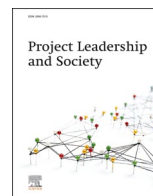




Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Review

Impact of Covid-19 on field and office workforce in construction industry



Apurva Pamidimukkala, Sharareh Kermanshachi*

Department of Civil Engineering, University of Texas at Arlington, 425 Nedderman Hall, 416 Yates Street, Arlington, TX, 76019, USA

ARTICLE INFO

Keywords:

COVID-19
Health and safety
Construction workforce
Workplace
Pandemic

ABSTRACT

The COVID-19 outbreak is the greatest global health crisis in many years. It has had a dramatic effect on workforces and workplaces all around the world, as it has spawned a massive change in the working atmosphere and raised the level of employees' concerns about their mental health and physical wellbeing. The construction industry has been significantly affected by the COVID-19 pandemic and has been challenged to improve the safety and wellbeing of its workforce. The objectives of this study are to identify the health and safety issues that construction workers have encountered during the pandemic and to recommend management strategies to combat them. A thorough literature search on recently published literature, industry experiences, reports, and other related documents was performed to collect and categorize the required data. Seventeen COVID-19 challenges were identified and classified into five categories, and the results revealed that the lack of a safe environment in the workplace, heavy workloads, home situations, and concerns about job stability often contribute to anxiety, depression, and even suicide. Eleven strategies were identified to overcome these challenges, and the results demonstrated that redefining worksite safety by placing signs, ensuring a safe distance between workers, providing sanitizers and washing stations in the fields, and utilizing effective technologies would enhance project productivity while keeping workers safe. The findings of this study will help the project managers and authorities in the construction industry understand the challenges of the pandemic and adopt effective strategies that will improve the health and safety of their workforce.

1. Introduction

The coronavirus, commonly known as COVID-19, is caused by the coronavirus 2 (i.e., SARS-COV-2), a serious acute respiratory disorder (O. (O) and Coronavirus, 2020). It has been reported that the virus can be transmitted from person-to-person and causes symptoms that include fever, dry cough, fatigue, and shortness of breath. As of January 2021, the virus had spread to more than 200 countries, affected 91.5 million people, and caused 1.96 million deaths. The most critical part of the outbreak has been its rapid spread and long incubation period (Henrickson and Rilett, 2020).

In addition to the serious health emergency, the outbreak has resulted in a global economic decline. The National Bureau of Economic Research (NBER) declared that the United States entered a period of recession in February; they called it the "Recession of COVID-19" (Chodorow-Reich and Coglianesse, 2020). The U.S. had record-high unemployment rates of 14.7 percent in April 2020 due to the economic downturn, which is appalling when compared with the unemployment rate of about 3.8 percent in February 2020.

The construction sector, like many other sectors, has been affected in a number of ways. Since the pandemic began, there have been fewer employment opportunities, partially due to the work disruptions that were caused by following constraints that were put in place to stop the progression of the virus, and a shortage of personal protective equipment (PPE) that was caused by the more pressing need for it by healthcare employees. Due to an interrupted supply chain and employee shortages due to quarantines, many projects have been halted or postponed (urvey: 28% of Member, 2020; Rouhanizadeh et al., 2019). A survey conducted by the Associated General Contractors of America (AGC) found that 28 percent of their members claimed that because of COVID-19 they had halted or delayed projects in the United States (urvey: 28% of Member, 2020).

A shortage of workers is always a concern for the construction industry, but the pandemic has intensified it as a large percentage of construction staff has reportedly screened positive for the coronavirus (Karimi et al., 2018). As the propagation of COVID-19 is largely related to individual contact, encounters between construction employees have played a major role in the delays in reopening projects. Physical

* Corresponding author.

E-mail addresses: apurva.pamidimukkala@mavs.uta.edu (A. Pamidimukkala), sharareh.kermanshachi@uta.edu (S. Kermanshachi).

distancing policies intended to decrease the virus spread have affected the number of workers permitted to work in an area, how the staff handles their jobs, and how project managers foresee the working environment (Araya, 2021).

Although recent studies have focused on the impacts of COVID-19 on the construction industry, few insights have been provided for the construction workforce in particular. Therefore, this study aimed to (1) identify and categorize the challenges faced by construction workers during COVID-19 and (2) identify and categorize management strategies to effectively address these challenges. The findings of this study will assist organizations in establishing safe working environments in which complete their projects during the pandemic.

2. Methodology

A multi-step research methodology was adopted to fulfill the goals of this study. In the first step, a detailed literature review was conducted to collect relevant articles by using different search engines such as Google Scholar, Science Direct, Scopus, American Society of Civil Engineers (ASCE), Center for Disease Control and Prevention (CDC), and Occupational safety and Health Administration (OSHA). Fig. 1 presents the structured research methodology adopted in this study.

As presented in Fig. 1, keywords such as COVID-19, physical and mental health, construction workforce, office workers, field workers, productivity, and project performance were used to find related articles in the existing literature. More than 200 journal articles, conference papers, and research reports were collected and reviewed. The title of each article was carefully reviewed and the articles relating to the construction workforce were selected for further analysis, the abstract of each article was examined for the purpose of selecting those that discussed the challenges that construction workers have faced during the COVID-19 pandemic, and the full text of each of the selected articles was screened. After this rigorous selection process, 82 peer-reviewed publications were retained. A descriptive analysis of the literature was performed, and the database was analyzed, based on the name of the journal, where frequency of articles in different journals was presented to identify the majors which have conducted most research in this area, and the continents of origin of most of the research, to evaluate its relationship to the spread of the coronavirus. Next, an in-depth analysis was performed to identify the potential challenges of the construction workforce during COVID-19 and to categorize them into organizational factors, economic factors, psychological factors, individual factors, and moderating factors, and

moderating factors. The management strategies were categorized into three main categories: workforce protection, project performance protection, and project continuity protection.

2.1. Journal name

A list of 82 publications from various journals, along with their frequencies and percentages, is presented in Table 1. These publications were extensively reviewed to identify the challenges and strategies associated with the health and safety of the workforce during COVID-19. As presented in Table 1, Safety Science, an international medium published by Elsevier that publishes multidisciplinary papers, ranked first with a frequency of 19, accounting for 23 percent of all of the papers. The Journal of Construction Engineering and Management published by the American Society of Civil Engineers (ASCE) received the second highest frequency of 15, accounting for 18 percent of all of the selected publications. As construction was impacted more than most other industries by COVID-19, most journals in Safety Science and Journal of Construction Engineering and Management focused on these challenges.

Table 1
Frequency and percentage of reviewed publications.

Journal Name	Frequency	Percentage
Safety Science	19	23 %
Journal of Construction Engineering and Management	15	18 %
Safety and Health at Work	7	9 %
Automation in Construction	4	5 %
Ergonomics	4	5 %
Journal of Safety Research	3	4 %
International Journal of Environmental Research and Public Health	3	4 %
The Lancet	3	4 %
Psychiatry Investigation	2	2 %
Built Environment Project and Asset Management	2	2 %
International Journal of Hygiene and Environmental Health	2	2 %
Other Journals*	18	22 %
Total	82	100 %

Note: * Journals that have a frequency of one, such as Emerald Open Research.

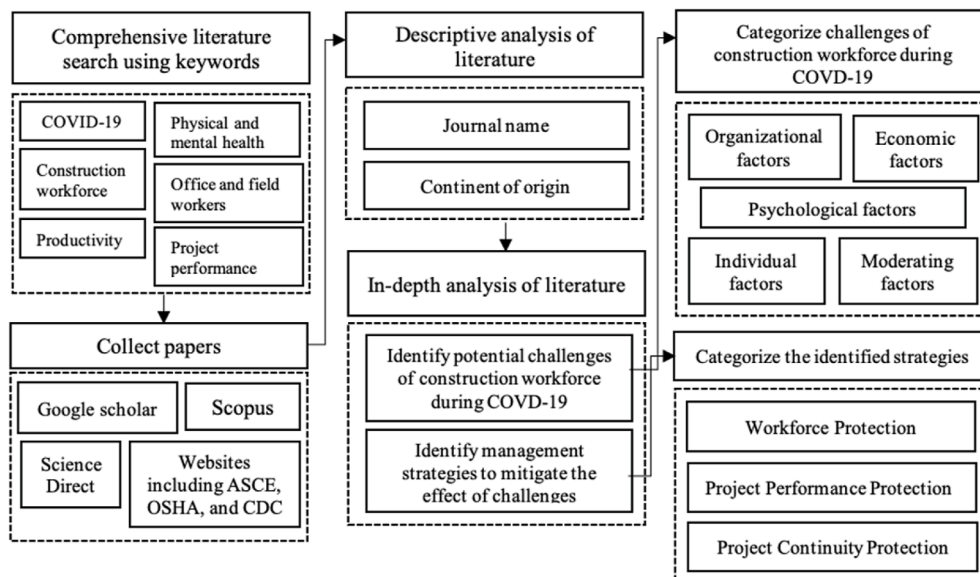


Fig. 1. Research framework.

2.2. Continent of origin

The distribution of publications associated with the health and safety of the construction workforce during COVID-19 is presented in Fig. 2. Countries worldwide identified the challenges faced by the construction industry during the pandemic and it was observed that developed countries are more concerned than developing countries about the health of their workforce.

As shown on the map, North America received the highest percentage (55 percent) and ranked as number one among the number of publications related to COVID-19. Due to the significant effect of the pandemic on the economy and health of North America, several research efforts were initiated in this region. Europe, East Asia, and South Asia also have produced notable research, with percentages of 17, 9 and 7, respectively. A low percentage of publications in certain regions does not indicate that the area has been less affected by the pandemic; rather, it may be an indication that there is a dearth of publications from areas where more research needs to be conducted.

3. Challenges and factors that impact the health and safety of construction workforce during the COVID-19 pandemic

The construction industry was one of the first industries to be impacted by COVID-19, and the workers have been subjected to an increased risk of contamination (Koh, 2020a). Projects have been suspended, delayed, or altered and new works have been postponed as management has tried to come to grips with new ways of operating. Workers have had to adjust to social distancing requirements, adhere to the latest policies for sanitation and PPE, and adapt to technology for performing tasks remotely if possible. The significance of hygiene, health, and protection has never been clearer, and it is a major challenge to provide a safe working environment and practices, especially when multiple entities of various sizes are working together (Peñaloza et al., 2020), (Woolley et al., 2020), (van der Molen et al., 2018), (Stiles et al., 2018). The temporary nature of such arrangements can make safety leadership challenging, which is key to involving the employees in their own safety (Stiles et al., 2012).

The virus is affecting not only people's physical health, but also their mental health and wellbeing. Contractors are observing their workers' mental health problems, as the workers mention anxiety as one of their main concerns during COVID-19. In a survey conducted by AGC, 70 percent of the participants identified "employee anxiety" as their main issue, citing concerns about supply shortages and local government shutdowns (urvey: 28% of Member, 2020). Psychological health issues in the workplace have been a significant issue for a long time, but the coronavirus outbreak has exacerbated the. Many workers feel stressed about their job stability, the need to work remotely, and/or the need to conduct field work amid rising challenges to their health. Many individuals who lost their jobs during COVID-19 also face mental challenges, as they are anxious about whether they will have a job to go back to and how they will fulfill their financial obligations (Woolley et al., 2020).

Psychological issues and mental health problems are common to those who have experienced traumatic events. Workers often have increased feelings of uncertainty, disappointment, anxiety, anger, exasperation, burn-out, and depression (Ekpanyaskul and Padungtod, 2021). They can also experience a sense of failure, insomnia, difficulty in focusing, and/or exhaustion. If such stress is not handled appropriately, it may result in abuse of alcohol, nicotine, or other narcotics (Karthick et al., 2021).

COVID-19 has also had an impact on employment factors such as wages, work schedules, workload, stress levels, relationships with co-employees and employers, and access to paid leave, all of which can have a direct effect on the physical and mental health of workers, their families, and their communities (Jahan Nipa et al., 2020). Table 2 depicts several additional challenges that are categorized as organizational, economic, psychological, and individual.

3.1. Organizational factors

3.1.1. Lack of safe working environment

Top management teams' lack of awareness has made it difficult for workers to have a safe workplace. Site personnel are likely to experience fear and apprehension as their level of exposure to the coronavirus

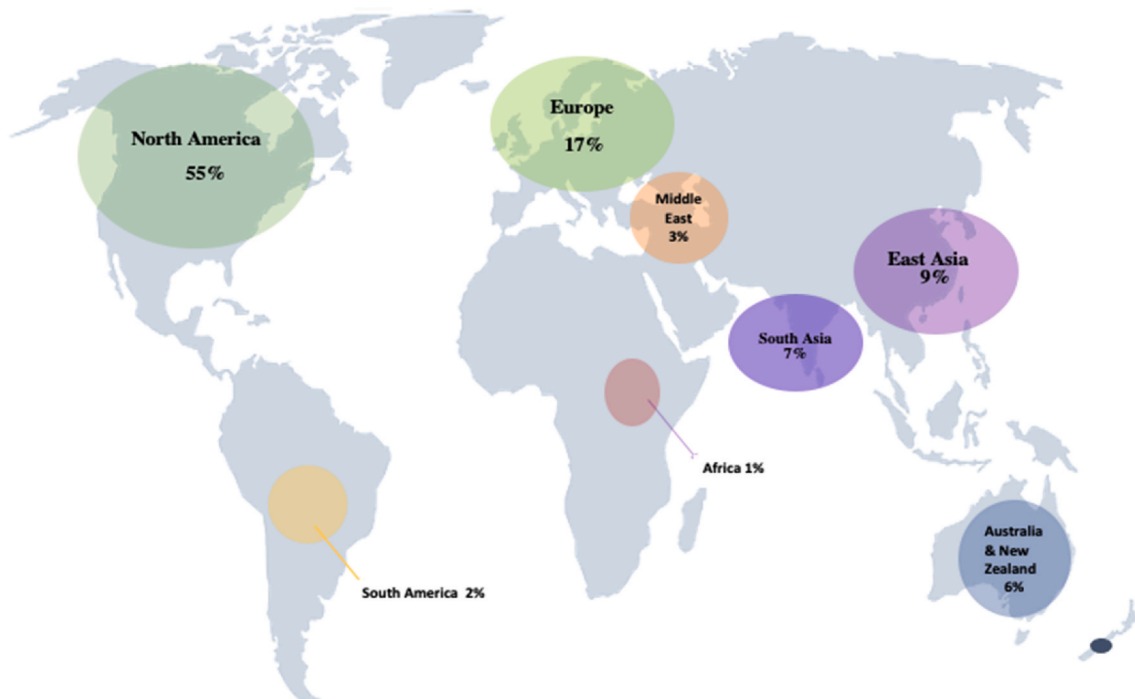


Fig. 2. Distribution of publications based on continent of origin.

Table 2
Factors affecting the health and safety of the workforce during COVID-19.

Category	Challenges	Source
Organizational Factors	<ul style="list-style-type: none"> Lack of safe working environment Challenges due to work-from-home practices Managing a heavier workload Management team's lack of leadership knowledge and skills 	(Ho et al., 2020; Yu-Tao XiangWen et al., 2020; Alsharef et al., 2021; Rowlin, 2020) (Kniffin et al., 2021; Ramarajan and Reid, 2013; Rouhanizadeh and Kermanshachi, 2021) Omran and Zaid (2014) (Dirani et al., 2020; Stiles et al., 2020; Sharma and Deng, 2019)
Economic Factors	<ul style="list-style-type: none"> Reduced accessibility to updated tools and equipment needed to accomplish the tasks Uncertainty regarding future of workplace Supply chain disruptions Cash flow delays 	(Zaid Alkilani et al., 2013; CDCgov, 2020) (urvey: 28% of Member, 2020; Alsharef et al., 2021; Rowlin, 2020) (del Rio-Chanona et al., 2020; Fernandes, 2020) (Pamidimukkala et al., 2021; Choudhari, 2020)
Psychological Factors	<ul style="list-style-type: none"> Social isolation due to teleworking Stress and burnout 	(Rowlin, 2020; Brooks et al., 2018; Tavares, 2017) (Obradovich et al., 2018; Bakker and Demerouti, 2017; Demerouti et al., 2010)
Individual Factors	<ul style="list-style-type: none"> Responsibility for personal and family needs when working Learning various communication tools and overcoming technical difficulties Feelings of not contributing enough to work Adjusting to new work schedules 	(Van Bavel et al., 2020; Hamouche, 2020) (Alsharef et al., 2021; CDCgov, 2020) (Van Bavel et al., 2020) (Alsharef et al., 2021; del Rio-Chanona et al., 2020)
Moderating Factors	<ul style="list-style-type: none"> Effect of COVID -19 on vulnerable groups (age) Gender-based impacts Impacts on migrant workforce 	(Brown et al., 2020; Bouziri et al., 2020) (Azcona et al., 2020; Wenham et al., 2020) Koh (2020b)

increases at work (Ho et al., 2020) (Yu-Tao XiangWen et al., 2020), especially if they feel that the vendors or other staff are not practicing safety measures such as social distancing. The number of people working in a workspace may also raise the employees' stress level (Alsharef et al., 2021). In most situations, employees share common areas, including restrooms, and sub-contractors are often involved in several projects simultaneously at different site locations, which increases their potential to spread the virus from one place to other and increases the employees' risk of exposure to the virus (Rowlin, 2020).

3.1.2. Challenges due to working from home (WFH)

Although COVID-19 unexpectedly supplanted typical work habits, it also sped up developments that were already occurring, such as transferring work to teleworking environments (Kniffin et al., 2021). Prior to the pandemic, whether or not to work remotely was usually the employee's choice. COVID-19 changed that, however, and has pushed many construction office personnel into mandatory remote working environments. Many employees face challenges due to lack of workspace at home and the need to set boundaries when transitioning from the work-to-home environment (Ramarajan and Reid, 2013). Isolation has exacerbated this problem, as the daily interactions with friends and co-workers, an important part of good mental health, is missing and the employees feel socially isolated (Rouhanizadeh and Kermanshachi, 2021).

3.1.3. Managing a different workload

Amid COVID-19, some companies have not adopted new timelines for their projects and are still pressuring their workers, to an extent that compromises their safety, to meet project deadlines as if things were normal (Omran and Zaid, 2014). As a result of social distancing initiatives, design and planning practices have slowed down. Employees may feel stressed or nervous when faced with increased workloads due to staff shortages caused by workers being affected by the virus and self-isolation. Workforce shortages have disrupted inspections and maintenance operations, resulting in many employees working overtime to finish their duties, more personal risks, and higher levels of anxiety (Nawi et al., 2017).

3.1.4. Management team's lack of leadership knowledge and skills

Effective leadership is more than just solving problems at work-places; it also entails having the necessary skills, competencies, and insight to navigate and mitigate the challenges presented in the midst and aftermath of crisis situations, such as COVID-19 (Stiles et al., 2012). It's still unclear what really constitutes effective onsite management, compliance reporting, and regulation (Dirani et al., 2020) in these types of environments, and construction employees are not yet clear about the level of support they need (Stiles et al., 2018). Top management's lack of leadership, knowledge, and skills pose threats to workers due to misinformation that may be disseminated regarding worksite policies and practices (Stiles et al., 2020).

3.2. Economic factors

3.2.1. Reduced accessibility to tools and equipment

A large number of non-site employees have begun working from home, but they have faced significant challenges due to companies not having the requisite digital infrastructure (Zaid Alkilani et al., 2013). There also have been major difficulties in obtaining access to the requisite software packages and other tools, which has resulted in inefficiency and employees struggling to meet project deadlines (Alsharef et al., 2021).

3.2.2. Uncertainty related to the future of the workplace

Unemployed individuals have zero threats to their health and safety from the coronavirus in the workplace; however, they may experience a loss of motivation that causes them to worry about their work status and financial situation and contributes to poor mental health. A significant number of furloughs and layoffs are being mandated due to reduced workloads. An online survey conducted by the Associated General Contractors of America (AGC) showed that more than 40 % of U.S. construction firms have recently furloughed their workers due to the cancellation of contracts and the lack of machinery or equipment caused by the outbreak (urvey: 28% of Member, 2020). Additionally, many organizations are facing challenges of delayed cash flows, resulting in employers having to lay off their workers (Alsharef et al., 2021). All of these factors act as additional stressors for workers (Rowlin, 2020).

3.2.3. Supply chain disruptions

COVID-19 has interrupted and will likely continue to disrupt sub-contractor scheduling as well as the supply of goods and materials (del Rio-Chanona et al., 2020). Material delays that stalled overall project progress and triggered major schedule disruptions were experienced due to the social distancing and quarantining requirements that resulted in a smaller workforce within supply chain organizations. The delays were particularly evident when the supply chain included materials or raw materials from other countries (Fernandes, 2020).

3.2.4. Cash flow delays

Cash flow delays are likely to occur due to delays in construction activities, and productivity is negatively affected as contractors struggle to pay their employees, subcontractors, and suppliers on time

(Pamidimukkala et al., 2021). Due to material costs and difficulties that owners had making timely payments to contractors during the pandemic, cash flow delays became a major issue and negatively affected the delivery of materials, slowed productivity, delayed projects' progress, and sometimes even led to projects being suspended (Choudhari, 2020).

3.3. Psychological factors

3.3.1. Social isolation due to teleworking

Social isolation resulting from teleworking has some negative impacts on workers' mental health and eventually leads to anxiety, depression, and even suicide (Henke et al., 2016). A new work environment, different working habits, and a lack of materials and equipment essential to carry out their work (Rowlin, 2020) all affect the workers' mental health. Employees who are already experiencing mental health issues are more likely to encounter new psychological symptoms and illnesses during a pandemic, and the workers who are required to quarantine are at a higher risk of psychiatric illness as they have no interactions with people (Brooks et al., 2018). Workplace isolation has been shown to have major detrimental impacts on workers' effective engagement, affiliative attitudes, and efficiency (Ozcelik and Barsade, 2018).

3.3.2. Stress and burnout

The uncertainty and complexities caused by the pandemic have forced companies to intervene to promote the safety and welfare of their workers. In view of these stresses, COVID-19 has led to more workers suffering from job burnout – a recurrent state of stress such as persistent feelings of fatigue and less motivation to excel in their profession (Demerouti et al., 2010). In addition, the constant exposure to up-to-the-minute news of COVID-19 creates fear and makes it easy to dwell on traumatizing signs and the potential effects of contracting the virus. Findings have revealed that workers who were subjected to Hurricane Katrina still had the aforementioned signs of anxiety and depression a year after the event (Obradovich et al., 2018), thus adding credence to the fact that mental health is affected long after a crisis is over.

3.4. Individual factors

3.4.1. Responsibility for personal and family needs

Site personnel who work with inadequate resources in an environment with elevated risks and are pressured to meet project timelines worry about the safety and wellbeing of their families and their ability to meet the challenges of providing care for elderly or young dependents (Stiles et al., 2020; Hamouche, 2020). They might also be worried or feel guilty about the potential for transferring the virus to their families. Many workers, including those who work in the field and require frequent interactions with people, are at a higher risk of exposure to unhealthy and asymptomatic people suffering from COVID-19 (Choudhari, 2020). Other problems encountered are that the employees are often unable to report to work because of the lack of available child-care facilities, school closures, and the need to take care of sick family members. All of these factors induce pressure and adversely affect their mental health (Van Bavel et al., 2020).

3.4.2. Learning various communication tools

Lack of familiarity and expertise with digital solutions and communication tools translates to high stress levels for employees (CDCgov, 2020). For instance, some persons lack knowledge about how to use a virtual private network (VPN) to remotely link to the organization's network; how to participate in Zoom meetings, Microsoft Teams, Slack, etc.; and/or how to link their office desktop to their personal networks. They are overwhelmed and unequipped to meet challenges like low internet quality and speed, and internet outages that impact their

productivity and mental health (Alsharif et al., 2021).

3.4.3. Feelings of not contributing enough to work

Many of the construction office workers who are working in virtual environments during COVID-19 have limited, if any, access to office equipment like printers, which makes their jobs more difficult and affects their overall performance (Van Bavel et al., 2020). Employees are burdened by the stress of obtaining their own resources, having to learn to use new technology, a sense of unease about what's going to happen, being unaccustomed to paperless administration and protocols, fear of virus contamination, maintaining office space at home, and achieving a work-life balance, all of which cause them to feel that they are not contributing enough to work (CDCgov, 2020).

3.4.4. Adjusting to new work schedules

Adjusting to new work schedules during COVID-19 such as rotating shifts, night shifts, flextime, and more have varying effects on absenteeism, turnover, and the efficiency of construction employees (Alsharif et al., 2021). Working the night shift is linked to higher absenteeism and lower productivity, while flextime schedules are linked to lower turnover and absenteeism. Different work schedules not only affect employee's productivity but also impact their attitudes and well-being, and ultimately undermine their overall job satisfaction (del Rio-Chanona et al., 2020).

3.5. Moderating factors

3.5.1. Effects of COVID-19 on vulnerable age groups

Although COVID-19 has impacted the entire construction industry, there is growing evidence that it has had a heightened impact on certain groups of employees. Older employees, whose immune systems are compromised by aging, are more vulnerable to the virus, which creates disparities in the workforce (Brown et al., 2020). The challenges of telework are also exacerbated for older employees who struggle with technology, self-organization, segregating work and family responsibilities, and an absence of regular communication with project managers and co-workers. Adults with a pre-existing mental health disorders have experienced substantially more negative emotions and anxiety during the pandemic (Newby et al., 2020).

3.5.2. Gender-based impacts of COVID-19

Men and women have been affected differently by the COVID-19 pandemic. It has had a much more serious impact on female workers than on male workers, which has intensified the gender disparities throughout the workforce (Wenham et al., 2020). Since the pandemic has caused widespread shutdowns in childcare facilities and schools, women have been encumbered with increased family responsibilities, and many have had to juggle their unpaid daily chores while dealing with the loss of income (Azcona et al., 2020). The stress of balancing family and job obligations has caused women to experience more health problems than men, including insomnia, nervousness, depression, migraines, and post-traumatic stress disorder (PTSD).

3.5.3. Impacts on migrant workers

The vulnerability of migrant workmen has become even more apparent during the pandemic of COVID-19. Prior to the pandemic, migrant workers had more psychological health problems than non-migrants (Firdaus, 2017; Virupaksha et al., 2014), but multiple issues during the pandemic have made them even more vulnerable to these problems. They are unable to isolate or social distance because of resource and/or space constraints, and separation from their families, loss of friends and/or family members to the pandemic, and a sense of helplessness in attending to the needs of their family while working increase the likelihood that they will develop anxiety, psychotic, and post-traumatic disorders (Mucci et al., 2020). These socio-environmental adversities impact their economic status and

encourage discrimination (Zhou et al., 2020).

4. Strategies to overcome the health and safety challenges of the construction workforce during COVID-19

The safety challenges of COVID-19 are different for each type of project. For example, those working in outdoor environments and physically apart from one another are in a better position to adhere to the new safety codes than those who are working in contained spaces. It is vital, however, to conduct health and safety risk assessments, require employees to comply with scientific and policy requirements regardless of their work environment, and ensure that the workplace is safe (Kermanshachi and Rouhanizadeh, 2019). All the efforts expended by employers to promote the health and safety of employees during COVID-19 should comply with the provisions of the Occupational Health and Safety Act (Bailey JMadalena, 2020). A survey showed that 80 percent of construction sites had made significant improvements to their safety and health policies (Achilles, 2020). The list of management practices is presented in Table 3.

4.1. Workforce protection

4.1.1. Redefining worksite safety

Project managers are expected to provide a healthy workplace environment for employees during disease outbreaks such as COVID-19 by redefining their safety regulations. The safety measures include ensuring a minimum distance of 1.5 m between workers; using face masks to mitigate the transmission of the virus (Stiles et al., 2020); conducting regular health screenings, i.e., temperature checks to monitor for presence of any COVID-19 signs among the workers; sanitizing equipment, machines and surfaces (Stiles et al., 2020); installing signs in workspaces that encourage workers to physically distance themselves (Katherine Vines and Beech, 2020); marking one-way traffic in areas inhabited by more than a few workers (Alsharef et al., 2021); and promoting realistic PPE rules.

4.1.2. Supporting employees who work remotely

Working remotely is the most effective way for companies to keep functioning while ensuring their workers' health and safety (Greer and Payne, 2014). Many office employees, including construction estimators and schedulers, work remotely in order to encourage social distancing (Hamouche, 2020). To minimize the negative impacts on employee mental health and wellbeing that may arise from remote working, however, companies must formulate measures that assist workers during these organizational changes. Greer and Payne (2014) identified several approaches that remote workers can use to cope with the difficulties that arise with teleworking. These approaches include maintaining continuous communication with co-workers and supervisors, participating in virtual interactive sessions that provide suggestions on how to handle the changes inherent in working from home, utilizing online tools to enhance productivity, taking breaks for self-care during the workday, checking in with management when additional support is needed. Workers must also establish and maintain their connections with their employers and establish boundaries between work and home responsibilities (Hamouche, 2020), and teleworkers must be trained how to the technologies that are vital to the quality of their work and communication.

4.1.3. Initiate flexible work schedules to promote social distancing

Various approaches can be adopted to promote social distancing among field personnel (Alsharef et al., 2021), and employers and employees are required to follow them while working on construction sites. These include staggered times for work teams so that they report to work at different times, which minimizes the number of staff at the workplace at a particular time; staggered break times for workers; restricting the number of people in the workplace; regulating the number of individuals using the elevators at the same time; and modifying work sites to facilitate proper physical distances, i.e., 1.5 m between workers during shifts (Katherine Vines and Beech, 2020).

4.1.4. Teaching employees to be aware of and manage the signs of stress

The pandemic has changed the way workers operate, whether in the field, in the office, or remotely. Anxiety and fear about the outbreak can

Table 3
List of effective management strategies.

Category	Strategies	Description	Source
Workforce Protection	<ul style="list-style-type: none"> • Redefine worksite safety • Support personnel who work remotely • Initiate flexible work schedules to promote social distancing • Teach employees to recognize and manage stress symptoms 	<ul style="list-style-type: none"> • Adopting site safety measures such as regular temperature checks for workers, sanitizing equipment, providing PPE to staff. • Offering support to teleworkers by organizing virtual interactive sessions, training on the use of technologies, offering required online tools. • Providing flexible work schedules by staggering times for different project groups and breaks, limiting the number of persons working in each zone. • Facilitating awareness of signs of stress including feeling depressed, difficulty in sleeping, feeling nervous and anxious. 	(Alsharef et al., 2021; Stiles et al., 2020; Katherine Vines and Beech, 2020) (Hamouche, 2020; Greer and Payne, 2014) (Rouhanizadeh et al., 2019; Alsharef et al., 2021) (CDCgov, 2020; Newby et al., 2020; Katherine Vines and Beech, 2020; James et al., 2020)
Project Performance Protection	<ul style="list-style-type: none"> • Expand use of technology • Educate the employees about COVID-19 policies and procedures, and train them to incorporate them • Establish a system to maintain effective communication 	<ul style="list-style-type: none"> • Providing technologies like BIM to share information between team members, and AR and VR for conducting virtual inspections • Educating workers about COVID-19 policies, acceptable social distance space and hygiene practices, and how the virus spreads. • Developing a plan to facilitate regular communication among management and workers, as well as among workers 	(Karakhan et al., 2019; Li et al., 2018; Firm, 2021; Safapour et al., 2019; Wang et al., 2018; Yu et al., 2018) (Katherine Vines and Beech, 2020; Subramanya and Kermanshachi, 2021) (Safapour et al., 2020; Kamalirad et al., 2017; Nipa et al., 2019)
Protecting Project Continuity	<ul style="list-style-type: none"> • Allow longer timelines for project delivery • Perform a contractor assessment to increase productivity • Conduct a risk analysis • Create an end-end supply chain map 	<ul style="list-style-type: none"> • Increasing project timelines to allow workers to follow safety guidelines • Performing contractor assessments to help identify delays, current schedule status, and material procurement status • Re-evaluating risk assessment and considering the use of modelling methods to evaluate possible cost and plan outcomes with various degrees of confidence • Developing a robust framework with enough flexibility to prevent future disruptions 	(Stiles et al., 2020; Firm, 2021) (Lingard et al., 2021; Bsisu, 2020; Zhang et al., 2019) (Stephany et al., 2020; Sharma et al., 2016; Zhu et al., 2021) [76,77, 80, 81, 82]

be debilitating for staff and can impair their well-being. It is, therefore, necessary for employees to be able to recognize and identify symptoms of stress that may include feeling irritable, angry, unhappy, depressed, confused, nervous and/or anxious; lack of motivation; insomnia; and inability to concentrate (Katherine Vines and Beech, 2020). Workers must identify the areas in which they feel they have lost control and try to improve their sense of control by developing a consistent daily routine that utilizes the available resources (CDCgov, 2020).

4.2. Project performance protection

4.2.1. Enhanced use of technology

The use of technology has increased during the pandemic, as workers have performed activities remotely rather than in the office. While construction does not seem to be a field that lends itself to Zoom meetings and technology tools, a range of technological advances are being used, such as web-based tools that facilitate virtual, rather than in-person, interaction with customers to address on-going projects (Firm, 2021). Information modeling and digital twins provide a single source of reality across teams, assisting with virtual signoffs and handoffs, and comprehensive visualization of the design process provides greater transparency for decision-makers (Vithana et al., 2020). Some of the emerging technologies like Building Information Modeling (BIM) enable knowledge sharing and effective communication between project teams and the stakeholders and enhance safety inspections, planning, and communication (Karakhan et al., 2019; Yu et al., 2018). Advanced technologies such as augmented reality (AR) and virtual reality (VR) boost safety inspections and instruction and can be used for safety training (Li et al., 2018; Wang et al., 2018).

4.2.2. Training and educating employees on organizations' COVID-19 policies

Training is a useful tool for preventing mental, physical, and emotional problems, and employers must clearly convey their rules in a language that everyone can understand to promote the health and safety of their workforce (James et al., 2020). Training provides the workers knowledge about the significance of requisite behaviors and how they effectively combat the spread of outbreaks (Brooks et al., 2018). The amount of training that the workers should receive for a specific work site or assignment depends on the level of risk involved. OSHA suggests that staff be educated to identify the signs and symptoms of COVID-19, be cognizant of acceptable social distance and hygiene procedures, know how to use PPE appropriately, be aware of the need to observe company rules and regulations, and understand how the virus spreads. In light of the current remote working environments, workers must also be instructed about managing virtual teams in order to support their team members. Co-development initiatives must be introduced to promote the workers abilities to comply with the effects of COVID-19 in the workplace (Hamouche, 2020).

4.2.3. Establishing a system to maintain effective communication

Good communication between employers and their employees is essential to successfully containing the coronavirus. Employers must develop a communication plan that clearly presents any changes in rules and regulations to all of their employees in a language that they can understand (Greer and Payne, 2014) and must assist them in adjusting to the new practices (Hamouche, 2020). It is also important to provide workers with information about what changes might occur after the pandemic, the key steps that will be taken to restore all of the operations to their pre-pandemic functioning, and the possible effects of these measures on the employees. Project managers should consider investing in a workflow platform that everyone can use, which might also serve as a repository for notes and data (Brooks et al., 2018). Workers have a responsibility to report possible symptoms, hazards, and exposure to the pandemic at the jobsite to their employers. Thus, communication and transparency on everyone's part can help to reduce the workers' stress

levels and promote optimistic attitudes.

4.3. Protecting project continuity

4.3.1. Longer timelines for project delivery

Despite a decrease in productivity caused by a loss of workers, many companies are operating under the same project deadlines and delivery dates that were projected for their clients prior to the pandemic (Stiles et al., 2020). New social distancing rules, significant safety improvements, smaller workforces, the need for adequate PPE, and the time needed for sanitation increase the amount of time that is required to complete projects. Extending project deadlines benefits workers by enabling them to concentrate on their health and safety while conducting their assigned tasks (Firm, 2021).

4.3.2. Perform a contractor assessment to increase project productivity

As a consequence of COVID-19, contractors may not be financially able to complete contracts, resulting in management encountering change orders and allegations (Lingard et al., 2021). The potential risks for this are multiplied for high-value or experienced contractors. Productivity and workforce consistency can be enhanced by performing continuous, extensive analyses during the development stage of the project (Bsisu, 2020). To establish a baseline, these analyses must provide a pre-pandemic outline of development, disruptions, and anticipated contractor claims, accompanied by an evaluation of the contractor's cash flow and significance of the project. It is more important than ever for managers to carefully examine the contracts to be prepared for change orders and allegations (Zhang et al., 2019).

4.3.3. Conducting risk analysis

Performing a risk exercise is an effective way to update the risk registers. This consists of considering a variety of ways that the project could unfold, including risks such as disturbances with supply chains; lack of cash flow of investors, subcontractors, and contractors; and permitting challenges (Stephany et al., 2020). The benefits and costs of project closures and delays should be considered, and priorities for responses and prevention initiatives should be assigned, based on the likelihood and severity of the potential threats. The risk registers should be reviewed on a regular basis and potential threats and risk assessments should be considered (Sharma and Deng, 2019).

4.3.4. Create an end-to-end supply chain map

Suppliers that transport materials across several regions have been affected by COVID-19 in varying ways and with varying consequences that have the potential to compromise the overall project. The inability to deliver materials or the limited availability of even one major element can bring a project to a halt (Zhu et al., 2021). Construction companies must plan extensively and be strategic in searching for additional vendors from which to procure needed materials and in updating estimates for procuring and facilitating essential materials (Wang et al., 2018).

5. Discussion

The authors analyzed the relationships between the seventeen challenges and eleven strategies, and the results are depicted in Fig. 3. The lack of a safe working climate and the occurrence of health and safety challenges create a stressful working environment for field workers; therefore, the challenges related to the organizational category are recognized as being of utmost importance in the existing literature. Fig. 3 presents that adopting strategies such as redefining job-site safety rules, encouraging more remote work, extending project timelines, and initiating flexible work schedules helps field workers overcome the challenges of an unsafe working environment. Fig. 3 also illustrates that a slow cash flow is a major challenge for both office and field workers, as it results in a lack of PPE, delays in the delivery of materials, and decreased productivity. Performing contractor assessments and risk

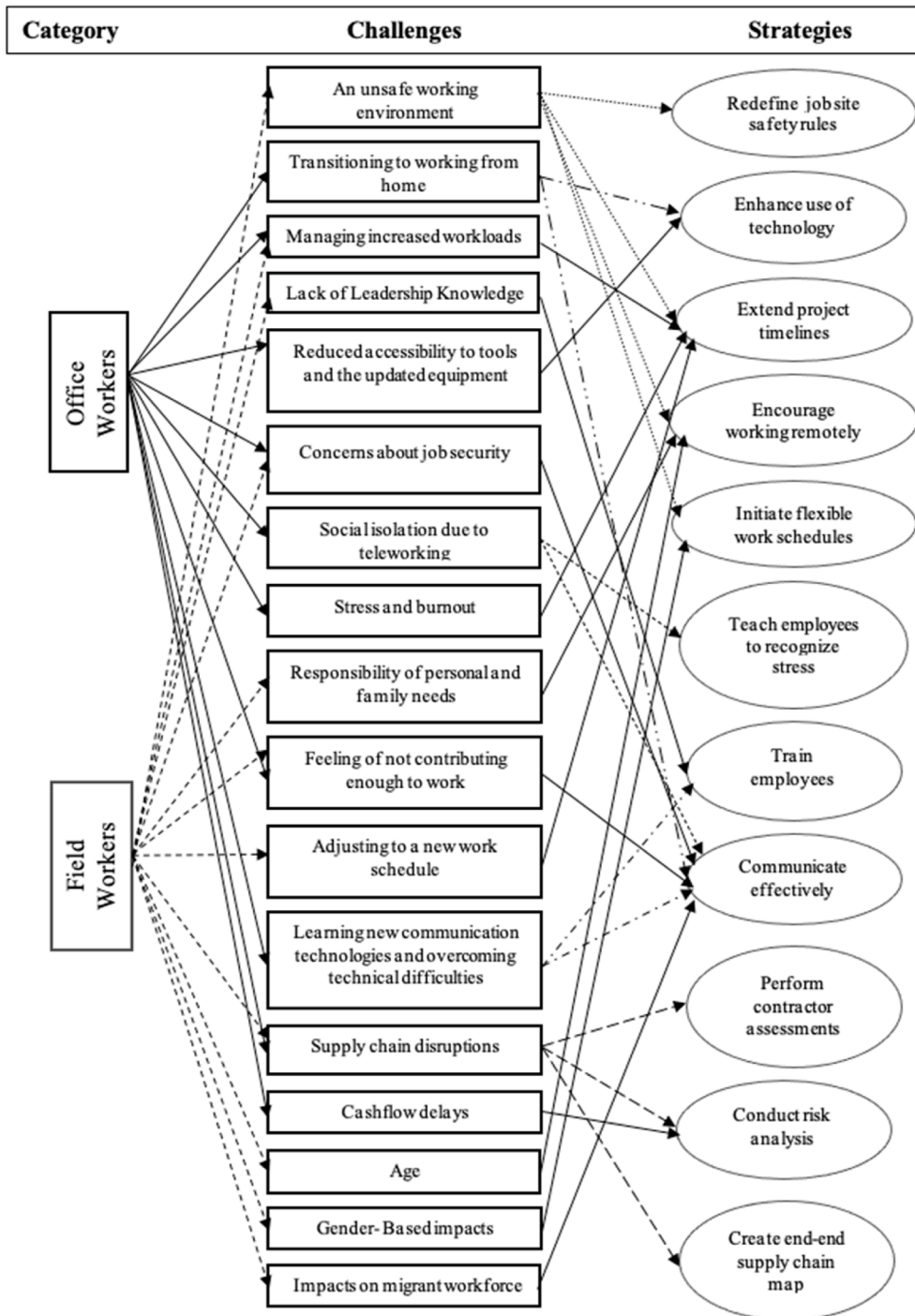


Fig. 3. Systematic representation of relationships between COVID-19 challenges and strategies.

analyses, and mapping supply chains can effectively manage cash flows and facilitate a project’s continuity. Office workers can overcome their challenges of reduced accessibility to tools and equipment, stress, social isolation, and concerns about job security by using enhanced technologies, recognizing their stress symptoms, and communicating with employers, respectively. Employers can help the workers who are more vulnerable to the pandemic due to their age by allowing them to work remotely and teaching them how to use technological tools.

In summary, the most important strategy for both office and field workers is effective communication. Most of the challenges presented in Fig. 3 can be mitigated through effective communication between employers and employees. Workers should feel comfortable reaching out to

their employers about any safety concerns at work sites and difficulties they encounter while working remotely.

The novelty of this work is based on the identification of Covid-19 challenges faced by both field and office workforces and the development of strategies that can prevent or at least minimize the unintended consequences of these challenges. The potential challenges and strategies addressed in this work can serve as guidelines for practitioners and decision-makers as they take appropriate actions and/or develop effective policies during similar situations.

6. Conclusion

This study documents the impacts of the COVID-19 pandemic on construction workforces and proposes strategies to effectively mitigate the challenges. Seventeen challenges were identified through the existing literature and were classified into five categories: organizational, economic, psychological, individual, and moderating. Eleven strategies that effectively address the challenges were identified and classified into three main categories: workforce protection, project performance protection, and protecting project continuity. The challenges of unsafe working environments, reduced accessibility to tools and equipment, social isolation due to teleworking, personal and family-related responsibilities during the work day, and age were the main concerns in the organizational, economic, psychological, individual, and moderating categories, respectively. The lack of a safe working environment exposes workers to the virus, the lack of access to required tools and equipment makes it difficult for workers to finish their assigned tasks, and social isolation due to teleworking can cause mental health issues. Eleven strategies were identified to control these challenges. Redefining job site safety by ensuring physical distancing between workers, frequent temperature checks, and flexible and staggered work schedules can improve the working environment and minimize workers' exposure to the virus. Providing the required tools and promoting the use of technology by hosting virtual meetings and frequently interacting with the remote workers helps to reduce their anxiety and stress. Extending project deadlines, conducting contractor analyses to identify delays, performing risk analyses, and mapping supply chains were also found to prevent disruptions and promote project continuity. The results of this study will greatly benefit project managers by helping them understand the workers' COVID-19 challenges and prioritize their plans so that they can provide safe working conditions that protect their employees and support them both mentally and physically. The outcomes can be useful to government entities also as they address the adverse impacts of the pandemic. For further research, this study recommends conducting a survey of construction field and office workforces, based on the identified factors and assessed the implementation and effectiveness level of each strategy.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- Achilles, 2020. Impact Of Covid-19 In The Workplace: New Health And Safety Measures. <https://doi.org/10.1044/leader.aag.25102020.30>. <https://www.achilles.com/industry-insights/impact-of-covid-19-in-the-workplace-new-health-and-safety-measures/>. (Accessed 15 October 2020).
- Alsharif, A., Banerjee, S., Uddin, S.M.J., Albert, A., Jaselskis, E., 2021. Early impacts of the COVID-19 pandemic on the United States construction industry. *Int. J. Environ. Res. Publ. Health* 18 (4), 1559. <https://doi.org/10.3390/ijerph18041559>.
- Araya, F., 2021. Modeling the spread of COVID-19 on construction workers: an agent-based approach. *Saf. Sci.* 133, 105022. <https://doi.org/10.1016/j.ssci.2020.105022>.
- Azcona, G., Bhatt, A., Davies, S.E., Harman, S., Smith, J., Wenham, C., 2020. Spotlight on Gender, COVID-19 and the SDGs: Will the Pandemic Derail Hard-Won Progress on Gender Equality? <https://doi.org/10.18356/ee038877-en>.
- Bailey J, B.N., Madalena, I., 2020. COVID-19: the Current Impact on Construction and Engineering Projects. (Accessed 30 October 2020).
- Bakker, A.B., Demerouti, E., 2017. Job demands–resources theory: taking stock and looking forward. *J. Occup. Health Psychol.* 22 (3), 273. <https://doi.org/10.1037/ocp0000056>.
- Bouziri, H., Smith, D.R., Descatha, A., Dab, W., Jean, K., 2020. Working from home in the time of covid-19: how to best preserve occupational health? *Occup. Environ. Med.* 77 (7), 509–510. <https://doi.org/10.1136/oemed-2020-106599>.
- Brooks, S.K., Dunn, R., Amlöt, R., Rubin, G.J., Greenberg, N., 2018. A systematic, thematic review of social and occupational factors associated with psychological outcomes in healthcare employees during an infectious disease outbreak. *J. Occup. Environ. Med.* 60 (3), 248–257. <https://doi.org/10.1097/jom.0000000000001235>.
- Brown, S., Brooks, R.D., Dong, X.S., 2020. Coronavirus and Health Disparities in Construction.
- Bsuis, K.A.-D., 2020. The impact of COVID-19 pandemic on Jordanian civil engineers and construction industry. *Int. J. Eng. Res. Technol.* 13 (5), 828–830. <https://doi.org/10.37624/ijert/13.5.2020.828-830>.
- CDCgov, Employees, 2020. How to Cope with Job Stress and Build Resilience during the COVID-19 Pandemic | CDC. <https://www.cdc.gov/coronavirus/2019-ncov/comm-unity/mental-health-non-healthcare.html>. (Accessed 13 February 2021). accessed.
- Chodorow-Reich, G., Coglianesi, J., 2020. Projecting Unemployment Durations: A Factor-Flows Simulation Approach with Application to the COVID-19 Recession. National Bureau of Economic Research. <https://doi.org/10.3386/w27566>.
- Choudhari, R., 2020. COVID 19 pandemic: mental health challenges of internal migrant workers of India. *Asian J. Psychiatr.* 54, 102254. <https://doi.org/10.1016/j.ajp.2020.102254>.
- del Rio-Chanona, R.M., Mealy, P., Pichler, A., Lafond, F., Farmer, J.D., 2020. Supply and demand shocks in the COVID-19 pandemic: an industry and occupation perspective. *Oxf. Rev. Econ. Pol.* 36 (Supplement_1), S94–S137. <https://doi.org/10.1093/oxrep/graa033>.
- Demerouti, E., Mostert, K., Bakker, A.B., 2010. Burnout and work engagement: a thorough investigation of the independency of both constructs. *J. Occup. Health Psychol.* 15 (3), 209. <https://doi.org/10.1037/a0019408>.
- Dirani, K.M., Abadi, M., Alizadeh, A., Barhate, B., Garza, R.C., Gunasekara, N., Ibrahim, G., Majzun, Z., 2020. Leadership competencies and the essential role of human resource development in times of crisis: a response to Covid-19 pandemic. *Hum. Resour. Dev. Int.* 23 (4), 380–394. <https://doi.org/10.1080/13678868.2020.1780078>.
- Ekpanyaskul, C., Padungtod, C., 2021. Occupational Health Problems and Lifestyle Changes Among Novice Working-From-Home Workers amid the COVID-19 Pandemic, Safety and Health at Work. <https://doi.org/10.1016/j.shaw.2021.01.010>.
- Fernandes, N., 2020. Economic Effects Of Coronavirus Outbreak (COVID-19) On The World Economy. Available at SSRN 3557504.
- Firdaus, G., 2017. Mental well-being of migrants in urban center of India: analyzing the role of social environment. *Indian J. Psychiatr.* 59 (2), 164. <https://doi.org/10.4103/psychiatry.indianjpsychiatry.272.15>.
- Firm, T.P., 2021. Here's How Covid-19 Is Changing The Construction Industry. <https://www.perecman.com/blog/2020/may/heres-how-covid-19-is-changing-the-construction-/>. (Accessed 28 November 2020). accessed.
- Greer, T.W., Payne, S., 2014. Overcoming telework challenges: outcomes of successful telework strategies. *Psychol. Manag. J.* 17, 87–111. <https://doi.org/10.1037/mgr0000014>.
- Hamouche, S., 2020. COVID-19 and employees' mental health: stressors, moderators and agenda for organizational actions. *Emerald Open Res.* 2 <https://doi.org/10.35241/emeraldopenres.13550.1>.
- Hendrickson, C., Rilett, L.R., 2020. The COVID-19 Pandemic and Transportation Engineering. American Society of Civil Engineers. <https://doi.org/10.1061/JTEPBS.0000418>.
- Henke, R.M., Benevent, R., Schulte, P., Rinehart, C., Crighton, K.A., Corcoran, M., 2016. The effects of telecommuting intensity on employee health. *Am. J. Health Promot.* 30 (8), 604–612. <https://doi.org/10.4278/ajhp.141027-quan-544>.
- Ho, C.S., Chee, C.Y., Ho, R.C., 2020. Mental health strategies to combat the psychological impact of COVID-19 beyond paranoia and panic. *Ann. Acad. Med. Singapore* 49 (1), 1–3. <https://doi.org/10.47102/annals-acadmedsg.202043>.
- Jahan Nipa, T., Kermanshachi, S., Patel, R.K., 2020. Impact of Family Income on Public's Disaster Preparedness and Adoption of DRR Courses, Creative Construction E-Conference 2020. Budapest University of Technology and Economics, pp. 94–102. <https://doi.org/10.3311/ccc2020-060>.
- James, G.A.F., Chivilo, P., Koger, Gregory H., 2020. A Look At Covid-19 Impacts On The Construction Industry. <https://www.hklaw.com/en/insights/publications/2020/05/a-look-at-covid19-impacts-on-the-construction-industry>.
- Kamalirad, S., Kermanshachi, S., Shane, J., Anderson, S., 2017. Assessment of construction projects' impact on internal communication of primary stakeholders in complex projects. Proceedings for the 6th CSCE International Construction Specialty Conference.
- Karakhan, A., Xu, Y., Nnaji, C., Alsaffar, O., 2019. Technology Alternatives For Workplace Safety Risk Mitigation In Construction: Exploratory Study, Advances In Informatics And Computing In Civil And Construction Engineering. Springer, pp. 823–829. https://doi.org/10.1007/978-3-030-00220-6_99.
- Karimi, H., Taylor, T.R., Dadi, G.B., Goodrum, P.M., Srinivasan, C., 2018. Impact of skilled labor availability on construction project cost performance. *J. Construct. Eng. Manag.* 144 (7), 04018057 [https://doi.org/10.1061/\(asce\)co.1943-7862.0001512](https://doi.org/10.1061/(asce)co.1943-7862.0001512).
- Karthick, S., Kermanshachi, S., Rouhanizadeh, B., 2021. Short-and-Long Term Health Challenges of Transportation Workforce Due to Extreme Weather Conditions, Transportation Consortium of South-Central States (Tran-SET) Conference.
- Katherine Vines, P.W., Beech, Nicholas, 2020. The impact of COVID-19 on the safety of workers in the WA construction industry: navigating risk. KWM. <https://www.kwm.com/en/au/knowledge/insights/the-impact-of-covid-19-on-the-safety-of-workers-in-the-wa-construction-industry-navigating-risk-20200428>.
- Kermanshachi, S., Rouhanizadeh, B., 2019. Sensitivity Analysis of Construction Schedule Performance Due to Increased Change Orders and Decreased Labor Productivity, 7th CSCE International Construction Specialty Conference. ICSC), pp. 12–15.
- Kniffin, K.M., Narayanan, J., Ansel, F., Antonakis, J., Ashford, S.P., Bakker, A.B., Bamberger, P., Bapuji, H., Bhave, D.P., Choi, V.K., 2021. COVID-19 and the workplace: implications, issues, and insights for future research and action. *Am. Psychol.* 76 (1), 63. <https://doi.org/10.1037/amp0000716>.
- Koh, D., 2020a. Migrant workers and COVID-19. *Occup. Environ. Med.* 77 (9), 634–636. <https://doi.org/10.1136/oemed-2020-106626>.
- Koh, D., 2020b. Occupational risks for COVID-19 infection. *Occup. Med. (Oxf.)* 70 (1), 3.

- Li, X., Yi, W., Chi, H.-L., Wang, X., Chan, A.P., 2018. A critical review of virtual and augmented reality (VR/AR) applications in construction safety. *Autom. Construct.* 86, 150–162. <https://doi.org/10.1016/j.autcon.2017.11.003>.
- Lingard, H., Peihua Zhang, R., Räisänen, C., Miang Goh, Y., Bowen, P., Bhandari, S., 2021. What have we learnt from the COVID-19 global pandemic: improving the construction industry's abilities to foresee, respond to and recover from future endemic catastrophes. *Construct. Manag. Econ.* 39 (2), 192–197. <https://doi.org/10.1080/01446193.2020.1869480>.
- Mucci, N., Traversini, V., Giorgi, G., Tommasi, E., De Sio, S., Arcangeli, G., 2020. Migrant workers and psychological health: a systematic review. *Sustainability* 12 (1), 120. <https://doi.org/10.3390/su12010120>.
- Nawi, M.N.M., Ibrahim, S.H., Affandi, R., Rosli, N.A., Basri, F.M., 2017. Factor affecting safety performance construction industry. *Int. Rev. Manag. Market.* 6 (8S), 280–285.
- Newby, J.M., O'Moore, K., Tang, S., Christensen, H., Faasse, K., 2020. Acute mental health responses during the COVID-19 pandemic in Australia. *PLoS One* 15 (7), e0236562. <https://doi.org/10.1371/journal.pone.0236562>.
- Nipa, T.J., Kermanshachi, S., Kamalirad, S., 2019. Development of Effective Communication Framework Using Confirmatory Factor Analysis Technique, Computing in Civil Engineering 2019: Data, Sensing, and Analytics. American Society of Civil Engineers Reston, pp. 580–588. <https://doi.org/10.1061/9780784482438.073>.
- W.H.O. (WHO), coronavirus disease (COVID-19), 2020. <https://www.who.int/health-topics/coronavirus>. (Accessed 13 February 2021).
- Obradovich, N., Migliorini, R., Paulus, M.P., Rahwan, I., 2018. Empirical evidence of mental health risks posed by climate change. *Proc. Natl. Acad. Sci. Unit. States Am.* 115 (43), 10953–10958. <https://doi.org/10.1073/pnas.1801528115>.
- Omran, A., Zaid, H., 2014. Determining factors affecting safety performance practices OF construction contractors IN Gaza strip, Palestine. *J. Acad. Res. Econ.* 6 (3).
- Ozcelik, H., Barsade, S.G., 2018. No employee an island: workplace loneliness and job performance. *Acad. Manag. J.* 61 (6), 2343–2366. <https://doi.org/10.5465/amj.2015.1066>.
- Pamidimukkala, A., Kermanshachi, S., Jahan Nipa, T., 2021. Impacts of COVID-19 on Health and Safety of Workforce in Construction Industry. *International Conference on Transportation and Development*, pp. 418–430.
- Peñalzo, G.A., Saurin, T.A., Formoso, C.T., 2020. Monitoring complexity and resilience in construction projects: the contribution of safety performance measurement systems. *Appl. Ergon.* 82, 102978. <https://doi.org/10.1016/j.apergo.2019.102978>.
- Ramarajan, L., Reid, E., 2013. Shattering the myth of separate worlds: Negotiating nonwork identities at work. *Acad. Manag. Rev.* 38 (4), 621–644. <https://doi.org/10.5465/amr.2011.0314>.
- Rouhanizadeh, B., Kermanshachi, S., 2021. Causes of the Mental Health Challenges in Construction Workers and Their Impact on Labor Productivity, *Transportation Consortium of South-Central States (Tran-SET) Conference*.
- Rouhanizadeh, B., Kermanshachi, S., Nipa, T.J., 2019. Identification, Categorization, and Weighting of Barriers to Timely Post-disaster Recovery Process, Computing in Civil Engineering 2019: Smart Cities, Sustainability, and Resilience. American Society of Civil Engineers Reston, pp. 41–49. <https://doi.org/10.1061/9780784482445.006>.
- Rowlin, L., 2020. Mental Health and Wellbeing during the COVID-19 Pandemic. <https://doi.org/10.15405/eph.20101.4>. <https://www.willistowerswatson.com/en-GB/Insights/2020/05/mental-health-and-wellbeing-during-the-covid-19-pandemic>. (Accessed 13 February 2021).
- Safapour, E., Kermanshachi, S., Kamalirad, S., Tran, D., 2019. Identifying effective project-based communication indicators within primary and secondary stakeholders in construction projects. *J. Leg. Aff. Dispute Resolut. Eng. Constr.* 11 (4), 04519028. [https://doi.org/10.1061/\(asce\)la.1943-4170.0000332](https://doi.org/10.1061/(asce)la.1943-4170.0000332).
- Safapour, E., Kermanshachi, S., Kamalirad, S., 2020. Analysis of Effective Project-Based Communication Components within Primary Stakeholders in Construction Industry. *Built Environment Project and Asset Management*. <https://doi.org/10.1108/bepam-02-2020-0026>.
- Sharma, K., Deng, L., 2019. Reconnaissance report on geotechnical engineering aspect of the 2015 Gorkha, Nepal, earthquake. *J. Earthq. Eng.* 23 (3), 512–537. <https://doi.org/10.1080/13632469.2017.1342299>.
- Sharma, K., Deng, L., Noguez, C.C., 2016. Field investigation on the performance of building structures during the April 25, 2015, Gorkha earthquake in Nepal. *Eng. Struct.* 121, 61–74. <https://doi.org/10.1016/j.engstruct.2016.04.043>.
- Stephany, F., Stoehr, N., Darius, P., Neuhäuser, L., Teutloff, O., Braesemann, F., 2020. The CoRisk-Index: a data-mining approach to identify industry-specific risk assessments related to COVID-19 in real-time, arXiv preprint arXiv:2003.12432. <https://doi.org/10.2139/ssrn.3607228>.
- Stiles, S., Golightly, D., Wilson, J.R., 2012. Behavioural Safety Amongst Construction Industry Supply Chain Contractors, Contemporary Ergonomics and Human Factors 2012: Proceedings of the International Conference on Ergonomics and Human Factors 2012, 16–19. CRC Press, Blackpool, UK, p. 303. <https://doi.org/10.1201/b11933-72>. April 2012.
- Stiles, S., Ryan, B., Golightly, D., 2018. Evaluating attitudes to safety leadership within rail construction projects. *Saf. Sci.* 110, 134–144.
- Stiles, S., Golightly, D., Ryan, B., 2020. Impact of COVID-19 on Health and Safety in the Construction Sector, Human Factors and Ergonomics in Manufacturing & Service Industries. <https://doi.org/10.1002/hfm.20882>.
- Subramanya, K., Kermanshachi, S., 2021. Impact of COVID-19 on transportation industry: comparative analysis of road, air, and rail transportation modes. In: *International Conference on Transportation and Development*, pp. 230–242.
- Tavares, A.I., 2017. Telework and health effects review. *Int. J. Health* 3 (2), 30.
- AGC survey: 28% of members report halted or delayed projects due to COVID-19, 2020. <https://www.enr.com/articles/48976-agc-survey-28-percent-of-members-report-halted-or-delayed-projects-due-to-covid-19>. (Accessed 13 February 2021).
- Van Bavel, J.J., Baicker, K., Boggio, P.S., Capraro, V., Cichocka, A., Cikara, M., Crockett, M.J., Crum, A.J., Douglas, K.M., Druckman, J.N., 2020. Using social and behavioural science to support COVID-19 pandemic response. *Nat. Human Behav.* 4 (5), 460–471. <https://doi.org/10.31234/osf.io/y38m9>.
- van der Molen, H.F., Basnet, P., Hoonakker, P.L., Lehtola, M.M., Lappalainen, J., Frings-Dresen, M.H., Haslam, R., Verbeek, J.H., 2018. Interventions to prevent injuries in construction workers. *Cochrane Database Syst. Rev.* (2) <https://doi.org/10.1002/14651858.cd006251.pub4>.
- Virupaksha, H., Kumar, A., Nirmala, B.P., 2014. Migration and mental health: an interface. *J. Nat. Sci. Biol. Med.* 5 (2), 233.
- Vithana, N., Bandara, K., Jayasooriya, S., 2020. Impact of Covid-19 Pandemic to Construction Industry in Sri Lanka.
- Wang, P., Wu, P., Wang, J., Chi, H.-L., Wang, X., 2018. A critical review of the use of virtual reality in construction engineering education and training. *Int. J. Environ. Res. Publ. Health* 15 (6), 1204. <https://doi.org/10.3390/ijerph15061204>.
- Wenham, C., Smith, J., Morgan, R., 2020. COVID-19: the gendered impacts of the outbreak. *Lancet* 395 (10227), 846–848. [https://doi.org/10.1016/s0140-6736\(20\)30526-2](https://doi.org/10.1016/s0140-6736(20)30526-2).
- Woolley, M., Goode, N., Salmon, P., Read, G., 2020. Who is responsible for construction safety in Australia? A STAMP analysis. *Saf. Sci.* 132, 104984. <https://doi.org/10.1016/j.ssci.2020.104984>.
- Yu, Z., Peng, H., Zeng, X., Sofi, M., Xing, H., Zhou, Z., 2018. Smarter Construction Site Management Using the Latest Information Technology. *Proceedings of the Institution of Civil Engineers-Civil Engineering*, Thomas Telford Ltd, pp. 89–95. <https://doi.org/10.1680/jcien.18.00030>.
- Yu-Tao Xiang, Y.Y., Wen, Li, Zhang, Ling, Zhang, Qing, Cheung, Teris, H Ng, Chee, 2020. Timely mental health care for the 2019 novel coronavirus outbreak is urgently needed. *Lancet Psychiatr.* 7 (3), 228–229. [https://doi.org/10.1016/s2215-0366\(20\)30046-8](https://doi.org/10.1016/s2215-0366(20)30046-8).
- Zaid Alkilani, S., Jupp, J., Sawhney, A., 2013. Issues of construction health and safety in developing countries: a case of Jordan. *Australasian J. Constr. Econ. Build.*, 13 (3), 141. <https://doi.org/10.5130/ajceb.v13i3.3301>.
- Zhang, J., Yang, J., Gao, Q., Liu, K., Jin, C., Huang, H., Wang, J., Tang, J., Xu, S., 2019. Research on the Progress Supervision Technology of Electricity Grid Construction Projects Based on Multi-Service Collaboration, IOP Conference Series: Earth and Environmental Science. IOP Publishing, 052055. <https://doi.org/10.1088/1755-1315/371/5/052055>.
- Zhou, X., Snoswell, C.L., Harding, L.E., Bambling, M., Edirippulige, S., Bai, X., Smith, A.C., 2020. The role of telehealth in reducing the mental health burden from COVID-19. *Telemed. e-Health* 26 (4), 377–379. <https://doi.org/10.1089/tmj.2020.0068>.
- Zhu, S., Xie, K., Gui, P., 2021. Dynamic adjustment mechanism and differential game model construction of mask emergency supply chain cooperation based on COVID-19 outbreak. *Sustainability* 13 (3), 1115. <https://doi.org/10.3390/su13031115>.