

HEALTH AND SAFETY MEASURES FOR MANAGING THE COVID-19 PANDEMIC IN THE CONSTRUCTION INDUSTRY: A COMPARISON STUDY

Albert P.C. CHAN^{1,2},
ORCID.org/0000-0002-4853-6440

Yang YANG^{1,2},
ORCID.org/0000-0002-3648-6001

Janet Mayowa NWAOGU^{2*},
ORCID.org/0000-0002-5389-4816

Wen YI^{1,2},
ORCID.org/0000-0001-5487-5353

Junfeng GUAN²
ORCID.org/0000-0002-5090-1937

¹The Shenzhen Research Institute, The Hong Kong Polytechnic University, Shenzhen 518057, China

²Department of Building and Real Estate, The Hong Kong Polytechnic University, Hong Kong 999077, China

* Corresponding author

Abstract

The Covid-19 pandemic has resulted in an unprecedented loss of life, economic slowdowns, and business disruptions. There has been growing interest in examining how the construction industry coped with the pandemic to minimise its negative impacts. However, health and safety (H&S) measures can vary depending on context. This study examines the implementation of H&S measures in the COVID-19 era in two developing countries, China and Nigeria. Semi-structured interviews were carried out with the management staff of construction companies in China and Nigeria, and data collected were subjected to content analysis. It was deduced that H&S measures employed on construction sites included checking body temperature, wearing face masks, disinfecting offices, and sensitising employees. When both countries are compared, unlike in Nigeria, construction firms in China engaged sophisticated technologies such as big data analysis, onsite tracer app, and health QR code to prevent the onset and spread of COVID-19 on their sites. The research findings amplify the importance of deploying H&S measures to facilitate pandemic planning and management on construction sites. This study recommends that further studies probe the impact of COVID-19 on the bidding process and health and safety plans for construction projects.

Keywords: COVID-19; Health and Safety; Semi-structured Interview; Construction Industry; QR code

Word Count: 5047

Number of Figures: 3

Introduction

The construction sector is a major part of an economy in terms of revenue provision, unemployment reduction, and poverty alleviation (Agyekum et al., 2022, Nwaogu and Chan, 2021, Omatule Onubi et al., 2021). However, construction employees, especially site workers, work in unhygienic conditions and are susceptible to the spread of infectious diseases on sites; they are exposed to harsh weather, which causes them to sweat profusely (Olanrewaju et al., 2021). Thus, COVID-19 presents a health and safety challenge to the construction sector. The COVID-19 pandemic led to the loss of lives, economic recession, struggling businesses, high unemployment rates, and way of gathering (Yang et al., 2021). To effectively continue construction projects during the COVID-19 period, some industry-friendly health and safety anti-epidemic measures must be sought (Ebekozi and Aigbavboa, 2021, Olanrewaju et al., 2021). Such measures include workforce education, hand washing, wearing face masks, regular temperature checks, staggered shifts, remote working, 6-foot physical distance between workers, and engaging Covid-19 supervisor to ensure compliance (Ebekozi and Aigbavboa, 2021, Agyekum et al., 2022).

Studies have been conducted with respect to COVID-19 and its impact on the construction industry (Sami Ur Rehman et al., 2022, Agyekum et al., 2022, Olanrewaju et al., 2021, Yang et al., 2021, Simpeh and Amoah, 2021, Ebekozi and Aigbavboa, 2021, Alsharef et al., 2021). The studies have been conducted in Nigeria (Ebekozi and Aigbavboa, 2021), China (Yang et al., 2021), the United Arab Emirates (Sami Ur Rehman et al., 2022), Ghana (Agyekum et al., 2022), South Africa (Simpeh and Amoah, 2021), United States of America (Alsharef et al., 2021) and the United Kingdom. (Jallow et al., 2021). The studies focused only on the impact of COVID-19 on the construction industry and/or general health and safety measures employed to manage the spread of COVID on construction sites. In contrast, Ebekozi and Aigbavboa (2021) examined the role of digital technologies such as cyber-physical systems, big data, blockchain, digital twin, augmented reality, robots, and 3D printing curtail the spread of the COVID-19 pandemic on construction sites in Nigeria. Yang et al. (2021) detailed the role of health and safety technologies in managing COVID-19 on construction sites and the issues associated with technology adoption in Chinese construction projects. However, comparative investigations into health and safety measures taken to curb the spread of the COVID-19 disease on construction projects while the industry is trying to deliver on its economic goals are lacking.

This study moves the conversation forward by evaluating the health and safety measures employed for managing construction projects in Nigeria and China under the COVID-19 pandemic. A comparative study between Nigeria (a Lower Middle-Income Country) and China (an Upper Middle Income Country) is deemed necessary because several Chinese companies are engaged in infrastructure projects in Nigeria. Confronted with significant infrastructure needs, Nigeria sought help from China so much that Chinese investments in Nigeria between 2009 and 2010 increased from US\$6 billion to US\$8 billion (Babatunde and Low, 2013). Information from this study can help investors learn what is expected of them and technologies to adopt to enhance the safety of their workers and continuity of their projects during the COVID-19 era.

This study aims to examine the health and safety measures deployed in the construction industry of China and Nigeria in the COVID-19 era to facilitate effective pandemic planning. The specific objectives were: (i) to determine the health and safety measures used to respond to the COVID-19 pandemic unique to each country; (ii) to determine strategies used to manage or engage the construction projects during the COVID-19 pandemic. This study will inform policies that can help the construction industry ensure good health among its employees in order to meet its development and economic goals. The findings of this study will be helpful to governments of

various economic statuses and their construction industry as they implement safety policies to prevent the spread of the COVID-19 disease and other epidemics to ensure the well-being of construction workers.

Measures Recommended for the Fight Against COVID-19

The construction site has been described as an epicentre for spreading infectious diseases (Olanrewaju et al., 2021). This implies that working on construction sites during a pandemic such as COVID-19 is risky for employees and challenging for employers. Therefore, actions that are vital to curbing the spread of the disease must be implemented. In 2020, during the wake of the pandemic, measures recommended by the World Health Organization (WHO) to control the pandemic on construction sites were classified into general guidelines, screening process before entering sites, preventive measures related to the use of transportation and procedure to follow in case of contagion (Agyekum et al., 2022). The general guidelines recommend that contractors restrict visitors' entry, assign a central point for implementing and monitoring COVID-19 prevention measures, ensure that employees who fall ill stay home, and hold health-related pep talks each day to discuss COVID-19. It also stipulates taking of body temperature, ensuring that employees practice hand washing before entering the site or project office, ensuring social distancing on construction sites, observing all safety protocols, and following further instructions given by their local authorities (Agyekum et al., 2022).

Yang et al. (2021) classified the anti-epidemic measures employed on Chinese construction projects into three categories, personal, managerial, and technological. Personal control measures included mask-wearing, daily disinfection of work sites and offices, vaccinations, quarantine, health screening for temperature checkups, setting up isolation rooms, and conducting regular nucleic acid tests (Yang et al., 2021). Managerial controls included developing an emergency plan, online meetings, rescheduling jobs, and purchasing hygiene items. Health and safety technologies measures include using an onsite tracer app, health QR code, and COVID-19 big data analysis. The COVID-19 big data analysis in China identifies high-risk and low-risk COVID-19 areas. Big data technology is deployed through a health code system to prevent and control COVID-19 in China (Wu et al., 2020). The big data health code system is divided into three colour levels: red, yellow, and green. People with red or yellow codes will be quarantined. At the same time, green indicates that the person did not go to a virus-infected area and can carry out regional activities and movement. If someone with green codes has been to high-risk areas or is in contact with high-risk people, their code will turn red and have to be quarantined (Wu et al., 2020). In essence, the colour-coded health QR codes are used as electronic certificates to differentiate the COVID-19 status of individuals, and the QR codes are presented when using public services or before being allowed into the workplace (Sharara and Radia, 2022).

Simpeh and Amoah (2021) noted that government measures recommended for health and safety with regards to COVID-19 in the workplace in South Africa comprise four key aspects: plan for reopening workplaces following the lockdown, administrative actions, social distancing measures, and health and safety measures (Simpeh and Amoah, 2021). Administrative measures are instituted to minimise the number of workers at the workplace to ensure social (physical) distancing and raise awareness about COVID-19 among their workers (Simpeh and Amoah, 2021). Simpeh and Amoah (2021) further pointed out that the recommended health and safety measures include symptom screening, sanitisation (hygiene), ventilation, and PPE (e.g., use of mask, face shield, sanitisers, disinfectants, and hand gloves).

Agyekum et al. (2022) mentioned that health and safety measures outlined by the Government of Ghana are those put in place by construction firms in Ghana to fight COVID-19. They include sensitisation of workers, use of PPEs, shift working times, regular COVID-19 testing and checks, use of screening questionnaires, and isolation of workers who show symptoms of sickness. In Nigeria, governmental recommendations for businesses changed rapidly. By August 2020, the recommendations for the manufacturing industry (which includes the construction sector) were four, namely: ensure the provision of sanitisers and appropriate PPEs to all workers, limit the number of workers to 75% to allow physical distancing, mandatory use of non-medical facemask and conducting of temperature checks (NCDC, 2020).

Methodology

This study adopted the qualitative methodology to probe in-depth the views and experiences of participants on the subject. With qualitative methodology, a particular phenomenon can be understood from the perspective of those experiencing it (Vaismoradi et al., 2013). A semi-structured interview, a qualitative data collection method, was used to collect data from 34 purposively selected respondents. This semi-structured interview approach was adopted because it could facilitate an interactive discussion. The interview was carried out using an interview guide adapted from Yang et al. (2021) via zoom for 30 minutes (see Appendix I).

The interviewees were selected by purposive sampling to ensure the reliability of the interview and data collected. The interviewees were from varying professional backgrounds, firm sizes and different positions. They included project managers, product managers, project general managers, directors, health and safety officers, and site supervisors. Following Yang et al. (2021), interviewees with work experience of at least three years were invited to the survey. Twenty-four interview invitations were emailed to potential respondents in China and Nigeria, of which 23 were received from China and 11 from Nigeria. Since similar qualitative studies (Agyekum et al., 2022, Ebekozien and Aigbavboa, 2021) interviewed nine to twelve professionals, the sample size of the interview survey is considered adequate.

Data Analysis

The audio recordings were transcribed and analysed in the MAXQDA Plus software version 2022. The interviews with the practitioners in Nigeria were conducted in English, while others conducted with practitioners in the People's Republic of China were conducted in Chinese. The researchers translated Chinese scripts into English (Yang et al., 2021). Content analysis through deductive and inductive reasoning was used to determine the themes, and it followed the procedure described in Yang et al. (2021). Themes and categories were first drawn from the context of the data and later refined using themes in existing literature (Nwaogu et al., 2021).

Results and Discussion

The interviewees provided relevant information on the response of their construction firms to COVID-19. When asked, "can you describe how you respond to the COVID-19 pandemic and how you manage or engage in construction projects under the Covid-19 era? The interviewees indicated that in the COVID-19 era, health and safety measures employed on the construction sites included checking body temperature before accessing the workplace, using PPEs (wearing face

masks), disinfection of the site and offices, and sensitisation of employees (see Figure 1). As shown in Figure 1, the interviewees further revealed that the projects were managed using various strategies (approaches), such as online meetings, rediscussing the project cost and time with clients, using mechanised equipment, and planning for anti-epidemic items at the tender stage.

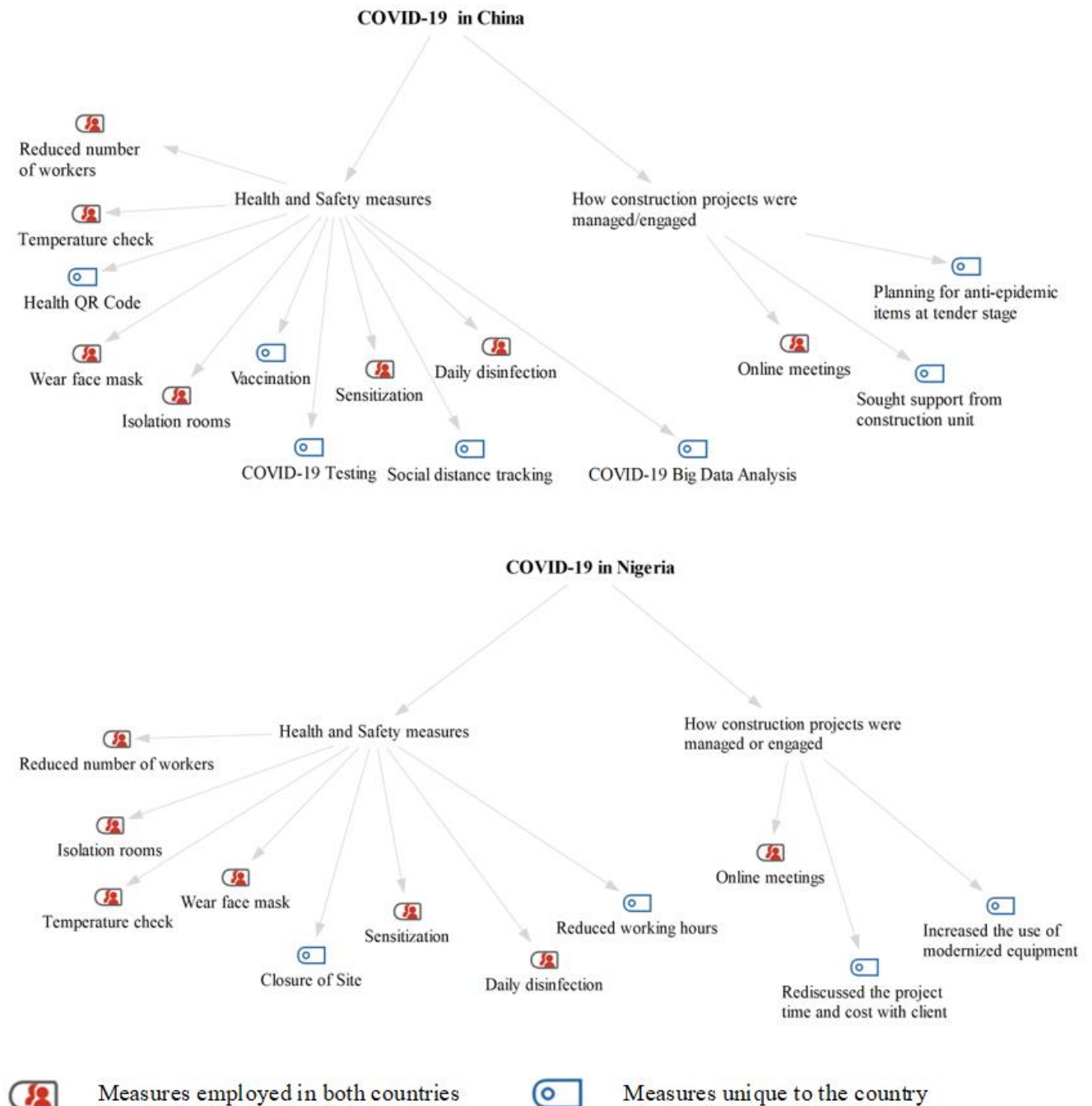


Figure 1: COVID-19 in the Construction Industry of Nigeria and China

Health and Safety Measures

Following the classification of health and safety measures detailed in Simpeh and Amoah (2021) and Yang et al. (2021), the measures can be further categorised into anti-epidemic public health measures, lockdown, administrative controls, and health and safety technology. Figure 2 and Figure 3 illustrate transcripts on health and safety measures employed by construction firms in Nigeria and China, respectively.

Administrative actions

The administrative actions taken included sensitising workers, reducing the work hours, and minimising the number of site workers at the workplace to allow for social distancing. These findings align with the recommended administrative actions mentioned in Simpeh and Amoah (2021). It was deduced that work hours were reduced on some sites in Nigeria, unlike in China. Like Nigeria/Interviewee 9 stated, *"since they said that COVID-19 can spread through sweat, in April 2020 during that lockdown, in my place of work, we reduced work hours to 4 hours to 6 hours to ensure they didn't have to sweat profusely"*.

Based on the interviews, it was deduced that in Nigeria, the number of craftsmen and administrative staff was reduced, while in China, the interviewees indicated that only the number of administrative staff was reduced. As detailed in Figure 2, the number of craftsmen on a particular site in Nigeria was reduced to 10 to allow social distancing (Nigeria/Interviewee 3). Also, Interviewee 1 mentioned that *".....to keep to the social distancing rules, if crafts didn't necessarily have to work at the same time, we ensured that one craft finished its aspect before having another craft in the same space"*.

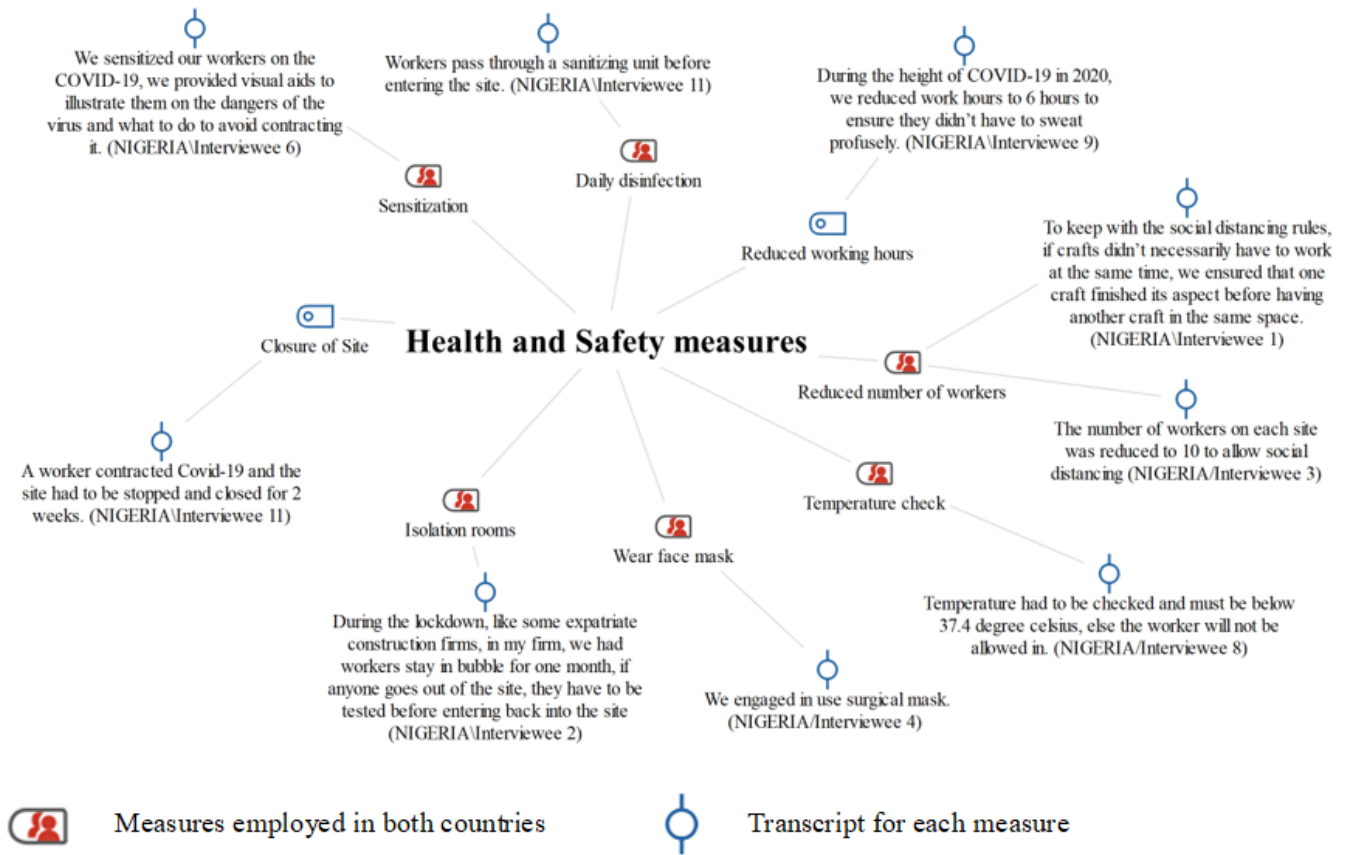


Figure 2: Some Health and Safety measures employed in the Nigerian Construction Industry

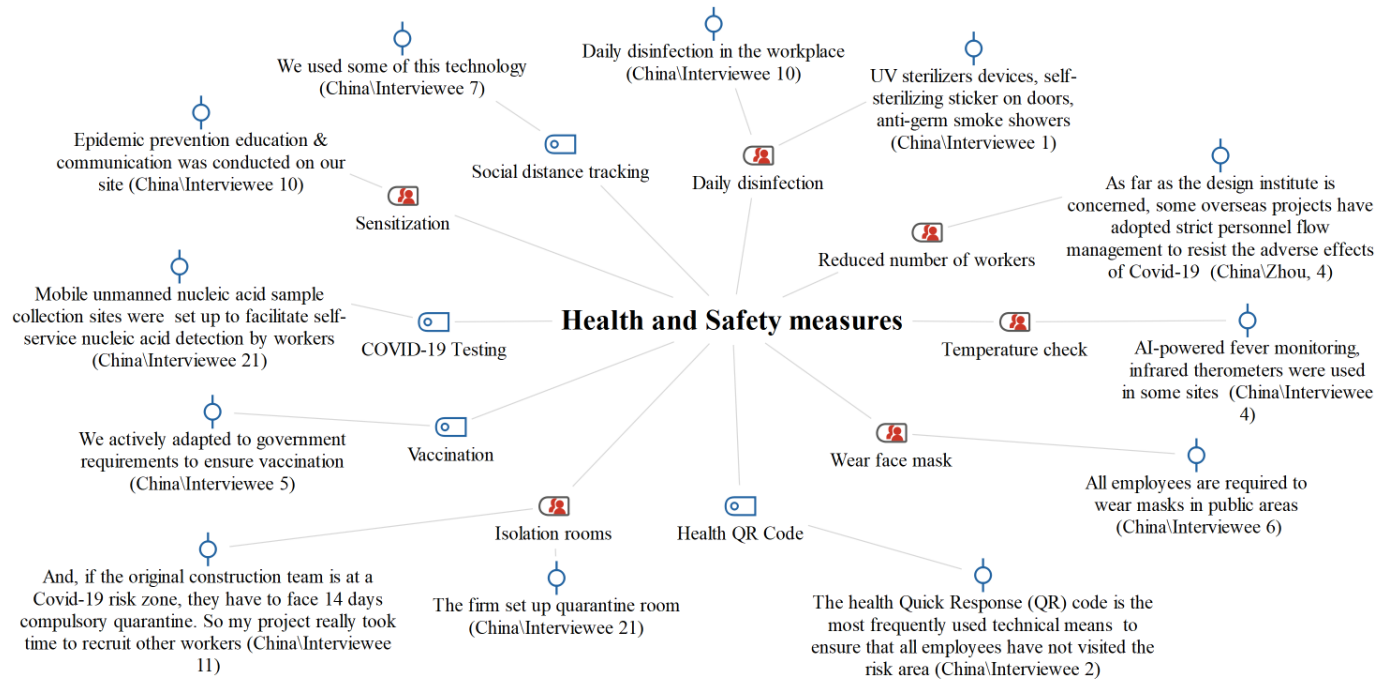


Figure 3: Some Health and Safety measures employed in the Chinese Construction Industry

Anti-epidemic Public Health Measures

The anti-epidemic public health measures taken by construction firms in both countries included checking body temperature (using infrared thermometers or AI power fever monitoring devices) before accessing the workplace, wearing face masks, and daily disinfection of the workplace. These measures are part of those recommended by WHO for contractors (Agyekum et al., 2022). While workers on construction sites in Nigeria mainly had to pass through a sanitising unit before entering the site" (see Figure 2), it was deduced that various kinds of sterilising units were adopted in China (see Figure 3).

".... ultraviolet (UV) sterilisers devices, self-sterilising sticker on doors, anti-germ smoke showers are used to disinfect the workplace" (China\Interviewee 1).

Although wearing face masks by employees was compulsory in both countries, construction firms in China made provisions for masks, as boxes of 50 pieces were periodically distributed to employees. *"We regularly distribute masks and disinfectants to frontline workers"* (China\Interviewee 20). This corroborates Simpeh and Amoah (2021), who reported that some construction companies in South Africa supplied PPEs to their workers.

On some sites in Nigeria and China, periodic safety meetings / daily toolbox meetings were also used to educate and reeducate the workers about the COVID-19 pandemic. This finding agrees with Simpeh and Amoah (2021), who suggested that most companies in South Africa revise their induction, toolbox talk, and training sessions to include COVID-19.

"Every Monday, we always had a safety meeting to remind the workers about the intensity of the COVID-19 virus. We reminded them not to throw handkerchiefs, tissues anywhere to ensure cleanliness and reduce the spread of diseases" (Nigeria\Interviewee 8).

Health and Safety Technologies

It was deduced that aside from public health measures, health and safety technologies such as health QR code systems, COVID-19 testing, social distance tracking, and COVID-19 big data analysis were employed in China but not in Nigeria (see Figure 2 and Figure 3). This finding is similar to Yang et al. (2021), where the health QR code system was reported in Mainland China but not in Hong Kong or Dubai. Nevertheless, the technologies appeared not to be used on all sites in China, as revealed by" China\Interviewee 4 and China\Interviewee 7.

"..... AI-powered fever monitoring, social distance tracking, health QR code, nucleic acid detection technologies. Some of the above techniques are used" (China\Interviewee 7).

"..... technologies such as online collaboration platforms, AI-powered fever monitoring, social distance tracking can be used. But they are not used" (China\Interviewee 4).

Some transcripts from the interviewees on the health and safety technologies not included in Figure 3 are detailed below:

"At present, we require all personnel entering the workplace to undergo temperature testing and keep records; show the Health QR Code, and wear masks. We regularly organise nucleic acid tests for all employees and encourage them to get vaccinated" (China\Interviewee 9).

"We adopted the "Covid-19 big data analysis map" to avoid entering medium & high-risk areas to reduce the probability of personnel being infected. Employees' health QR code has been maintained as normal. Using mobile signalling data to track the movement of internal personnel helps to track social distance" (China\Interviewee 3).

The use of the health and safety technologies such as health quick response (QR) code systems, COVID-19 testing, social distance tracking, and COVID-19 big data analysis in the Chinese construction industry may have been influenced by governmental requirements instituted for businesses. According to Yang et al. (2021), "the COVID-19 big data analysis enables the management to identify medium- and high-risk areas within China and formulate corresponding coping strategies for workers from those risk areas". While some of these measures are unique to China's construction industry, they can be implemented and tested in other countries. For instance, the digital approach of using QR codes with big data analytics has been reported successful in containing and tackling the COVID-19 pandemic in China (Sharara and Radia, 2022).

Lockdown

The measures in this theme category include the closure of site and creation of isolation rooms on site. For some construction companies in China and Nigeria, isolation rooms had to be set up. While in China, the isolation rooms appeared to be a place where workers would stay temporarily for some hours, as inferred from China/Interviewee 20, in Nigeria, the workers had to be isolated together on some construction sites for one month so that construction activities could continue (Nigeria/Interviewee 2).

"We set AI-powered fever monitoring devices at the construction site entrance. If we find employees with abnormal body temperature, we will immediately take them to the quarantine room for observation" (China/Interviewee 20).

"During the lockdown, like some expatriate construction firms, in my firm, we had workers stay in a bubble for one month, if anyone goes out of the site, they have to be tested before entering back into the site" (Nigeria/Interviewee 2).

Likewise, it was deduced that in 2020, some sites had to be closed for 14 days in Nigeria. "A worker contracted Covid-19, and the site had to be stopped and closed for two weeks" (Nigeria/Interviewee 11). This could affect such firms' ability to meet the contract conditions as the contract duration may have to be extended due to the closure, as pointed out in Agyekum et al. (2022).

Strategies used to Manage or Engage Construction Projects during the COVID-19 Pandemic

When asked how construction projects were managed or engaged during the COVID-19 pandemic, it was deduced that a variety of strategies (i.e., approaches) were taken to manage the project. The most recurring strategy among 80% of interviewees in China and all the interviewees in Nigeria was conducting administrative and site meetings online. However, the potential of online meetings could not be entirely tapped in some cases because of confidentiality concerns (China/Interviewee 3). The issue of confidentiality draws attention to some factors affecting effective information sharing and the adoption of digital assets in various supply chains. This is why information confidentiality preservation with regard to the use of information technology and digital assets is receiving increased attention (Ghondagsaz et al., 2022).

"Because our company has high-level confidentiality measures, raw data is not allowed to be uploaded to the Internet. Therefore, we cannot use remote collaboration to continue the project's development. We can only handle schedule adjustments and design changes through online meetings, but work involving big data governance and analysis cannot be performed. In the late

period of Covid-19, the government adjusted anti-epidemic policy, and we gradually resumed the operation of the project by health QR codes and nucleic acid testing" (China/Interviewee 3).

Among the 20% in China that indicated that online meetings were not conducted, it was due to the nature of their job (China/Interviewee 22). This further suggests that flexible work schedules (e.g., teleworking) would not fit all professions in the construction industry, as noted by Nwaogu and Chan (2021).

"For teams specialising in software, jobs can be easily converted to online mode, and remote meetings have become the norm. My team's biggest challenge is the inability to communicate face-to-face, which inevitably damages communication efficiency" (China/Interviewee 22).

Interviewees in Nigeria indicated that since the number of craftsmen had to be reduced, the firms resorted to using mechanised equipment to replace labour. According to an interviewee, *"we employed the concrete placement equipment to reduce the number of artisans needed for concrete placement. You know, for a medium-firm like ours, we do more manual placement, but now we have to engage the services of the concrete pump even for small jobs. The construction workers were reduced to meet social distancing rules"* (Nigeria/Interviewee 9).

Aside from the strategies discussed above, it was deduced that some companies in Nigeria addressed issues relating to the project cost and time with clients. For instance, Nigeria/Interviewee 3 stated, *"we had to meet with the client to rediscuss project time frame and cost. We also discussed cost because craftsmen were reduced to 10 people on a site to meet social distancing rules. So, we had to discuss the impact of the Covid-19 regulations on project delivery time and cost."*

Additionally, interviewees from China revealed that they managed their construction project by seeking financial support from the construction unit in their province. Some interviewees hinted that they have started including the cost of anti-epidemic items at the tender stage so they can include it in the bid (see China/Interviewee 6). This may be unique to China since the COVID-19 rules are still strictly enforced, unlike in Nigeria.

"At the contract level, the builder needs to increase the stock of anti-epidemic items and arrange anti-epidemic measures (such as infrared thermometers, masks, medicines, monitoring stations, personnel deployment). At the tender stage, anti-epidemic costs in the contract are regarded as measure cost (or start-up cost)" (China/Interviewee 6).

These findings support previous studies that have suggested that health and safety concerns should be costed for during the tendering process (Sumner and Farrell, 2003, Boadu et al., 2021). While globally, every construction project is deemed to have a health and safety manual and/or plan (Nwaogu and Chan, 2021), in developing countries, they are given low priority, and health and safety objectives are not clearly spelt out (Boadu et al., 2021). They mostly focus on accident prevention, while other health-related issues are not catered for or properly planned for (Nwaogu and Chan, 2021). With the COVID-19 experience, anti-epidemic measures should be catered for in such a document.

Implications for Practice

The construction industry in China and Nigeria followed laid-down government measures/protocols for curbing COVID-19 unique to each country. Some of the measures/protocols are part of those recommended by WHO. These form the shared similarities between the health and safety measures adopted in Chinese and Nigerian construction industries to curb the spread of COVID-19. The difference between the health and safety measures adopted in both industries emanates from:

- (i) The difference in government recommended measures and regulations for businesses and the country – the local authority regulations and recommendations in China appeared to be more rigorous than the protocols by WHO and those recommended by the Nigerian government.
- (ii) Infrastructural development- China is at the forefront of the fourth industrial revolution (Ito, 2019). Therefore, it is more convenient for the construction industry in China to adopt health and safety technologies leveraging information technology because of heightened infrastructural development in China.

The findings offer some implications for the diffusion of health and safety technologies in the construction industry. Regularly distributing masks to workers would help with compliance and ensure that they do not repeat used face masks the next day. Therefore, it is recommended that some epidemic or pandemic support be provided for businesses. Construction firms in China leveraged sophisticated technologies to curb the spread of COVID-19. Therefore, some of these measures can be implemented and tested in Nigeria and other countries. The government should provide financial support or subsidies to construction firms interested in technology transformation to relieve the financial burden on such firms. This would boost technological and infrastructural development in the country.

Conclusion

The COVID-19 pandemic has impacted businesses directly or indirectly and brought a new reality to how everyone carries out their daily jobs. This study determined health and safety measures that Chinese and Nigerian construction firms instituted to curb their employees' exposure to the COVID-19 disease. Semi-structured interview was conducted among 34 purposively selected construction practitioners. The data collected were content analysed. The respondents' views were sought around two specific areas, how they responded to the COVID-19 pandemic with reference to health and safety measures and strategies used to manage or engage the construction project.

The responses indicate that most of WHO's health and safety measures and local authority measures for each country were implemented on construction sites. Health and Safety measures employed on construction sites in China and Nigeria are checking body temperature before accessing the workplace, wearing face masks, disinfection of the site and offices, sensitisation of employees, minimising the number of workers and setting up isolation rooms. It was gathered that construction firms managed their projects and the impact of the pandemic using various approaches, such as conducting online meetings, rediscussing the project cost and time with clients, use of mechanised equipment, and planning for anti-epidemic items at the tender stage.

It was deduced that the potential of online meetings could not be entirely tapped because of confidentiality concerns. Hence, this study recommends that further study should probe trust and confidentiality concerns with respect to the use of health and safety technology and remote working engaged in curbing COVID-19. Additionally, it is recommended that further research should be conducted to determine the impact of COVID-19 on the construction bidding process and health and safety plans for construction projects.

Acknowledgement

The study forms part of the research project funded by the National Natural Science Foundation of China (No. 71971186). The authors are grateful to the funding body and all the interviewees for their contribution.

References

- Agyekum, K., Kukah, A. S. & Amudjie, J. 2022. The impact of COVID-19 on the construction industry in Ghana: the case of some selected firms. *Journal of Engineering, Design and Technology*, 20, 222-244. 10.1108/JEDT-11-2020-0476
- Alsharef, A., Banerjee, S., Uddin, S. M., 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. 10.3390/ijerph18041559
- Babatunde, O. K. & Low, S. P. 2013. Chinese construction firms in the Nigerian construction industry. *Habitat International*, 40, 18-24. <https://doi.org/10.1016/j.habitatint.2013.01.002>
- Boadu, E. F., Sunindijo, R. Y. & Wang, C. C. 2021. Health and Safety Consideration in the Procurement of Public Construction Projects in Ghana. *Buildings*, 11, 128
- Ebekozien, A. & Aigbavboa, C. 2021. COVID-19 recovery for the Nigerian construction sites: The role of the fourth industrial revolution technologies. *Sustainable Cities and Society*, 69, 102803. <https://doi.org/10.1016/j.scs.2021.102803>
- Ghondagsaz, N., Chokparova, Z., Engesser, S. & Urbas, L. 2022. Managing the Tension between Trust and Confidentiality in Mobile Supply Chains. *Sustainability*, 14, 2347
- Ito, A. 2019. Digital China: A Fourth Industrial Revolution with Chinese Characteristics? *Asia-Pacific Review*, 26, 50-75. 10.1080/13439006.2019.1691836
- Jallow, H., Renukappa, S. & Suresh, S. 2021. The impact of COVID-19 outbreak on United Kingdom infrastructure sector. *Smart and Sustainable Built Environment*, 10, 581-593. 10.1108/SASBE-05-2020-0068
- NCDC 2020. Guidelines for Employers and Businesses in Nigeria Nigeria.
- Nwaogu, J. M., Chan, A. P., Naslund, J. A., Hon, C. K., Belonwu, C. & Yang, J. 2021. Exploring the Barriers to and Motivators for Using Digital Mental Health Interventions Among Construction Personnel in Nigeria: Qualitative Study. *JMIR formative research*, 5, e18969
- Nwaogu, J. M. & Chan, A. P. C. 2021. Evaluation of multi-level intervention strategies for a psychologically healthy construction workplace in Nigeria. *Journal of Engineering, Design and Technology*, 19, 509-536. 10.1108/JEDT-05-2020-0159
- Olanrewaju, A., Abdulaziz, A., Preece, C. N. & Shobowale, K. 2021. Evaluation of measures to prevent the spread of COVID-19 on the construction sites. *Clean Eng Technol*, 5, 100277. 10.1016/j.clet.2021.100277
- Omatule Onubi, H., Yusof, N. A. & Sanusi Hassan, A. 2021. Perceived COVID-19 Safety Risk and Safety Behavior on Construction Sites: Role of Safety Climate and Firm Size. *Journal of Construction Engineering and Management*, 147, 04021153. 10.1061/(ASCE)CO.1943-7862.0002201
- Sami Ur Rehman, M., Shafiq, M. T. & Afzal, M. 2022. Impact of COVID-19 on project performance in the UAE construction industry. *Journal of Engineering, Design and Technology*, 20, 245-266. 10.1108/JEDT-12-2020-0481
- Sharara, S. & Radia, S. 2022. Quick Response (QR) codes for patient information delivery: A digital innovation during the coronavirus pandemic. *Journal of Orthodontics*, 49, 89-97

- Simpeh, F. & Amoah, C. 2021. Assessment of measures instituted to curb the spread of COVID-19 on construction site. *International Journal of Construction Management*, 1-19. 10.1080/15623599.2021.1874678
- Sumner, S. & Farrell, P. The influence of clients on health and safety standards in construction. Proceedings of the 19th Annual Association of Researchers in Construction Management (ARCOM) Conference, University of Brighton, 2003. 193-202.
- Vaismoradi, M., Turunen, H. & Bondas, T. 2013. Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. *Nursing & health sciences*, 15, 398-405
- Wu, J., Wang, J., Nicholas, S., Maitland, E. & Fan, Q. 2020. Application of Big Data Technology for COVID-19 Prevention and Control in China: Lessons and Recommendations. *Journal of medical Internet research*, 22, e21980-e21980. 10.2196/21980
- Yang, Y., Chan, A. P., Shan, M., Gao, R., Bao, F., Lyu, S., Zhang, Q. & Guan, J. 2021. Opportunities and Challenges for Construction Health and Safety Technologies under the COVID-19 Pandemic in Chinese Construction Projects. *International Journal of Environmental Research and Public Health*, 18, 13038

APPENDIX I

Title of project: Health and safety measures for managing the COVID-19 pandemic in the construction industry: a comparison study

You are invited to participate in a study led by Professor Albert P.C. Chan and Dr. Jackie Yang, staff members of the Department of Building and Real Estate in The Hong Kong Polytechnic University (PolyU). The study forms part of the research project funded by the National Natural Science Foundation of China (No. 71971186).

This study aims to examine the implementation of construction Health and Safety (H&S) measures in China and Nigeria in the COVID-19 era to facilitate effective pandemic planning for the effective deployment of H&S measures. Your response is valuable to us because we can help the construction industry meet its development and poverty alleviation goals with it.

If you choose to participate in the study, we would like to meet and talk with you over zoom. This will take about 25-30 minutes. We would ask you a short series of questions about the impact of COVID-19 on construction activities and steps taken by your organisation to ensure that projects are delivered within time without jeopardising the health of workers. We will make the questions available to you before the interview. You can also see the questions overleaf.

The talk is a structured interview that will take 25 to 30 minutes, and the audio will be recorded so that it can be transcribed and analysed later. Audio recordings and transcriptions will be stored in password-protected cloud servers. All information related to you will remain confidential and identifiable by codes only known to the researchers, and your details will not be stored or reported in any research outputs. Also, none of the activities will cause any physical discomfort.

You have the right to withdraw from the study at any phase without penalty of any kind. If you want to obtain more information about this study, don't hesitate to contact Dr. Janet Mayowa Nwaogu (email: janet.nwaogu@connect.polyu.hk).

Thank you for being so interested in participating in this study.

Yours faithfully,

Dr. Jackie Yang, Principal Investigator.

The Interview questions

1. Please, for record purposes, what service does your company render, what is your position, how many years of work experience in the industry?
2. Can you describe how you respond to Covid-19 pandemic and how you manage/engage in construction projects under Covid-19 pandemic?