu X, Cai H, Abraham DM, Bowman MD (2018) Risk-based prioritization of construction inspection. Transportation Research Record: Journal of the Transportation Research Board 2672(26): 96-105.

[11] Kim DY, Persad KR, Khwaja NA, Chi S (2016) Assessment of staffing needs for construction inspection. KSCE Journal of Civil Engineering 20(7): 2598-2603.

[12] Mohamad M, Tran DQ (2021) Risk-based prioritization approach to construction inspections for transportation projects. Journal of Construction Engineering and Management 147(1): 04020150.

[13] Hamledari H, Sajedi S, McCabe B, Fischer M (2021) Automation of inspection mission planning using 4D BIMs and in support of unmanned aerial vehicle–based data collection. Journal of Construction Engineering and Management 147(3): 04020179.

[14] Yuan C, McClure T, Dunston P, Cai H (2016) Leveraging construction inspection and documentation for asset inventory and life cycle asset management. Journal of Information Technology in Construction 21: 72-85.

[15] May KW, KC C, Ochoa JJ, Gu N, Walsh J, Smith RT, Thomas BH (2022) The identification, development, and evaluation of BIM-ARDM: A BIM-based AR defect management system for construction inspections. Buildings 12(2): 140.

[16] Lu W, Wu L, Xu J, Lou J (2022) Construction E-Inspection 2.0 in the COVID-19 pandemic era: A blockchain-based technical solution. Journal of Management in Engineering 38(4): 04022032.

[17] Ahmed S, Haq I, Anam SMA (2022) Impacts of COVID-19 on the construction sector in the least developed countries. International Journal of Building Pathology and Adaptation (Published online August 8, 2022).

[18] Wang Z, Cai X, Liu Z (2022) Survival and revival: Transition path of the Chinese construction industry during the COVID-19 pandemic. Engineering Management Journal (Published online August 18, 2022).

[19] Sami Ur Rehman M, Shafiq MT, Afzal M (2022) Impact of COVID-19 on project performance in the UAE construction industry. Journal of Engineering, Design and Technology 20(1): 245-266.

[20] Badawy M, Alqahtani FK, Sherif MA (2023) Impact of the COVID-19 pandemic on risk factors in residential projects. Journal of Asian Architecture and Building Engineering 22(3): 1637-1647.

[21] Kisi KP, Sulbaran T (2022) Construction cost and schedule impacts due to COVID-19. Journal of Legal Affairs and Dispute Resolution in Engineering and Construction 14(4): 04522024.

[22] Chigara B, Moyo T (2022) Factors affecting the delivery of optimum health and safety on construction projects during the COVID-19 pandemic in Zimbabwe. Journal of Engineering, Design and Technology 20(1): 24-46.

[23] Oo BL, Lim BTH, Kim S (2023) Working from home during COVID-19 and beyond: Exploring the perceptions of consultants in construction. Buildings 13(1): 166.

[24] Soliman E, Al-Tabtabai H, Almusalam A, Hussein M (2023) Impact of COVID-19 on labor's motivational factors and construction productivity. International Journal of Construction Management 23(15): 2699-2708.

[25] Tan CKL, Abdul-Samad Z (2023) A study of the impact of COVID-19 on construction workforce productivity in Malaysia. International Journal of Productivity and Performance Management 72(8): 2376-2396.

[26] Gumusburun Ayalp G, Çivici T (2023) Factors affecting the performance of construction industry during the COVID-19 pandemic: A case study in Turkey. Engineering, Construction and Architectural Management 30(8): 3160-3202.

[27] Aslan S, Türkakın OH (2022) A construction project scheduling methodology considering COVID-19 pandemic measures. Journal of Safety Research 80: 54-66.

[28] Tekin H (2022) The impact of COVID-19 on construction labor productivity: The case of Turkey. Engineering, Construction and Architectural Management 29(9): 3775-3806.

[29] Aladağ H, Demirdöğen G, Işık Z (2021) Investigation of dispute factors and effects on construction projects arising from COVID-19 pandemic as a force majeure event. Journal of the Faculty of Engineering and Architecture of Gazi University 36(3): 1213-1228.

[30] İlter AT (2022) Architects reactions to COVID-19 pandemic with evidence from their social media accounts. ICONARP International Journal of Architecture and Planning 10(1): 158-178.

[31] Li CZ, Xue F, Li X, Hong J, Shen GQ (2018) An Internet of Things-enabled BIM platform for on-site assembly services in prefabricated construction. Automation in Construction 89: 146-161.

[32] AI-Hajj M, Ozcan-Deniz G, Ozorhon B (2022) Critical success factors for implementation of Unmanned Aerial Vehicles (UAVs) in construction. Journal of Construction Engineering, Management & Innovation 5(4): 228-252.

[33] Pan W, Zhang Z (2022) Evaluating modular healthcare facilities for COVID-19 emergency response—A case of Hong Kong. Buildings 12(9): 1430.

[34] Assaad RH, El-adaway IH, Hastak M, LaScola Needy K (2022) The COVID-19 pandemic: A catalyst and accelerator for offsite construction technologies. Journal of Management in Engineering 38(6): 04022062.

[35] Jiang L, Zhong H, Chen J, Cheng J, Chen S, Gong Z, Lun Z, Zhang J, Su Z (2023) Study on the construction workforce management based on lean construction in the context of COVID-19. Engineering, Construction and Architectural Management 30(8): 3310-3329.

[36] AlRushood MA, Rahbar F, Selim SZ, Dweiri F (2023) Accelerating use of drones and robotics in post-pandemic project supply chain. Drones 7(5): 313.

[37] Bou Hatoum M, Faisal A, Nassereddine H, Sarvari H (2021) Analysis of COVID-19 concerns raised by the construction workforce and development of mitigation practices. Frontiers in Built Environment 7: 1-15.

[38] Shooshtarian S, Caldera S, Maqsood T, Ryley T (2022) Evaluating the COVID-19 impacts on the construction and demolition waste management and resource recovery industry: Experience from the Australian built environment sector. Clean Technologies and Environmental Policy 24(10): 3199-3212.