

Research article



Opportunities and Challenges for Construction Health and Safety Technologies Under COVID-19 Pandemic in Northern Province - A Case Study of the Construction Projects Under Lake Tanganyika Projects.



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ABSTRACT

The paper aims at evaluating the adoption of Health and Safety technologies for construction during the COVID-19 pandemic. The paper identifies and explores three theories in the literature surrounding the topic of evaluation and adoption of construction health and safety for construction during the COVID-19 pandemic which includes; the Diffusion of Innovation (DOI) theory, the Agency Theory, and the Stakeholder theory. It also outlines and identifies three conceptual frameworks from previous studies that relate to the subject under study. The paper further proposes a conceptual framework aimed at addressing the research problem by depicting and operationalizing the independent, moderating, and dependent variables.

Keywords: Theory, Construction, Health, Safety, Independent, Dependent, Moderating, variables

Introduction

After the corona virus pandemic hit, the Government of the People's Republic of China shut down businesses immediately, and people had to work from their homes to curb the spread of the pandemic. However, some construction sites such as the ones dealing with healthcare could not be fully closed because they had to continue and be completed on time to help mitigate the new risk (Yang et al., 2021). Following the onset of the pandemic, the construction sector has faced unpredicted safety and health challenges (Covid- et al., 2020). The pandemic has brought in unpredicted time and cost overrun to the construction sector, the pandemic has disturbed the sector in such a way that workers whose professions are required on-site are at high risk of being exposed and getting infected with the corona virus disease from aerosol and droplet contamination (Iqbal et al., 2021). The construction sector has been among the hardest hit by the COVID-19 pandemic, with all the labor-intensive nature of a construction project on-site, construction projects have become the most hazardous industry in the world (Stiles, Golightly and Ryan, 2021). The lack of awareness, unsafe work practices, risky working conditions, insufficient technical and material support, negligence of the safety rules and law, and lack of communication have worsened construction site safety and health status. (Iqbal et al., 2021; Nsefu, Mutale and Mwanaumo, 2021).

Various innovative technologies have been developed to improve the performance of construction safety and promote the health and wellness of construction personnel (Mambwe, Mwanaumo, Nsefu and Sakala, 2020). Contract implementation is one of the most fundamental but challenging part of procurement contract management (Nsefu et al., 2020). Despite this rapid development, the construction sector has been criticized because it is slow to adopt innovation and does not take full advantage of health and safety (H&S) technologies (Akinlolu, M; 2020). The implementation of H&S precautionary measures is one of the most paramount strategies to curb the spread of COVID-19 in workplaces and protect the workforce (Amoah, C.; Simpeh, F; 2021). H&S technologies, such as artificial intelligence (AI)-powered fever monitoring and social distance tracking, have been implemented to monitor the H&S status of construction workers at their workplaces. However, the use of technologies to combat the pandemic may induce new challenges such as privacy, ethics, and the digital divide (He, W. Zhang, Z.J 2021). This concern motivated this research to explore the opportunities and issues associated with the implementation of H&S technologies in construction projects work being done in the Lake Tanganyika Development Projects (LTDP).

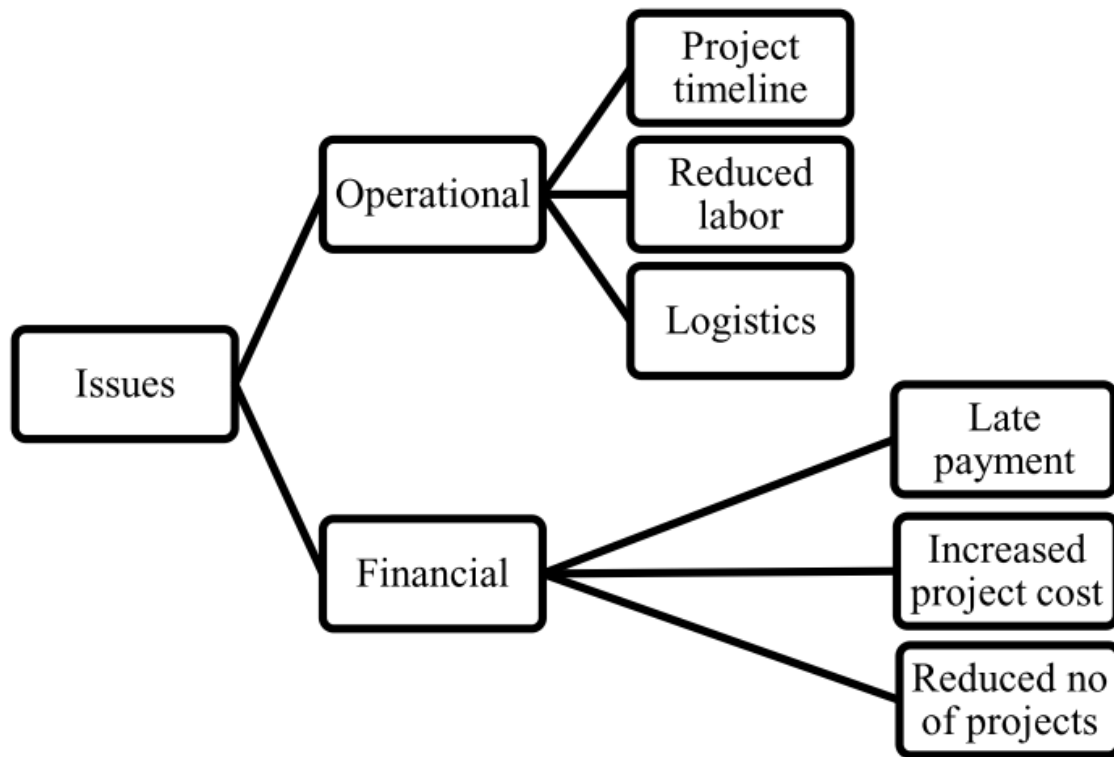


Figure 1: Summary of the effects of COVID-19 on construction projects
 Source: (Zamani et al., 2021)

Theoretical and Conceptual Framework

To ensure that significant success factors are attained a Theoretical Framework is utilized; the following theories were identified and used to help in the investigation of the findings.

Diffusion of innovation (DOI) theory

The social process involved around to learn about an innovation based on a new evident approach to improve safety and health. This involves innovative classical formulation that is communicated through channels among the members (**James W. Jeffrey G. 2018**). The innovation of the firm is mainly driven by either an external influence or an internal factor (**Kale, S; Ardit, D 2010**). Outside existence factors are considered external factors such as policy regulation and market demand (**Mitropoulos; 2000**). Authorities may enforce certain rules that may force firms to adopt certain innovations through grants (**Tatum, CB 2000**). Firms fail to get involved when they are not internally and externally strong; hence some quit (**Walker, D.H 2006**). The DOI theory shall be used to explain the challenges and factors causing the adoption of the H&S technologies for construction under the pandemic being done in this study, with external influence in the use of new technologies being the regulatory agency such as the National Council for construction (NCC) that can force firms to use the innovations through creating certain specifications and details that will encourage innovation through offering classes on new H&S technologies for infrastructure development under the pandemic.

The Agency Theory

The theory rotates around its problems and solutions (**Meckling, 1976**). This is an old-age problem that evolved through the joint-stock companies, the relationship between agent and principle is the agent theory. (**Sappington 1991**) With the change of time and the coming of the COVID-19 pandemic, various forms and costs have been put in place to try and minimize the problem, especially in the construction industry.

Agency Theory in H&S technologies for projects under the pandemic has an impact on how successful a project become. Infrastructure projects being long-term, are subjected to a lot of constraints that end up as a reason for poor delivery if this principal-agent relationship is not well nurtured. The theory will ensure that there are checks and balances at any given time in ensuring that the adopted H&S technologies are workable.

The Stakeholder Theory

An emphasis on the intersected among suppliers and clients involved in the construction sector. A stakeholder is any individual or group who is affected by or can affect the achievement of an organization's objectives After the COVID-19 hit, a lot of restrictions such as the closing of the borders, social distancing, and working from home have cost the stakeholder engagement in the construction sector. Stakeholder Theory within H&S technologies for construction under the COVID-19 pandemic shall involve the employers (management) engaging the workers in the construction sector to be acquainted with the new adopted H&S technologies that will help the firm to meet the contractual obligations and keep the workers safe. The Construction sector has a vast number of casual workers who may tend to fail to understand the new H&S technologies being introduced to the system to help prevent the corona virus on-site stakeholder theory may help make all stakeholders acquainted with the new adopted H&S technologies. as alluded from the DOI Theory the regulatory policy and other NCC is a stakeholder in all the construction being undertaken, the regulatory agency makes sure that the contractors are complying with the policies and regulations put in place to help adoption of the H&S technologies.

Conceptual Framework

The conceptual framework gives the methodology conducted by analyzing the literature review on the given topic. According to Gilbert (2002) "theories comprise concepts linked by relationships." An understanding of the independent and dependent variables is illustrated in the conceptual framework. The conceptual framework outlines variables the researcher utilizes to respond to the set research objectives.

Figure 1 explains the conceptual framework of the anti-epidemic mitigations done on infrastructure development in China. Personal control, technological control, and managerial control were the three categories looked at in the ant-epidemic response.

Self-check and care, vaccination against the virus, and observing the five golden rules were measures taken under personal control. The managerial team formulated certain work culture to help the team cope with the challenges being faced at work, for non-essential workers working at home was recommended to reduce the number of people at the station, for essential workers stays in was formulated where workers had to start staying on-site, eliminated work trips, and zoom or Google meetings, first aid management system was implemented. Job rotation to comply with social distancing. Workforce education programs were offered to improve the project performance by capacity building in workers.

Technological management, China used health quick response, information recorded about the corona virus related health condition, history of the person’s travel, and if vaccinated. This helped monitor and track contact cases which were immediately attended to and helped mitigate the escalation of the virus. However, the QR code has received grave concern regarding data and privacy policies (Lui, J: 2020). Tracking technologies have greatly helped mitigate the spread of the virus (Urbaczewsk, 2020).

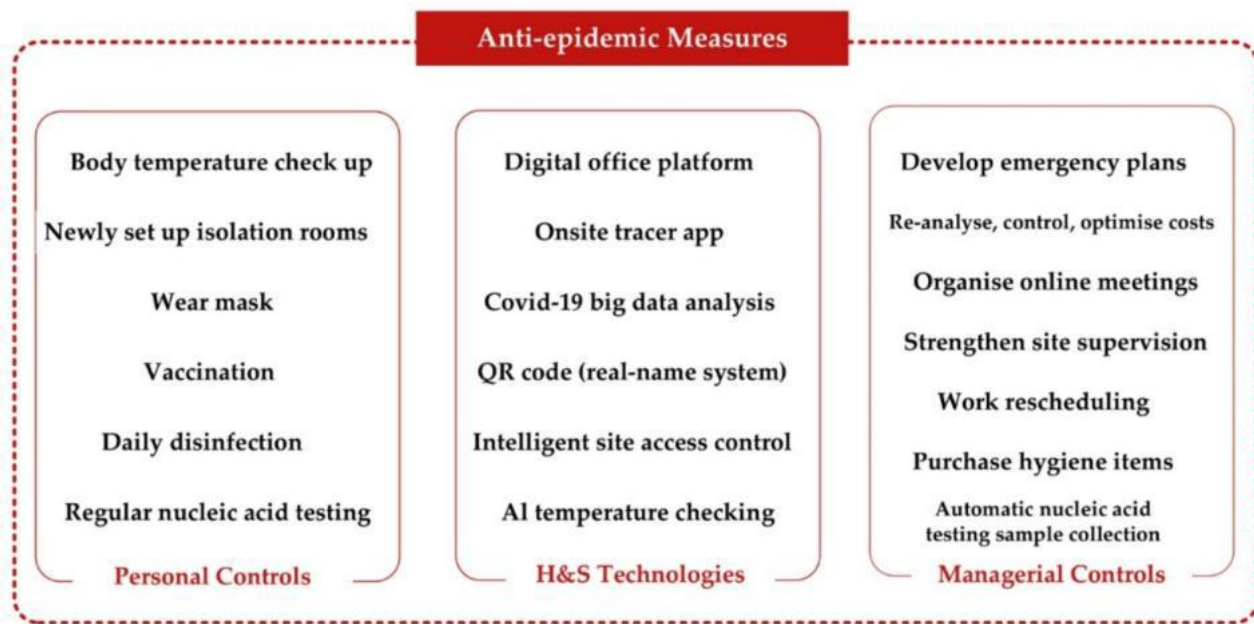


Figure 2: Theoretical Framework for COVID-19 Preventive Measures
Source: ((Yang, 2021).

Figure 2 explains how the pandemic has affected Nepal’s infrastructure development industry through financial, operational, and institutional support. Financial operation one of the critical issues in the sector. The government budget has been reduced for the construction sector focusing on mitigating the spread of the virus, causing late payment to contractors, hence resulting in the time overrun and cost overrun in infrastructure industry.

Financial constraints are one of the major challenges being faced in adopting the new H&S technologies for construction under the pandemic. Institutional support constitutes of the professional agencies and the Government, making regulations policies for the construction industry, however, the agencies lack adequate support such as financial and professional capacity (Ojha, 2021).

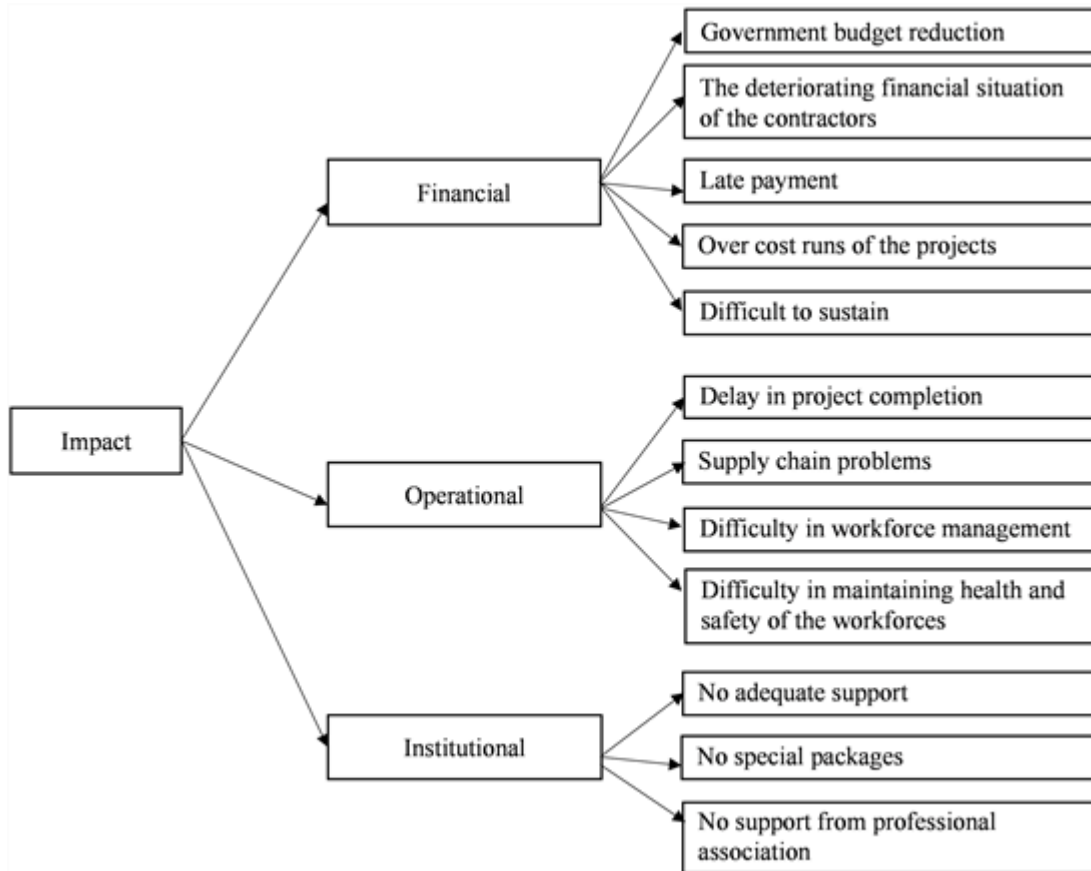


Figure 3: Framework for the Impact of COVID-19 on infrastructure development-Nepal
 Source: (Timilsina, 2021)

Conceptual Framework for Enhancing Construction Health and Safety technologies during the Pandemic

Exploring and identifying opportunities and challenges for H&S technologies for construction during the pandemic requires going through the entire construction management process both from Contractors on-site and from the legal regulatory bodies in charge of the construction development. This will give insight into the literacy level of technology or lack of technologies from the stakeholders involved in the construction sector, the institutional capacity to be able to explore and give an understanding on how many companies can plan, formulate, adopt and manage the new H&S technologies, and also to check if there is financial capacity to adopt or formulate the new H&S technologies for infrastructure development under the pandemic (Mambwe, Mwanaumo, Nsefu and Chiyombwe, 2020). The various frameworks have been reviewed to help public authority and private entity with equitable risk allocation. Thereafter a drafted concession is drafted. This will ensure a successful H&S technology framework for construction during the pandemic. The relation among all these

variables is to reduce the time overrun and cost overrun on the construction projects during the pandemic and make sure that the projects are done to the given specifications.

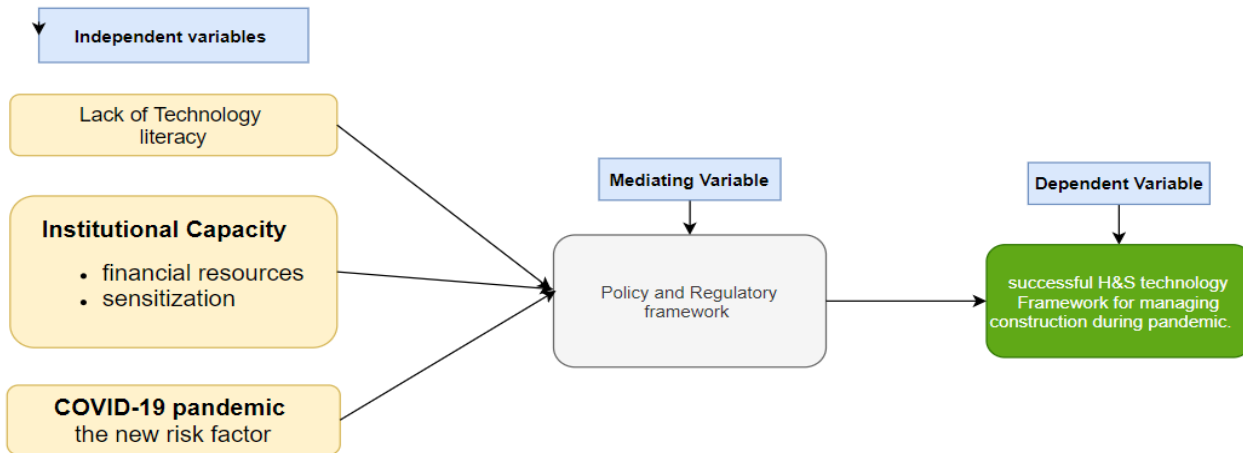


Figure 4: Conceptual Framework for Enhancing Construction Health and Safety technologies during the Pandemic

Operationalization of the Variables

The conceptual framework illustrated the independent, mediating, and dependent variables and their relationship connecting them. It has depicted an outline of the concept to be used to respond to the objectives of the study. The conceptual Framework has illustrated the key variables of the research and their relationship with each other (Shipuku, 2017).

Currently, the H&S technologies are being affected by digital divide, and ethics (**literacy levels**) on new technologies being adopted in the construction sector, the implementing stakeholders lack the **financial capacity** to develop and implement new H&S technologies for construction that will help curb the pandemic and improve the project performance parameters. **COVI-19** the new risk factor has been identified as an independent variable as they affect the project performance parameters in that the stakeholders have to take certain preventions on site to have a successful project performance.

The **regulatory and policy-making agencies** are being classified in the mediating section that will help work on the independent variables and come up with suitable solutions that will ensure the construction sector has successful H&S technologies for construction during the pandemic.

Conclusion and Recommendations

The study focused on evaluating the opportunities and challenges for Construction Health and Safety technologies during the COVID-19 pandemic in Mpulungu and Nsama District of Northern province with the view to understand the correlation existing between the impact of COVID-19 pandemic on H&S technologies for construction and project performance parameters in-terms of project cost, schedule, and specification and then give appropriate recommendations. The study conducted that the impact of COVID-19 on Health and Safety technologies for construction was strong and had a positive linear relationship to project performance parameters in the project construction under Lake Tanganyika Development projects in Mpulungu and Nsama District. The positive correlation signifies the existence of a direct relationship between the impact of COVID-19 on H&S technologies for construction and the project performance parameters whereas if one variable

increases the other one increases as well, implying that if the impact of COVID-19 on H&S technologies increases, the project cost, and time scheduling increase hence affecting the project specification and conformance. The study concluded also that stakeholder engagement to manage the COVID-19 pandemic (through the adoption and formulation of new health and safety technologies) on construction sites must be effectively engaged.

The study indicated that several H&S technologies were adopted to help mitigate the spread of the virus such as:

Regular **temperature screening**, it was indicated that workers were screened every time to check their temperature, and if the temperature was found to be high the worker was isolated and quarantined for observation.

The stakeholders engaged in the construction sector were asked to **mask up** at all times to prevent the spread of the virus, and manual foot press hand wash basins were used on the construction site to allow workers to wash their hands regularly however, several challenges also emerged. The study further established that to observe **social distancing**, online meetings were conducted on theoretical staff meetings and less practical site inspection meetings allowing only a few members to inspect and give findings and instructions to all the stakeholders involved. Later the study established that manual foot press hand wash basins were used on the construction site to allow workers to **wash their hands** regularly and **sanitize**. The study indicated that there were some **challenges** in the adoption of the H&S technologies for the construction site. **Digital divide**, because of the gulf between those who have ready access to computers and the internet and those who do not affect several stakeholders to participate in an online meeting to give the required information required for the project performance parameters. It was also discovered it was difficult to adopt the H&S technologies because of **illiteracy due to cultural beliefs** which made some local construction workers refuse to get vaccinated for COVID-19, because of their norms and beliefs. However, the study also established some of the opportunities attained during the pandemic, **Intense Sensitization** was done among the stakeholders to educate and give them the required knowledge on how to mitigate the spread of the COVID-19 pandemic. This gave leverage to several stakeholders to get vaccinated and avoid the spread of the pandemic. The study also established that stakeholders are becoming **innovative** in making a business out of the impact of the pandemic; some participants indicated that they are making and selling hand wash basins to maintain or rather cushion their company cash inflow. The study further discovered that due to the restriction closure of borders, **several companies have opened locally** (in Zambia) to produce goods and services which were being imported before the pandemic hit.

Recommendations

Based on the research results attained, below are some of the recommendations that would help concerned stakeholders and policymakers to put in place in the construction industry.

Contractual Obligations: First and foremost, the construction contracts must be understood by the all-important stakeholders to get acquainted with the contractual obligations, each part must know their right and responsibility on the project being executed to avoid breaching the contract, by paying attention to every clause in the contract especially the ones that refer to force majeure, government interference and legal changes. Frequent engagement with the client is also a key that will help, manage the expectations and effects faced on the projects.

Labour resource management: social distancing is one of the mitigative measures put in place to minimize the spread of the pandemic. Labour resource management is critical for the implementing stakeholders to manage, firms are set to reduce

the number of several people on-site to help curb the pandemic, firms are doing so by evaluating the critical staff required, returning the key skilled staff to the project, and laying off the non-essential workers to minimize the number of people on site. Site security or health and safety are now very critical on construction sites. The site must have the appropriate security measures in place and procedures implemented for maintaining critical site-holding infrastructure.

Adoption of the access control system is an essential method of managing workers on site. Management analysis technology can help the firm to know the number of workers accessing the construction site which later can help the firm now manage who should access and who should not. The construction sector can use this also to deter the public from the site.

Innovation decisions: Greater use of pre-fabrications in construction design and implementation is recommended. Prefabrication has several benefits, however, for this study, it has to be produced, transported, and installed on-site in a safe condition. This is the safest and most convenient way to have a project within time and cost. And fewer workers are involved hence complying with the social distancing rule.

To develop a system for ordering materials, the system must be developed to help facilitate the procurement of the materials to the site, including pre-fabrication according to the design of the client, this will help improve the quality of projects being implemented and prevent workers from the risk of meeting different people for the goods and services, a fumigation center must be installed on-site to disinfect all the delivered materials before use on site. **Financial capacity:** The Government and other capable stakeholders must come on board and help with small innovative ideas that are being proposed to help find a faster, reliable, and cheaper solution to mitigating the pandemic on the construction projects.

Policies must be formulated to help curb the spread of the pandemic on the project site. Sensitization and e-learning must be enforced among the stakeholders and the community at large to prepare them for another future pandemic. **Care for workers:** Stakeholders must be cared for at all costs by providing them with personal protective equipment (PPE) hampers to adequately safeguard them.

Management Framework for construction health and safety on site

Figure 5 shows an ideal Health and Safety technologies framework for managing the COVID-19 pandemic on-site. The framework for managing the COVID-19 pandemic was presented in a form of a process flow chart using 16 steps. The COVID-19 management model was also operationalized with application to some construction projects in Mpulungu and Nsama District.

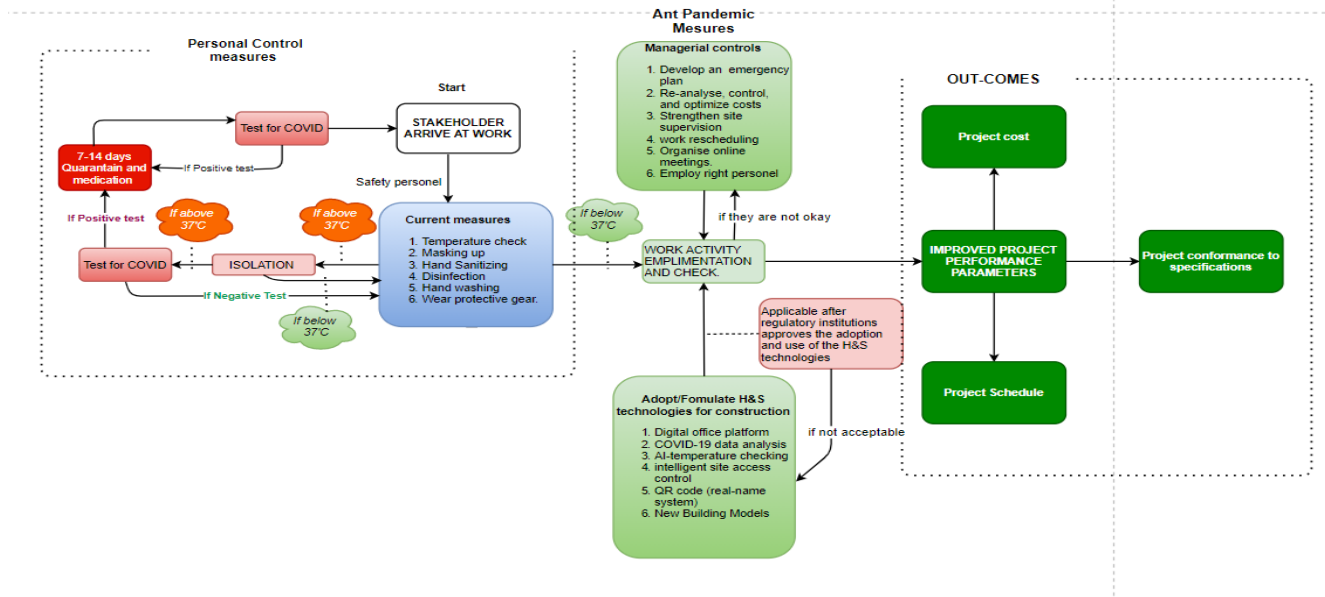


Figure 5: Shows an ideal Health and Safety technology framework for managing the COVID-19 pandemic on site.

Step 01: Stakeholders arrive at work

The first step in the model is to set up a security office at the entrance of the construction site which will regulate access to the site. There should be a barrier gate at the entrance to help observe social distancing between the staff at work and the incoming stakeholders, the security may ensure that all incoming stakeholders are masked up.

Step 02: Personal control measures

After the stakeholders have been cleared at the gate, they are directed to the safety office, here stakeholders are required to either sanitize or wash their hands with soap, Vehicles and other equipment/materials are disinfected at the disinfecting area, then a temperature check is done to all stakeholders, if found **normal** the stakeholders are given Personal Protective Equipment (PPE) either at the change room for the **site workers**, or within the safety office for **other stakeholders**, then are allowed to proceed for work , however, if the temperature is found to be **very high**, the person is **isolated** and observed for some time, then temperature is checked **again**, and if it is still high again the person referred to the site nurse who then does a **COVID-19 test** and if the test comes out **positive** the person is either **quarantined** at home or at the hospital for 7-14 days while getting the required treatment, after that the person is teste again, if found **negative** and has recovered he is allowed to report back for work following the same process again from **start**.

Step 03: Managerial Controls

Management must develop a certain work culture to be used on-site by the workers, managers should formulate the **work schedule** for the site to help them plan and allocate work to identify essential works at a particular time, this will help the manager **rotate the workers** according to the work being done at a certain particular time.

Management should **employ key personnel** that will help improve the performance of the project, starting from the cleaner to the engineers and managers. Management must ensure that the **supply chain** of materials to be used on site is well

arranged and organized to help the project be on track. Management should organize **online meetings** with other stakeholders that take part in decision-making on the projects, however essential project managers must strengthen the site supervision to make sure that the **contractual obligations** are being met. All the management control should be checked and applied on the site work, if there are still some challenges, management should go back on the table and replan until they get it right.

Step 04: H&S technologies

Also, the application of relevant technologies could reduce the spread of the virus on site and improve the efficiency of the implementation of relevant COVID-19 preventive measures. The health quick response QR code system should be used to record personal information about COVID-19-related conditions, vaccination conditions, and travel history. The QR code could easily monitor and track the potential contact case.

Step 5: Improved project performance

To reach this stage implies that the execution of the project was according to the given specifications and implementation of the ant-epidemic measures was successful.

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