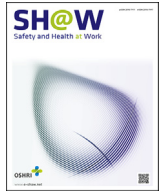




Contents lists available at ScienceDirect

# Safety and Health at Work

journal homepage: [www.e-shaw.net](http://www.e-shaw.net)

Short Communication

## COVID-19 and Return-To-Work for the Construction Sector: Lessons From Singapore

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### ARTICLE INFO

#### Article history:

Received 10 August 2020

Received in revised form

8 March 2021

Accepted 2 April 2021

Available online 20 April 2021

#### Keywords:

construction

COVID-19

migrant workers

### ABSTRACT

Singapore's construction sector employs more than 450,000 workers. During the height of the COVID-19 pandemic in Singapore from April to June 2020, migrant workers were disproportionately affected, including many working in the construction sector. Shared accommodation and construction worksites emerged as nexuses for COVID-19 transmission. Official government resources, including COVID-19 epidemiological data, 43 advisories and 19 circulars by Singapore's Ministries of Health and Manpower, were reviewed over 8 month period from March to October 2020. From a peak COVID-19 incidence of 1,424.6/100,000 workers in May 2020, the incidence declined to 3.7/100,000 workers by October 2020. Multilevel safe management measures were implemented to enable the phased reopening of construction worksites from July 2020. Using the Swiss cheese risk management model, the authors described the various governmental, industry, supervisory and worker-specific interventions to prevent, detect and contain COVID-19 for safe resumption of work for the construction sector.

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**What is already known about this subject?** Singapore is heavily reliant on migrant workers in the construction sector. While physical hazards conventionally account for most cases of work injuries and fatalities, the COVID-19 pandemic has highlighted an area of occupational health vulnerability that needs to be addressed.

**What are the new findings?** To prevent the development of a workplace COVID-19 cluster, safe management measures need to be implemented at multiple levels targeting construction worksites, workers and their places of accommodation. This layered risk mitigation strategy will facilitate safe resumption of work for construction workers.

**How might this impact on policy or clinical practice in the foreseeable future?** Until COVID-19 vaccine is widely available and proven to confer long-lasting immunity, COVID-19 will continue to pose a significant occupational health impact. Safe management measures need to be tailored according to the national-, industry-, workplace- and societal-specific context within which the construction sector and its stakeholders operate.

### 1. Introduction

Construction is an integral sector in Singapore to support the country's economic growth drivers such as finance and transportation. It accounts for 12.1% of employment at the end of 2019 or numbering 458,000 workers, of whom 293,300 are migrant rank-and-file construction workers from regional countries such as Bangladesh, India and Myanmar [1].

Since the first case of COVID-19 in a migrant worker in February 2020, Singapore has seen a surge in infected cases in this worker population. Many are epidemiologically linked to migrant worker dormitories, which are dedicated boarding premises for the communal living of migrant workers. Smaller factory-converted dormitories can house tens to hundreds of migrant workers, whereas large purpose-built dormitories, comprising blocks of housing units, can accommodate up to 25,000 migrant workers. Cooking, washing, showering and toileting facilities are communal in these dormitories.

In addition to migrant worker dormitories, workplaces such as construction sites have also been identified as COVID-19 clusters in

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Singapore [2]. Before the emergence of Coronavirus Disease 2019 (COVID-19), a pandemic preparedness blueprint was not a priority for the construction sector in Singapore, which focussed largely on physical hazards such as falls from height, vehicular incidents and heat injuries. Between 2010 and 2019, among the different industries in Singapore, the construction sector was the top contributor of fatal workplace injuries from physical hazards [3].

During the height of the COVID-19 pandemic in Singapore from April to June 2020, the country went into a ‘circuit breaker’ period where almost all physical work premises, less essential services, were closed. This included a near-total halt of all construction activities nationwide to prevent the spread of COVID-19 infection at the workplace. Mitigation measures that might otherwise have enabled some extent of continuation of construction work activities, such as workforce segregation, worker health surveillance and testing for COVID-19 infection, were not in place at that time. This severely disrupted work and further aggravated the economy. It also brought into sharp relief the need to have an industry framework to prevent, detect, contain and manage COVID-19 and other communicable disease hazards for the construction sector.

The construction ecosystem and the nature of its work activities pose a risk in the transmission of communicable diseases if occupational and public health measures are not in place. A construction project is typified by a relatively high degree of specialisation with many nodes of activities concurrently taking place. These include site preparation, excavation, piling, tunnelling, building, pathing and surfacing, sewage and drainage, power and communications works, and many more. The main contractor engages different subcontractors to handle the subspecialised works, resulting in a network of multiple teams from different companies working alongside within the same premises. Even with the implementation of mechanisation, there remain many work tasks that require physically strenuous lifting, manual handling and climbing, often under a hot and humid environment in tropical Singapore.

In the context of the COVID-19 pandemic, such work conditions in construction make it challenging and often impractical to rely solely on compliance to individual-level measures, such as the consistent donning of surgical masks and regular hand hygiene, to prevent workplace transmission. Interventions that involve syndromic surveillance, routine testing, early detection and timely containment are needed to enable the construction sector to restart safely even though the pandemic is far from over.

## 2. Methods

COVID-19 statistics from Singapore’s Ministry of Health (MOH) website, as well as COVID-19 related advisories and information from the Ministry of Manpower (MOM) and the Building and Construction Authority (BCA) online resource sites were reviewed over the period March to October 2020 [4–6]. The eight months covered the circuit breaker period from April to June 2020, when COVID-19 peaked and construction worksites were closed, to the gradual restarting of construction activities from July onwards.

The MOH website provided a daily case count of the number of COVID-19 cases in Singapore. COVID-19 cases in migrant workers are reported by their place of residence in migrant worker dormitories without any breakdown of the affected cases by the occupational sector. On COVID-19 clusters in construction sites, these were reported without the details of what constitutes a COVID-19 cluster, the number of workers infected or the worker population strength in these worksites [2].

**Table 1**

Weekly COVID-19 incidence in migrant worker dormitories and construction worksites with COVID-19 clusters

Month (Year 2020)	Weekly COVID-19 incidence in migrant worker dormitories (per 100,000 workers)	Number of construction worksites with COVID-19 clusters
March	1.2	0
April*	1,049.5	13 (+2 <sup>†</sup> )
May*	1,424.6	0
June	702.1	(2 <sup>†</sup> ‡)
July	606.1	0
August	333.8	0
September	63.4	0
October	3.7	0

\* Circuit breaker period from 7 April to 1 June 2020.

† Delayed epidemiological link of COVID-19 clusters to two construction worksites.

‡ Accounted under April 2020 before the start of circuit breaker period and closure of construction worksites.

The vast majority of the 293,300 migrant workers in the construction sector stay in migrant worker dormitories, with only about 27,000, or 9.2%, staying in other types of accommodation [7]. Given the lack of publicly available national data on COVID-19 infection by occupational sector, the authors used the number of construction worksites with reported COVID-19 clusters, as well as the COVID-19 infection rate in migrant workers dormitories as surrogate indicators as the COVID-19 situation in the construction sector.

The MOM and BCA advisories cover safe management measures for construction workers, worksites and accommodation before work resumption is permitted for the construction sector. Insights on the return-to-work policy planning considerations and measures were also drawn from the lead author, who was part of Singapore’s interagency task force managing COVID-19 in the migrant worker population.

The Swiss cheese model is applied to group occupational risk control measures for COVID-19 at the governmental, industry and supervisory levels, as well as interventions targeting individual workers. This illustrates the layered and multi-dimensional hazard control strategy needed to adequately prevent COVID-19 transmission at construction worksites. When overlaid against the backdrop of the trend of COVID-19, they reflect the effectiveness of these measures in enabling the safe resumption of work for the sector.

## 3. Results

### 3.1. COVID-19 situation in the migrant worker population and the construction sector

Nationally, the rising COVID-19 infection rate in Singapore first surfaced towards the end of March 2020. As of 31 October 2020, Singapore has recorded a total of 58,015 cases of COVID-19 infection. Of these, 54,497 (93.9%) are migrant workers.

From a very low weekly COVID-19 incidence of 1.2/100,000 workers in the migrant worker dormitories in March 2020, it rapidly rose to 1,049.5/100,000 in April 2020 and peaked at 1,424.6/100,000 in May 2020 (Table 1).

Both migrant worker dormitories (in view of their communal living design), as well as construction worksites, were implicated in disease transmission through contact tracing. In April 2020, at least

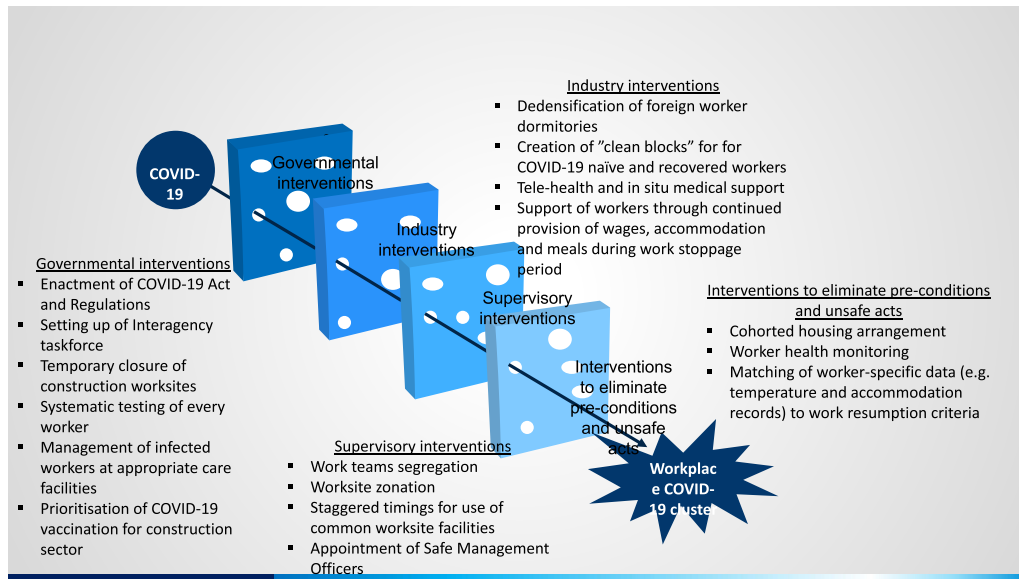


Fig. 1. Swiss cheese model of risk management.

15 construction sites were identified as COVID-19 clusters, with 1,148 workers infected. There are likely more cases of COVID-19 infection, which were linked to migrant worker dormitories based on stronger epidemiological association, but where exposure risks at worksites were probably also present.

On 7 April 2020, nationwide 'circuit breaker' measures were implemented to pre-empt escalating infections. These included the closure of most physical workplace premises. The suspension of almost all construction activities over the 'circuit breaker' period was implemented to reduce further COVID-19 transmission at the workplace, which would otherwise have caused a secondary transmission to the different migrant worker dormitories where the workers lived. During this period, they were not allowed to leave their accommodation except for medical

appointments and were required to monitor their temperature twice daily. All meals were catered and delivered to the dormitories.

The closure of construction and other worksites over the 'circuit breaker' period, coupled with other COVID-19 control measures such as mass COVID-19 testing, isolation of infected workers and quarantine of close contacts, contributed to a reduction in the weekly COVID-19 incidence to 702.1/100,000 in June 2020, and down to 3.7/100,000 workers at the end of the 8 months monitoring period in October 2020 (Fig. 1). The continued decline in weekly COVID-19 incidence is in spite of 'circuit breaker' measures being lifted in phases from 2 June 2020 and the gradual resumption of construction work activities with safe management measures in place.

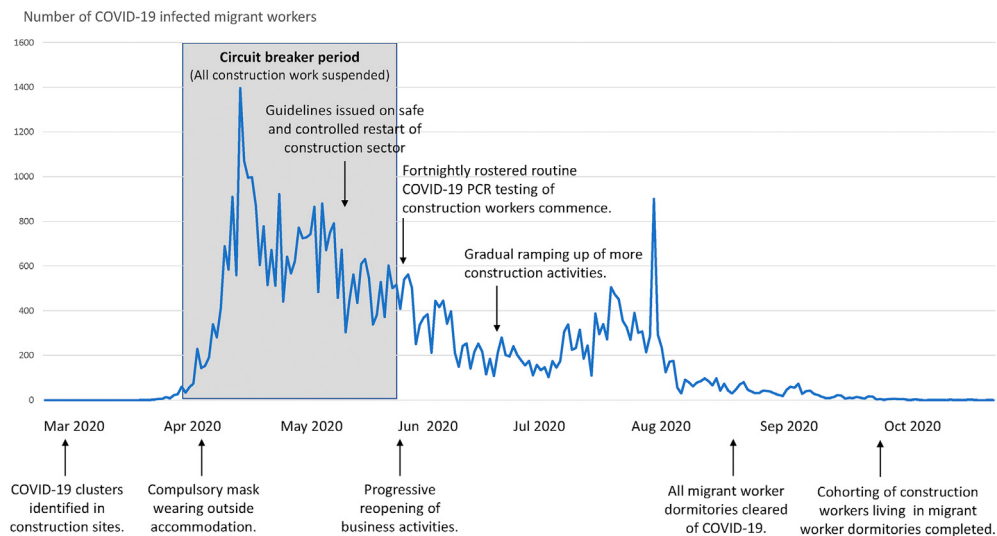


Fig. 2. Timeline and epidemiological curve of COVID-19 in migrant worker population.

### 3.2. COVID-safe return-to-work measures for the construction sector

A total of 43 MOM COVID-19 advisories and 19 BCA COVID-19 advisories and circulars issued from March to October 2020 were reviewed. Online resources on resumption of construction projects on BCA's website, including resource kits for construction firms, good practice guide, self-check tool and frequently asked questions, were also reviewed. Relevant findings were incorporated in the results of this review.

Each construction worksite can be regarded as an enterprise system where the Swiss cheese model of multi-level risk management is applied to prevent workplace COVID-19 transmission (Fig. 2).

#### 3.2.1. Governmental interventions

In Singapore, the COVID-19 (Temporary Measures) Act 2020 and its Regulations are enacted for the enforcement of wide-ranging public health measures. Safe distancing and the donning of masks outside places of residence are legally mandated, including at worksites.

A special interagency task force was formed to manage COVID-19 in the migrant worker population. A major undertaking is the large-scale, systematic testing of every worker in migrant worker dormitories to identify and separate those with active infection from those who are COVID-19 naïve or recovered. Over the 'circuit breaker' period with construction worksites closed, mass testing of workers was conducted in situ within dormitories.

The different design characteristics across migrant worker dormitories influence COVID-19 transmissibility among the occupants. With the capacity for SARS-CoV-2 polymerase chain reaction (PCR) testing limited in the early days of the pandemic, prevalence sampling was first conducted to group dormitories into uninfected, low, intermediate or high prevalence categories; however, prevalence definitions are not publicly available.

A workflow of systematic testing was then performed where the modality employed depended on the prevalence of the dormitory. In general, a combination of SARS-CoV-2 PCR and serology testing was used in high and intermediate prevalence dormitories, whereas pooled RT-PCR testing was used in low prevalence dormitories. Workers in any positive pooled sample would then be individually tested. Dormitories that did not uncover any cases of COVID-19 infection during prevalence sampling were monitored through regular wastewater-based COVID-19 surveillance [8].

Infected workers with risk factors for severe COVID-19 disease, such as comorbidities and age more than 35 years, were treated in hospitals, whereas those without risk factors were managed in community care facilities. Large exhibition centres and sports halls were retrofitted, equipped with health kiosks for temperature and pulse oximetry monitoring, and staffed by primary healthcare teams to care for stable workers in an out-of-hospital setting.

#### 3.2.2. Industry interventions

The construction sector, with the support from the Government, secured the use of hotels, hostels, unoccupied public housing blocks and military camps as temporary quarters to separately house groups of COVID-19 cleared workers from those who are on quarantine because of close contact with infected co-workers. The temporary decanting of infected workers from dormitories allowed dedensification, facility cleaning and the creation of 'clean blocks' to house COVID-19 naïve and recovered workers.

Medical coverage was provided for every dormitory and housing facility. Tele-medicine services were introduced where workers with acute ailments had timely access to medical consultation by a doctor. Medications were delivered to dormitories. For more

serious cases or workers with respiratory symptoms requiring a PCR test to exclude COVID-19 infection, they were attended to by in situ medical teams or conveyed by dedicated transport to a hospital's emergency department for further evaluation.

#### 3.2.3. Supervisory interventions

Every construction worksite implemented a system of safe management measures. Workers working on different activities are segregated into teams, with each team restricted to working in a single zone. Zonation is clearly demarcated and at least two metres apart. Interaction and cross-deployment of workers across teams or shifts are prohibited. The use of common facilities such as canteens and toilets is staggered by time to only accommodate one team at any time. Safe Management Officers are appointed to ensure compliance.

#### 3.2.4. Interventions to eliminate preconditions and unsafe acts

Unlike previous housing arrangements that cater to employees across companies and industries, workers in the same construction project are now required to be cohorted in dedicated onsite or offsite housing facilities. For offsite housing, dedicated transport is required to and from the worksite.

The health of workers is closely monitored. They are equipped with thermometers and pulse oximeters for daily health monitoring and are required to log this information in a health app (FWMOMCare). Those unwell will report sick to an in situ medical team or a designated clinic and be tested for COVID-19. To prevent incipient outbreaks at the workplace, workers placed on medical leave need to be afebrile and asymptomatic before resuming work.

Workers are also required to download an integrated app (SGWorkPass), which matches worker-specific data to work resumption criteria. The latter includes the worker's latest COVID-19 test result; daily temperature, pulse oximetry and symptom declaration records; not on the Quarantine Order list; the activation of a national contact tracing app in the worker's mobile device; and his accommodation status in a 'clean block'. All criteria must be met before workers are allowed to resume work.

## 4. Discussion

Previous pandemics, such as the Severe Acute Respiratory Syndrome (SARS) in 2003 and Influenza A (H1N1-2009) in 2009, did not significantly disrupt the operations of the construction sector. As a case in point, the advisory issued by Singapore's MOM on workplace measures for Influenza A (H1N1-2009) covered only general environmental and personal infection control measures, without providing specific guidance on the formulation of a pandemic business continuity and work resumption plan for the construction sector [9].

Construction worksites played a contributory role in cross-infections among workers from different companies. Singapore's strategy to enable the safe resumption of construction activities is multiprong, comprising the principles of disease prevention through environmental control; early detection through medical surveillance; and containment through rapid response and intervention to limit the impact of COVID-19 transmission on workers and work operations.

Environmental control needs to be applied both at the workplace and place of accommodation. Simulation studies show that a combination of quarantine and staged resumption of work is the safest approach to reduce the risk of workplace COVID-19 transmission [10]. Singapore's additional practice is for workers working on different construction activities in the same worksite to be geographically segregated (e.g. working in designated zones) and temporally spaced (e.g. staggered timings for entry and exit to



work, use of shared facilities such as toilets and canteens). Cohorting is also extended beyond work and similarly applied to transportation conveyance and housing arrangements in order to minimise cross-interactions with other worker groups.

COVID-19 has introduced the need for additional personal protective equipment apart from helmets and safety harnesses. The use of face masks is mandated even at the workplace, but this is fraught with challenges because of higher breathing rates, perspiration, fogging of safety glasses and overall discomfort, especially when performing strenuous tasks [11]. Strict enforcement remains problematic.

Medical surveillance with fortnightly routine SARS-CoV-2 PCR testing is mandated for every worker. This approach is based on the evidence of presymptomatic and asymptomatic COVID-19 transmission [12]. Routine testing is important also because cases of reinfection have been reported, suggesting that adaptive immunity from natural COVID-19 infection may not be long-lasting in all cases [13]. To complement Rueda-Garrido et al.'s proposed clinical guidelines for safe work resumption, there should be a system for the continued health surveillance of workers already at work [14]. To this end, Singapore has leveraged technology in the form of a health mobile application (FWMOMCare) and a return-to-work application (SGWorkPass) to facilitate the mass enforcement and monitoring of worker's health so that those with early symptoms can be expeditiously identified and managed [6].

Once a suspect or confirmed COVID-19 case is detected, work will stop immediately in the affected work zones, which will be cordoned off. Disinfection will be carried out for tools, construction equipment and shared facilities such as rest areas. Contact tracing will be conducted, aided by the TraceTogether tokens carried by all workers where anonymised proximity information using Bluetooth is exchanged [15]. Close contacts will be placed in quarantine and will be cleared with COVID-19 PCR testing after 14 days from the last contact with the infected case before being allowed to resume work.

Preliminary evidence supports the combined strategy of case isolation and close contact quarantining and workplace distancing in reducing COVID-19 outbreak size, with the estimated median number of infections reduced by 99.3% and 78.2% when reproduction numbers were 1.5 and 2.5, respectively [16]. While more data is needed to prove the effectiveness of these measures, it is noteworthy that there have been no construction worksite COVID-19 clusters by October 2020, five months after workers were progressively allowed to resume work.

The Singapore case study has cast the spotlight on the vulnerabilities faced by migrant workers [17]. The construction sector, conventionally viewed as a risky occupation with falls from heights, the collapse of structures and equipment as common causes of workplace injuries and fatalities, now has to grapple with another more pervasive occupational hazard. The availability of the COVID-19 vaccine is another risk control lever that is now available, with Singapore planning to prioritise vaccination for workers in jobs and settings where the risk of a super-spreading event is high, such as the construction sector [18]. The way in which work and workers are organised in the industry will have to change to mitigate, or better yet,

prevent worksites as the common denominator in communicable disease transmission.

### Conflict of interest

The authors, Wee Hoe GAN and David KOH, do not have any conflict of interest to declare.

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