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COVID-19 infection and the broader impacts of the pandemic on healthcare workers

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Abstract

The severe acute respiratory syndrome coronavirus (SARS-CoV-2) disease or COVID-19 pandemic is associated with more than 230 million cases and has challenged healthcare systems globally. Many healthcare workers (HCWs) have acquired the infection, often through their workplace, with a significant number dying. The epidemiology of COVID-19 infection in HCWs continues to be explored, with manifold exposure risks identified, leading to COVID-19 being recognised as an occupational disease for HCWs. The physical illness due to COVID-19 in HCWs is similar to the general population, with some HCWs experiencing a long-term illness, which may impact their ability to return to work. HCWs have also been affected by the immense workplace and psychosocial disruption caused by the pandemic. The impacts on the psychological well-being of HCWs globally have been profound, with high prevalence estimates for mental health symptoms, including emotional exhaustion. Globally, governments, healthcare organisations and employers have key responsibilities, including: to be better prepared for crises with comprehensive disaster response management plans, and to protect and preserve the health workforce from the physical and psychological impacts of the pandemic. While prioritising HCWs in vaccine rollouts globally has been critical, managing exposures and outbreaks occurring in healthcare settings remains challenging and continues to lead to substantial disruption to the health workforce. Safeguarding healthcare workforces during crises is critical as we move forward on the new path of 'COVID normal'.

KEYWORDS
COVID-19 infection, epidemiology, healthcare workers, mental, occupational medicine

INTRODUCTION

The severe acute respiratory syndrome coronavirus (SARS-CoV-2) disease or COVID-19 pandemic is now associated with more than 230 million cases and in excess of 4.7 million deaths, creating major challenges for healthcare systems globally. Amongst the millions of people infected with the virus worldwide are a significant number of healthcare workers (HCWs), who have acquired the infection through their workplace. For many reasons, including inconsistencies in reporting and the widespread disruption generated by the pandemic, the true number of HCWs infected, hospitalised or who have died remains unknown. Importantly, COVID-19 is now recognised as an occupational disease, with important responsibilities and consequence for employers and healthcare organisations. This article will review the epidemiology of COVID-19 infection and illness in HCWs, describe the psychosocial disruption that HCWs have experienced during the pandemic, including mental health impacts, and then discuss occupational policies and practices to prevent COVID-19 infection in HCWs.

EPIDEMIOLOGY OF COVID-19 INFECTION IN HCWs

The pandemic has likely had greater impact on healthcare systems as a result of repeated waves,[1] with heaviest impacts occurring during winter or wet seasons.[2] The combination of waves and seasonality places additional stress on healthcare systems and HCWs. The pathogenesis of COVID-19 can be described in three stages: infection with

SARS-CoV-2, the development of COVID-19 symptoms and possible progression to 'post-COVID-19 syndrome' (also known as 'Long-COVID').[3] COVID-19 is the acute disease and post-COVID-19 syndrome is defined as physical and mental health consequences of SARS-CoV-2 infection that persist for longer than 3 months.[4] Infection is the only necessary precursor to both acute disease and post-COVID-19 syndrome; however, the latter can occur without the expression of symptoms in the acute infection phase.[5]

The incubation period for SARS-CoV-2 is a median of 5 days and mean of 7.8,[6] now revised down to a mean of 4 days for the B.1.627.2 (Delta) variant, and the infectious period can begin within 2 days of exposure.[7,8] The infected person is therefore infectious for two or more days in the pre-symptomatic period, with no signs to alert them that they are unwell, or that can be picked up on symptom screening. Furthermore, there is a rapid rise to peak viral load, so the asymptomatic person may be most infectious in the pre-symptomatic period.[7]

SARS-CoV-2 is transmitted by exposure to infectious respiratory fluids, originally thought to be primarily via droplet spread, but increasingly airborne transmission has been implicated, leading to a rethink of standard definitions for close contacts that focused on those with direct contact for 15 minutes or more, or an extended exposure within a closed airspace. Higher viral loads, such as the 1000-fold higher load reported for the Delta variant,[7] can encourage the formation of aerosol clouds.[9] In the laboratory setting, viable virus particles can remain suspended in the air for up to 16 h.[10] There are now documented examples of aerosol transmission captured in outbreak investigations, including transmission between passing strangers in a department store in the first generation of spread of the Australian Delta wave.[11]

SARS-CoV-2 may also be transmitted via other routes including transfer from contaminated surfaces. Viral RNA has been found during environmental sampling in hospital settings, but there is no firm evidence of viable virus particles, and relatively scant contamination has been observed even when an infectious patient was present.[12,13] In general, contaminated surfaces are not considered to be a major risk, but remain a possible, if not common, transmission risk.[14] None of these mechanisms of transmission are mutually exclusive and all may be in play within high-risk transmission settings.

HCWs have been prioritised in vaccine rollouts globally, although some are still waiting on their first dose in countries that have limited vaccine supply. In other countries where vaccine supply is not a barrier (including Australia and the United States), vaccine uptake has been low enough among HCWs to warrant mandating.[15,16] The efficacy of vaccines against serious illness is generally very high, in the order of 95%, and remains undiminished for AstraZeneca and Pfizer vaccines for infections with the Delta variant.[17] However, the effectiveness against symptomatic infection, or any infection, has dropped to 30%–35%, posing a risk to even highly vaccinated settings.[4] Initial peak viral loads in Delta infections are also reported to be as high in vaccinated people as unvaccinated.[18] Viral loads have been observed to decrease faster in breakthrough infections in the fully vaccinated,[19] although the protection this might afford against forward transmission appears to diminish after 3 months.[20]

The occupational risks of acquiring COVID-19 associated with healthcare settings are multi-fold.[21,22] From an epidemiological perspective, there is an elevated exposure risk, both with symptomatic patients presenting who might be infectious, and workers (whether clinical or in another role) often working across different teams and workplaces increasing their potential exposure. In turn, if a worker is infected, they can potentially transmit the virus across teams, wards or hospitals if the infection is not detected between shifts. Additionally, HCWs such as paramedics may also work across many emergency departments in one shift. Repeat exposures are also likely when the virus is circulating in the community, patients are very unwell and highly symptomatic thus potentially generating high infecting doses, and with increased exposure during high-risk airway procedures that lead to virus aerosolization.[23] Healthcare settings are also high risk because of the vulnerability of the patients, who are more susceptible to infection and at risk of more serious outcomes.[24] There is the additional risk of nosocomial transmission involving workers or other patients leading to healthcare outbreaks.[25]

A review of infection prevalence in HCWs using data from 2020 across 97 healthcare settings in Europe, the United States and Asia found it to be in the order of 7% based on the presence of antibodies and 11% using reverse transcription PCR (RT-PCR) assays.[26] Nurses were found to have the highest infection rates. This is consistent with Australian data. In the Australian state of Victoria, 1034 of 3690 HCW infections reported in the pandemic were amongst nurses, and 1290 were aged care and disability workers.[27] The proportion of infections reported to be due to acquisition in the healthcare setting was 74%–78%.[27]

Managing exposures and outbreaks occurring in healthcare settings is challenging. The need to furlough staff deemed to be close contacts adds to the complexity of managing transmission risk in health care and has created substantial disruption to the health workforce. With vaccination coverage of HCWs on the rise (November 2021), the need to furlough or quarantine staff is likely to be reduced unless the outbreak is in a particularly sensitive setting with vulnerable patients, or a new variant of concern changes the epidemiology.

PHYSICAL HEALTH EFFECTS OF COVID-19 INFECTION IN HCWs

In the United States early in the pandemic, HCWs accounted for 11% of reported cases of acute COVID-19 infection, and 8% of infected HCWs had an illness severe enough to require hospitalization.[28] A survey of 37 nations found an average death rate of 0.05 per 100,000 population amongst HCWs infected with COVID-19.[29] A report from the Guardian Newspaper's Lost on the Frontline Investigation identified that over 3600 HCWs in the United States died in the first year of the pandemic.[30]

In Australia, a well-characterized hospital outbreak identified that the majority of COVID-19 cases were amongst nurses, with the second largest group infected being non-clinical, support staff.[31] Overall, the rate of very severe disease was not insignificant, with two of 262 cases requiring admission to the intensive care unit (ICU).[31] In the first 3 months (1 March to 31 May 2020) of the pandemic in the United States, HCWs comprised 5.9% of all adults requiring hospitalization, with nurses representing the greatest proportion of these at 36.3%. The nature of the COVID-19 illness was variable but often severe in HCWs, with 27.5% admitted to an ICU, 15.8% requiring invasive mechanical ventilation and 4.2% died during hospitalization.[32]

HCWs perform a variety of roles that may have greater or lesser degrees of contact and interaction with patients. Many staff are regarded as having a non-clinical role if they do not directly provide patient care, but support the healthcare institution by providing services such as cleaning, food preparation or security services. A prospective cohort study of HCWs presenting with symptoms for COVID-19 testing to a hospital[33] determined that the cumulative infection rate was 8.9% over a 9-month period, with staff in non-physician roles more likely to test positive even when controlling for contact with family or community members who were known to be infected. The likelihood of infection in an HCW has been demonstrated to be related to reduced hand washing and working longer shifts.[34] A retrospective study of HCWs infected with COVID-19 in Wuhan found that staff with severe illness were generally younger than those with milder disease.[35]

While HCWs are frequently younger adults without underlying medical conditions, they are not spared severe illness. The initial presenting symptoms of HCWs is similar to that of the general population, with shortness of breath, cough and fever being present in three quarters of HCWs admitted to hospital.[32] Where data were recorded for HCWs ($n = 327$), the chest radiograph findings comprised infiltrates or consolidation in 87% and pneumonia in 32%. Pleural effusions were uncommon, being identified on 6.3% of chest radiographs, but seen on 9.3% of computed tomography (CT) chest scans. This may reflect either the greater sensitivity of CT scans to detect abnormalities, or the increased disease severity of those HCWs referred for CT scanning.[32]

In a retrospective cohort described by the US Centers for Disease Control and Prevention,[32] HCWs admitted to hospital ($n = 438$) predominately had a respiratory illness with clinical discharge diagnoses revealing pneumonia in 57%, acute respiratory failure in 43% and acute respiratory distress syndrome (ARDS) in 9%. Extra-pulmonary complications were also seen with sepsis in 13% and acute renal failure in 10%. Data on thrombo-embolic events were recorded in a total of 159 HCWs, of whom 6% had pulmonary embolism.[32] Additionally, a retrospective cohort study of 121 HCWs, which was collected as part of a comparative study of COVID-19 illness in patients with sickle cell disease, identified that 23% of HCWs acquired COVID-19 infection over a 6-month period from June 2020 to January 2021.[36] These HCWs often had mild symptoms, with myalgia being the most commonly reported (66%); only 8% had abnormalities on chest radiograph and 2% had severe pneumonia or ARDS.[36]

A structured retrospective review of patients with COVID-19 infection presenting to a large tertiary hospital in New York identified 193 HCWs amongst 2842 patients.[37] HCWs were generally younger in age and had fewer comorbidities than the remainder of the cohort. The illness was generally milder but not insignificant in HCWs, with 6% having a raised respiratory rate at presentation, 8% were hypoxaemic and 20% had bilateral opacities on chest imaging. Compared with non-HCWs in the cohort, HCWs were more likely to have leukopaenia and elevated aspartate transaminase, but a similar proportion in both groups had an elevated C-reactive protein. These findings may represent a more robust immune response, despite milder disease, in the younger HCW cohort. Nevertheless, despite their younger age and milder disease, 20% of HCWs required admission to hospital, with 4% requiring admission to ICU and two dying.[37]

Infected HCWs generally have a similar pattern of disease symptoms compared to people infected with COVID-19 in the general population. However, one German cohort study of 200 asymptomatic to moderate COVID-19 illness in HCWs[38] described an increased incidence of cutaneous hyperaesthesia at 5%. It is unclear if this finding arose due to specific leading questioning or a true variation in the disease manifestation in these HCWs.[38]

In addition to the potential severity of acute COVID-19, persisting symptoms may last many months and can be significantly debilitating. The long-term consequences of COVID-19 infection vary from person to person and continue to be characterized. HCWs, similar to other people infected with COVID-19, may experience a long-term illness; however, to date, no studies have focused exclusively on the long-term effects of COVID-19 infection in HCWs. Therefore, our current understanding of post-COVID-19 syndrome is based on studies of all people who have been infected with the virus. In one prospective cohort study of hospitalized patients in Norway, half reported dyspnoea and one quarter had reduced gas transfer on lung function testing 3 months after the initial infection.[39] Early reports suggest that reduced gas transfer is the most common lung function abnormality at the time of discharge from hospital (mean of 28 days after symptom onset), followed by a restrictive ventilatory defect, with these impairments being more prevalent in people who had a severe initial viral pneumonia requiring oxygen support.[40] Furthermore, a systematic review and meta-analysis found a pooled prevalence, at an average of 30 days after symptom onset, of reduced diffusion capacity in 39%, a restrictive ventilatory defect in 15% and an obstructive defect in 7% of patients infected with COVID-19.[41] However, many of the studies in this analysis included a significant number of COVID-19 patients with underlying respiratory diseases, such as asthma and sarcoidosis, which would have contributed to impaired lung function.

Distinctive findings on CT chest scan change over time. While ground-glass changes tend to resolve following acute viral infection, interstitial thickening and parenchymal bands appear to precede pulmonary fibrosis.[42] A retrospective cohort study demonstrated that during the early convalescence phase (within 30 days of discharge) there was no significant correlation between the radiological total severity score and any lung function parameters, including spirometry and gas transfer measurements.[43] This study included a small percentage of patients who had no residual imaging abnormalities, but had a decreased gas transfer. However, in the acute phase, total radiological severity score was negatively correlated with total lung capacity and airways resistance (R20) measured by impulse oscillometry.[43] Therefore, impairment of pulmonary function may not be isolated to those with persistent changes on imaging. Persistent abnormalities of the pulmonary vascular bed have also been identified by imaging techniques including ventilation perfusion single-photon emission computerized tomography scans and dual-energy CT scans.[44] However, the ideal test for follow-up studies has not yet been determined.

Organ systems other than the lungs are affected by COVID-19 including the cardiac and musculoskeletal systems, and these effects can be sustained. A significant proportion of patients continue to have myocardial inflammation, as determined by MRI, more than 2 months after the initial COVID-19 infection, including many patients who were either asymptomatic or only mildly symptomatic during the initial illness.[45] Additionally, deconditioning may occur, including myopathy which reduce the ability to perform tests such as spirometry.

The long-term effects of infection specifically in HCWs have not been fully elucidated; however, HCWs make up a significant proportion of patients with persistent symptoms described as 'post-COVID-19 syndrome'.[46] A study of HCWs with mild or asymptomatic COVID-19 infection, as determined by seropositive status without significant symptoms, found that persistent symptoms were frequent and often debilitating.[47] In this study, HCWs without significant symptoms at baseline were invited to participate, and those with seroconversion during the study were excluded. Both cohorts were predominately female, with chronic illness present in one fifth of both groups. Seropositive patients were more likely to have symptoms markedly disrupting their work (relative risk [RR] = 1.8 [95% CI, 1.2–2.9]), social (RR = 2.5 [95% CI, 1.8–3.6]) or home life (RR = 2.3 [95% CI, 1.6–3.4]), and 11% of seropositive participants had moderate to marked disruption in any Sheehan Disability Scale category compared with 2% of seronegative participants.[47]

MENTAL HEALTH AND BROADER IMPACTS OF THE PANDEMIC

While a significant number of HCWs globally have been infected with COVID-19, importantly, *all* HCWs have been affected by the immense workplace and psychosocial disruption caused by the pandemic. Measures to contain the pandemic have included rapid adoption of social distancing restrictions, stay-at-home orders and major changes to the delivery and accessibility of health care, with impacts on the psychological well-being of the general public[48] and HCWs (Box 1).[49] Additionally, the pandemic has generated substantially increased workplace demands and stressors for HCWs including: increased workloads, large volumes of new information, new work practices (such as telehealth and the use of personal protective equipment [PPE]), redeployment or job insecurity and increased risks to their own lives and of family members.[50,51] The COVID-19 pandemic therefore represents a profound additional threat to the mental health of HCWs, who, prior to this crisis, were well recognised as experiencing increased rates of occupational burnout, anxiety, depression, suicidal ideation and completed suicide compared with other occupations.[52–58] Evidence regarding the impacts from the SARS pandemic demonstrated that the mental health of many HCWs was adversely affected, with potentially long-lasting mental health effects.[59,60] Importantly, poor mental health has major consequences not only for health practitioners themselves, but also affects the quality and safety of patient care, workforce retention and engagement.[61–64]

Estimates of the prevalence of mental health symptoms in HCWs during the COVID-19 pandemic have been examined in many countries, mostly through the use of single time-point, online surveys. A survey of 26,174 HCWs in the United States by the Centers for Disease Control and

BOX 1 Mental health effects of the pandemic

Common mental health impacts	Common risk factors
• Burnout • Anxiety • Depression • Post-traumatic stress disorder • Moral distress	• Younger age • Female sex • Nursing role • High exposure risk to COVID-19 • Low perceived workplace support • Low levels of training, workplace disruption • Perceived stigma • Family members infected with COVID-19 • Prior mental health diagnoses • Chronic physical health conditions

Prevention indicated that 53% had symptoms of at least one mental health condition; therefore, the overall illness burden was high.[65] Meta-analyses of data from surveys of HCWs undertaken early in the pandemic suggest that the prevalence of anxiety was 22.1%–25.8%, depression 21.7%–24.3% and post-traumatic stress disorder 21.5%.[49,66,67] By contrast, a large Australian survey, which included complete responses from almost 8000 HCWs undertaking all types of roles in primary and secondary care during the second wave of the pandemic (August to October 2020), identified higher prevalence estimates of mental health symptoms, including: anxiety 59.8%, burnout (emotional exhaustion) 70.9% and depression 57.3%, despite participants having very high resilience scores.[51] Some meta-analyses have examined the psychosocial impacts of the COVID-19 pandemic on HCWs compared to the general population.[68–71] These analyses demonstrated that the prevalence of anxiety, depression and other adverse mental health outcomes was significantly greater in HCWs than in the general public.[68–71]

Many studies have examined the independent personal or workplace risk factors associated with increased mental health symptoms in HCWs. Independent risk factors associated with anxiety, depression and burnout included: younger age,[51,72] female sex,[51,72–77] nursing role,[51] inadequate protection against COVID-19 or high risk of exposure to COVID-19,[51,73,74,77,78] having a family member with COVID-19,[51,78] pre-existing mental illness,[51,75] chronic physical health condition,[78] poor workplace communication and psychological support,[50,72] working increased unpaid hours,[50] being redeployed or changing role,[50] low levels of training or experience[72] and perceived stigma associated with working in frontline areas.[72,74,76,79] While working in high-risk environments with patients infected with COVID-19 has been identified as a risk factor for mental illness,[72] HCWs have experienced high levels of mental health symptoms irrespective of caseload of COVID-19 patients.[51] Importantly, access to sufficient medical resources (including PPE), up to date and accurate information and taking measures to reduce infection transmission have been associated with better psychological well-being during the COVID-19 pandemic.[50,51,66,69]

In addition to poor mental health, many HCWs have experienced moral distress during the COVID-19 pandemic.[80–83] Moral distress, also referred to as 'moral injury', is defined as '*perpetrating, failing to prevent, bearing witness to or learning about acts that transgress deeply held moral beliefs and expectations*'.[84] Moral distress can arise when HCWs cannot deliver usual 'best practice' patient care (e.g., due to scarcity of resources), or perceive that they have failed to meet patients' needs or are unable to prevent harm or death.[85–87] Moral distress has been identified in HCWs during previous infectious disease epidemics and pandemics.[88–90] During the COVID-19 pandemic, HCWs have commonly reported concerns regarding the inability of healthcare services to respond to increased caseloads of patients (both with and without COVID-19),[82] resource scarcity, excluding families from patients' bedsides and fears of letting co-workers down if they became infected with COVID-19.[82,83] Importantly, reporting these indicators of moral distress was associated with an increased risk of experiencing anxiety, depression, post-traumatic stress disorder and burnout. By contrast, HCWs who felt appreciated by the community were less likely to endorse indicators of moral distress.[83] Such public initiatives to demonstrate community appreciation and gratitude for HCWs have been popular throughout the COVID-19 pandemic.

To inform future policies and crisis preparedness, it is crucial that governments and a wide range of healthcare organizations understand both what types of coping strategies have been adopted by HCWs and their efficacy in preserving psychological well-being during the COVID-19 pandemic. Coping strategies can be broadly categorized as: social supports, positive thinking, problem-solving and escape-avoidance, with most people utilizing multiple strategies. Social support behaviours include discussing emotions and concerns with others or seeking advice. HCWs commonly utilize this adaptive strategy, particularly during crises, with evidence that utilizing social supports is associated with well-being and favourable mental health outcomes both during and after crises, including during the current pandemic.[91–95] Importantly, social restrictions and lockdowns, which have been imposed in many countries to control the dissemination of COVID-19, have made it challenging for HCWs to maintain social supports or access new support services, which is one explanation as to why this approach has been less commonly adopted during the pandemic.[96,97]

Escape-avoidance style coping is conventionally grouped into negative coping strategies and encompasses behaviours associated with denial, withdrawal and wishful-thinking. Whilst negative coping strategies are generally associated with poorer outcomes,[92,98] the prolonged and uncontrollable nature of COVID-19 restrictions has provided a unique setting in which escape-avoidance strategies can enable a sense of control and be both popular and favourable. Physical exercise has been one of the most frequently used escape-avoidance strategies adopted by HCWs during the COVID-19 pandemic,[97] with some evidence that it is associated with fewer mental health symptoms.[96] HCWs in some countries commonly use alcohol consumption as a maladaptive coping strategy to manage occupational stress both during daily life and crises.[96,99,100] During the COVID-19 pandemic, 26.3% of Australian frontline HCWs reported increasing their alcohol consumption as a coping strategy, with increased alcohol intake being associated with worse mental health symptoms.[96]

The prevalence of suicidal and self-harm ideation amongst HCWs is highly concerning. A meta-analysis of 61 studies identified that the prevalence of suicide attempts was 1.0% and of suicidal ideation was up to 17% in physicians during usual, daily life.[101] The prevalence of suicidal ideation has been reported as between 3.6% and 8.4% in HCWs during the COVID-19 pandemic,[102–104] and a UK study found that 13% of HCWs in the ICUs had had thoughts of self-harm during the pandemic.[105] Risk factors for suicidal ideation or thoughts of self-harm during the pandemic include: existing mental illness, having been hospitalized with COVID-19 infection, family members infected with COVID-19, self-rated probability of contracting COVID-19, perceived stress, lack of organizational communication and coordination, lack of personnel or supervision in the workplace and financial stress.[102–104] By contrast, those who reported increased social support, had higher self-rated health, were more willing to work with COVID-19 patients, felt supported and were confident in defeating COVID-19 were at lower risk.[103,104]

It should be noted that our current knowledge regarding HCW mental health during the COVID-19 pandemic is limited and predominantly arises from survey data. Many of these surveys were conducted very early in the pandemic and have been affected by selection bias due to the nature of voluntary participation, had low or incalculable response rates and generally only measured outcomes on a single occasion. Additionally, most surveys measured mental health symptoms from responses to validated symptom scales (not clinical assessments), as this is the only feasible method to understand and compare the impacts on very large numbers of HCWs worldwide. There have been no large studies that have specifically compared the mental health impacts of the pandemic on HCWs who have been infected with COVID-19 compared to those uninfected. Furthermore, current research has focused on the prevalence estimates of, and risk factors for, mental health symptoms in HCWs, with very little attention given to designing evidence-based approaches to preserve HCW well-being. Therefore, there remain many unanswered questions, particularly regarding the longitudinal mental health effects of the pandemic on HCWs.

BOX 2 Occupational medicine responses to the pandemic

- Vaccination of healthcare workers (including awareness campaigns and mandates)
- Patient isolation (including negative pressure rooms, patient cohorting, minimization of transfers)
- Restrictions on patient visitors
- Improving workplace ventilation and use of HEPA filters
- Staff education regarding infection control
- Contact and droplet precautions
- Implementation and revision of furlough and return-to-work guidelines
- Fit testing of respirators and masks
- Provision of staff PPE (including gloves, gowns, respirators or surgical/N95 masks, face shields, eye protection)
- Appropriate disposal of PPE

Abbreviations: HEPA, high-efficiency particulate air; PPE, personal protective equipment.

POLICIES AND PRACTICES TO PREVENT COVID-19 INFECTION IN HCWs

COVID-19 is the first new occupational disease to be described in the past decade,[106,107] with HCWs at risk.[108] There have also been suggestions that post-COVID-19 syndrome should be recognized as an occupational disease.[108] The public health principles of physical distancing, cough etiquette and hand washing proved difficult in practice to prevent worldwide transmission of COVID-19 and this difficulty increased with the emergence of the Delta variant with its increased transmissibility. Test, trace, isolate and quarantine interventions have only been partially effective in preventing the rapid spread of COVID-19 throughout the world, mainly because transmission occurs in asymptomatic individuals. Restriction of movement has been the most effective means of limiting spread.[109]

Initial guidelines were based on infection control procedures developed in response to the HIV epidemic of the 1980s and influenza pandemic planning.[110] Guidance recommended contact and droplet precautions, including surface cleaning, hand hygiene, the use of gloves and gowns, single-use equipment wherever possible and masks and eye protection. Additionally, patient isolation or cohorting and minimizing patient transfers were advised. Particulate respirators, eye protection and impervious gowns and gloves were advised for all aerosol-generating procedures (AGPs) performed in a negative pressure room, if available. Surgical masks were recommended for those entering an infectious area or coming within 1 or 2 m of an infectious patient.[111]

With the evolution of our knowledge of the SARS-CoV-2, clinical practice and procedures have been updated, and medical guidelines have been developed to better protect HCWs against acquiring the infection (Box 2).[112] Guidelines were based on pandemic influenza and included additional precautions based on the hierarchy of controls,[113] an established approach to control workplace hazards using different tiers of effectiveness to reduce exposure and hence workplace illness or injury (Figure 1). These tiers include elimination, substitution, engineering controls, administrative controls and PPE, with decreasing levels of degree of protection and reliability. Combining the hierarchy of controls with the predominant host–agent–environment infectious disease model can help guide efforts to stop occupational transmission,[113] especially as HCWs may be both the target and the source of infection.[115] Outbreaks in hospitals, primary care, aged care, disability care, community and home care services draw attention to the risks of HCWs contracting COVID-19 and also subsequently acting as vectors for transmission.[116]

Although PPE received considerable attention due to national shortages, process and system changes should be the primary tools to prevent unnecessary hazards to HCWs and to reduce PPE wastage. Eliminating or containing hazards and reducing the number of workers exposed are the most effective strategies.[110]

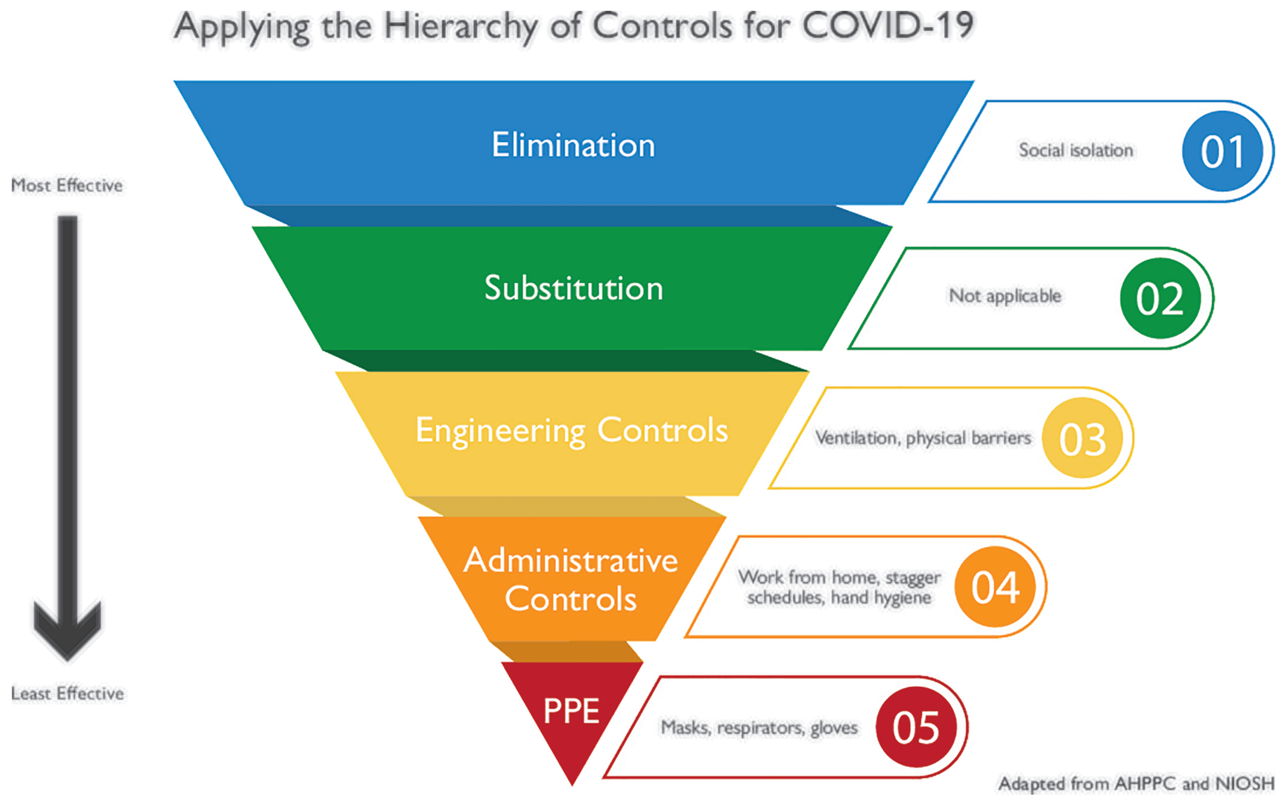

FIGURE 1 Hierarchy of controls. Image used with permission from WorkSafe Tasmania[114]

A sound understanding of the interplay between risk factors and potential controls can help inform policies such as an infectious disease prevention standard that effectively applies the precautionary principle[117] to protect workers. This has proven to be effective in practice but requires a risk assessment of workplaces to determine the appropriateness of controls[118,119] as the hazard from SARS-CoV-2 is not quantifiable in a workplace. Guidance has changed as evidence has emerged but has been included in advice on infection control.[120]

There have been considerable changes and advice on protection of HCWs and particularly on indirect transmission, ventilation and the use of PPE. The application of the hierarchy of controls for various disciplines and various procedures has been produced for a number of health disciplines, including: intensive care,[121] perioperative rooms,[122] dental surgeries,[123] laboratory workers,[124] pharmacists,[125] orthodontists,[126] anaesthesia[127,128] and operating theatres.[129]

Elimination of COVID-19 is unlikely to be achieved by immunization alone. Border controls, restricting access and telemedicine can protect HCWs by removing the hazard from the workplace or remove proximity to SARS-CoV-2.[110] Procedures can be substituted to be less aerosol generating[130] by the use of spacers instead of nebulizers[120] and the use of disposable bronchoscopes.[131] The American College of Occupational and Environmental Medicine has recently published guidelines for procedures to be followed for routine spirometry. These are based on the hierarchy of controls and recommend precautions to be used based on risk assessments.[119]

VACCINATION OF HCWs

HCWs are an especially important risk group where effective vaccination coverage is essential because of the risk of occupationally related infection.[132] Reports of vaccination intentions in HCWs for COVID-19 have been published from many regions and countries. A low rate of vaccination adverse events in HCWs should reduce vaccine hesitancy.[133] Messages emphasizing the personal risks of failing to vaccinate against COVID-19, as well as the potential collective public health consequences of low vaccine uptake, are effective at convincing individuals to have a COVID-19 vaccine,[134] while reporting of vaccine data provides accountability and transparency to build trust in public health.[135] Although mandatory vaccination of all HCWs would appear to be a sensible public health approach, this is difficult because of political and supply considerations and access to immunizations. Mandatory vaccination may be required as employers have a duty of care to eliminate or minimize risks as far as is reasonably practicable[120] including consideration of the precautionary principle.[117]

A rapid systematic review of HCWs noted that vaccine acceptance varied widely between countries and ranged from 27.7% to 77.3%.[136] Although HCWs had positive attitudes towards future COVID-19 vaccines, vaccine hesitancy was still common. Vaccine hesitancy was more common in women and nurses and in non-clinical HCWs. Concerns for safety, efficacy and effectiveness and distrust of the government were barriers.[136] A UK study reported a rate of vaccine hesitancy of 21.3% in White British HCWs but significantly higher in other ethnic groups.[137] Predictors of hesitancy were younger age, female sex, higher score on a COVID-19 conspiracy beliefs scale, lower trust in employer, lack of influenza vaccine uptake in the previous season, previous COVID-19 and pregnancy.[137] Only 38.1% of HCWs in primary care in Dubai reported using scientific journals or research papers as their primary sources of information during the outbreak.[138] Correct knowledge about the virus was significantly associated with pro-vaccine attitudes of HCWs of an inner city hospital in New York.[139] Investing in the staff responsible for delivering vaccines in the workplace, as well as other potential vaccine allies, such as managers, can help reduce COVID vaccine hesitancy amongst HCWs.[140]

WORKPLACE VENTILATION

Ventilation has emerged as an important factor in reducing transmission of COVID-19. Controversy arose in the different guidance regarding the appropriate infection control procedures and use of PPE[141] reducing the transmission of SARS-CoV-2. Differences arose between guidance based on evidence, the precautionary principle and traditional concepts of aerosols. Evidence from influenza favoured direct or indirect (fomite) contact or droplet spread. Airborne spread was only considered to occur during AGPs.[112] No study had definitively established airborne transmission as a major route of influenza transmission, but multiple studies suggested that some airborne influenza transmission may occur. The presence of significant airborne transmission would indicate the greater need for ventilation procedures and respiratory protection than that afforded by a surgical mask.[142]

Early in the COVID-19 pandemic, there was evidence of airborne spread beyond 2 m, notably in a restaurant in Korea where there was video evidence that indirect transmission had occurred over at least 6 m.[143] There were calls to recognize the potential for airborne spread[144] and increased when the Delta variant arrived with its increased transmissibility. Airborne transmission of a virus has been reported previously. Measles was contracted in a paediatrician's office by indirect spread,[145] and in a measles outbreak in a US school[146] even where 97% of students were vaccinated.

Guidance changed with emerging knowledge of respiratory transmission which challenged the existing dogma about how infectious disease is transmitted in droplets and aerosols. The traditional dichotomy between droplet versus aerosol-based transmission was considered overly simplistic.[147] A review of the evidence of aerosol transmission of SARS-CoV-2 added support that aerosol transmission of SARS-CoV-2 was plausible.[148] Bourouiba[149] asserted that it has been established over the past decade that 'exhalations consists of a continuum of droplet sizes embedded in a turbulent exhalation cloud trapping and transporting them'. A forensic review of the literature revealed how the misconception of aerosols had arisen and been perpetuated.[150]

Respiratory particles of all sizes can carry virus and all are potentially capable of transmitting infection. Transmission risk during medical procedures is related to a combination of forced air, symptoms and disease severity, distance and duration of exposure.[147] Virus-laden aerosols up to 100 μm in diameter[151] can accumulate in poorly ventilated spaces and can be dispersed by air movement.[152] The growing body of evidence showing aerosolization of COVID-19 highlights the risk of inadvertent exposure for HCWs and supports the use of airborne precautions at all times.[153,154] Following increased awareness of the aerosol transmission, the Centers for Disease Control and Prevention updated guidance on improving ventilation and building design.[155] Some recommended modifications to buildings are not necessarily cost effective. UV light can be effective at infection control but has limitations with large volumes of air and is associated with occupational hazards.[119,156] Recommendations for UV light to be installed in air conditioning ducting overlook that most transmission occurs in the immediate proximity to infected people. High-efficiency particulate air (HEPA) filters are a cost-effective means of control to supplement ventilation and can be used with AGPs and when negative pressure rooms are not available, but with a requirement for increased maintenance and changing of filters.[119,157–159]

MASKS, RESPIRATORS AND FIT TESTING

In March 2019, the World Health Organization (WHO) recommended that particulate respirators (e.g., NIOSH-certified N95, EU FFP2 or equivalent masks) be used by HCWs only when AGPs are performed and not during routine care of pandemic influenza patients.[160] In contrast, the US Occupational Safety and Health Administration (OSHA) recommended implementation of airborne precautions against a respiratory illness, when the circulating pathogen was known to cause severe disease, and the transmission characteristics of the infecting organism were not well characterized.[142]

The conflict between evidence-based and the precautionary principle-based guidance resulted in differences in recommendations especially with respect to PPE.[161] This was exacerbated by the shortage of PPE particularly with respect to the availability of N95 masks. The research gap, and the risk of aerosol transmission during AGP, was summarized in a systematic review of SARS-CoV-1, noting this may not be generalizable to other acute respiratory pathogens, including influenza virus.[162]

Surgical masks are designed to protect the sterile field from contaminants generated by the wearer. Air leakage occurs around and through them, and they only provide minor protection to the wearer against airborne droplet infection.[163] Surgical masks may be useful in public, if the risk is low or to prevent transmission to others.[164] Respirators are effective against aerosols and provide protection against particles of dust, dirt, viruses and bacteria, but not gases or vapours.[165] They are classified by the efficiency at which they remove particles (95%, 99%, and 100%). Filtration efficiency alone does not guarantee protection.

Although low certainty evidence suggests that medical masks and N95 respirators offer similar protection against viral respiratory infection in HCWs during non-aerosol-generating care,[166] a high infection rate of COVID-19 was found among HCWs despite safety guidelines. Therefore, respirators are recommended in all patient contacts with confirmed or suspected COVID-19.[167,168] A particulate respirator that has not been fitted properly may leave unprotected gaps between the respirator and the wearer's face which impairs its effectiveness. Where job duties require respirators to be worn, annual fit testing is required. Fit testing is also required if a different respirator is used or for changes in facial characteristics.[169] Wearers should be provided with a health assessment and training on the use of the device. There are now detailed procedures published on annual fit testing, or when there are changes in respirators, or changes in facial features from either weight changes or illness.[119] An excellent review of fit checking and fit testing of respirators has been published.[151] Prolonged use of N95 and surgical masks during COVID-19 is reported to have caused adverse effects such as headaches, rash, acne, skin breakdown and impaired cognition.[170]

PANDEMIC PREPAREDNESS

Policies, procedures and protocols developed for the protection of HCWs against COVID-19 will now become standard within health care. Given the SARS-CoV-2 experience, pandemic plans will need regular revision and must consider the development of new viruses with high or higher transmissibility. The WHO provides a checklist[171] and framework for countries to prepare for an influenza pandemic and sets out minimum and desirable elements for pandemic preparedness: preparing for an emergency; surveillance; case investigation and treatment; preventing the spread of the disease in the community; maintaining essential services; research and evaluation; and implementation, testing and revision of national plan.

The H1N1 influenza 2009 pandemic confirmed the unpredictability of pandemic influenza, the rapid and efficient spread by air travel during the incubation period when people are asymptomatic and its ability to cause significant impacts on health systems and the community.[172] A critique following the H1N1 influenza 2009 pandemic highlighted a number of areas directly related to the increased demands on HCWs. Plans include staff protection, priority vaccination for at-risk staff, pre- and post-exposure prophylaxis, the use of PPE and access to pandemic stockpiles, with exposed or ill staff expected to self-isolate. HCW illness needs to be planned for with use of agency, retired staff and volunteers. Other identified needs include anticipatory training of key personnel and suspension of non-essential and/or non-emergency hospital functions during the crisis.[172] A survey of UK and Australian hospitals assessed their preparedness with respect to protecting HCWs during a pandemic.[173] Scores for preparedness, infection control, education and training were generally good with variability for vaccination. The lowest scores were for psychosocial welfare and assistance, although previously reported as important to HCWs.

Public health challenges include increasing acceptance of vaccination by both the general public and HCWs, provision of targeted education for culturally and linguistically diverse populations and other at-risk groups and improving dissemination of information during a pandemic, especially via the media.[172] A WHO resolution called for an effective public health response to the COVID-19 pandemic and other ongoing epidemics.[174]

Current pandemic plans will need to be amended to address airborne transmission of viruses with possible increased pathogenicity and transmissibility. The design of healthcare facilities will need to consider improved ventilation,[175] the use of HEPA filters and UV light. In view of the shortage of PPE worldwide, there is need for review of policies on the stockpiling and appropriate disposal of PPE.

Employers have a duty of care to eliminate or minimize risks as far as is reasonably practicable[120] applying the precautionary principle.[117] The COVID-19 experience indicates that the development of best practice guidelines should include expert advice from specialist occupational medicine physicians[176,177] with the goal of mitigating viral transmission in the workplace, facilitating business continuity and advancing worker well-being.[118] Task analysis and application of the hierarchy of controls will provide risk assessment and determine appropriate control measures. A guide and summary of existing best practices, standards and regulations related to infection control and their application to COVID-19 was published in late 2020.[110]

The mental health and psychological support to HCWs in current pandemic plans is cursory or non-existent and need to be incorporated into pandemic plans.[51,178] This will maximize staff support and morale, and minimize staff absenteeism. HCWs' compliance with infection control procedures is enhanced by training, monitoring and reinforcement of correct behaviours and effective communication.[179]

RETURN TO WORK FOR HCWs INFECTED WITH COVID-19

HCWs and their employers have necessarily led the way in developing successful strategies to mitigate workplace risk and safe return to work, as they have been forced to do so while caring for COVID-19 patients and simultaneously maintaining other critical functions throughout the pandemic. A detailed consideration of issues to guide return to work in HCWs has been published.[180]

Managing the return to work of HCWs who are occupationally at risk of developing diseases during a pandemic is vital in order to sustain a viable workforce. This may include the delaying of retirement of some HCWs, and promoting return to work for those who have recently retired.[22] There is an increased risk to older workers, so these people may need to work in roles that are not patient facing, or care for patients by telehealth only. Regardless of the demands, prioritizing self-care remains important while identifying tasks that are manageable.[181]

Presenteeism is high among HCWs[172,182] with the risk of increasing the transmission of infection to co-workers.[112] Many strategies can be used to determine fitness to return to work following infection with COVID-19. The three strategies are RT-PCR testing, serology testing for antigens and return to work following resolution of symptoms. The ability to provide RT-PCR testing or serology testing depends on the availability of resources and may not be applicable in some countries. In addition, serology testing is less reliable as having a high sensitivity and specificity and particularly important with false negatives.[183] The Cochrane Infectious Diseases Group has reviewed point-of-care antigen and molecular-based tests for the diagnosis of SARS-CoV-2 infection.[183]

Testing HCWs after COVID-19 infection with RT-PCR is the most conservative approach. Two consecutive negative swabs would ensure that viral shedding has ceased, although this will likely overestimate the period of infectivity.[184] Serology is likely the next most conservative strategy, with seropositivity used to infer non-infectivity, while a symptoms-only policy is the least conservative but may be appropriate when resources are scarce or testing is not possible.[184,185]

Return-to-work guidance for HCWs evolved during the pandemic and current guidance depends on the vaccination status, risk of exposure and PPE used.[186] Asymptomatic HCWs who have had a higher-risk exposure do not require work restriction if they have been fully vaccinated or if they have recovered from COVID-19 infection in the prior 90 days. A symptom-based strategy for determining when HCWs with COVID-19 infection could return to work is preferred in most clinical situations. Time and symptom-based (non-test) protocols for return to work are attractive because they are simple, do not require repeated testing and follow-up and invariably lead to shorter work absences.[187] Return-to-work dates should be guided more by symptomatology and fitness for work rather than infectivity status.[188]

Workers compensation for HCWs may be an important consideration. Some jurisdictions have introduced presumptive rules for workers compensation for HCWs diagnosed with COVID-19.[189]

Persistence of symptoms should be a potential sign of post-COVID-19 syndrome. Strategies promoting return to work for these workers may be similar to those developed for other chronic conditions. HCWs with ongoing fatigue, neuropsychiatric and respiratory symptoms of post-COVID-19 syndrome may require specific return-to-work guidance and gradual reintroduction into the workforce, with return-to-work strategies being guided by a multidisciplinary team.[190] Survivors of critical illness often experience poor outcomes after hospitalization, including delayed return to work.[191] Return to work should be promoted as a treatment as employment can maintain and even improve an employee's health and well-being.[192] Finally, the consequences of the pandemic must be evaluated over time for people who suffered from functional limitations before COVID-19 as their physical and mental condition may be modified by the epidemic and, specifically, the consequences of lockdown.[193]

CONCLUSION

HCWs have been profoundly impacted by the COVID-19 pandemic, with many infected in the workplace and a substantial number dying. The specific epidemiology of COVID-19 as an occupational disease affecting HCWs has been increasingly understood as the pandemic has continued. In survivors, the long-term effects of infection are well recognized and are likely to significantly impact the ability of some HCWs to return to work. The pandemic has generated global, social and workplace disruption with profound effects on healthcare delivery and HCWs' mental health. Furthermore, there are likely to be significant, long-term impacts on healthcare systems globally from further waves of COVID-19, pandemic fatigue, possible attrition of the health workforce (particularly in the aged care sector) as some HCWs decide to change occupations and the reduction due to border closures in overseas trained HCWs (who are vital in supporting health services). The broad and far reaching consequences of this pandemic and other recent crisis events therefore represent an urgent call to leaders and healthcare systems globally to be better prepared, with clear, comprehensive disaster response management plans. Safeguarding healthcare workforces during crises is critical as we move forward on the new path of 'COVID normal'.

CONFLICT OF INTEREST

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