

Healthcare workers, epidemic biological risks - recommendations based on the experience with COVID-19 and Ebolavirus

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SUMMARY

Infectious disease outbreaks frequently cause illness and death among Healthcare Workers (HCWs). We compare strategies from recent, past and ongoing outbreak measures used to protect HCWs, including those facing additional challenges such as racial disparities, violence and stigmatization. Outbreaks and pandemics superimposed on countries with preexisting crises have also affected emergency response to these viral outbreaks. Strategies to protect HCWs include adherence to recommended infection prevention and control measures; new technology such as rapid point-of-care

tests and remote monitoring; adopting national public health preparedness plans to ensure the supply and allocation of PPE, staff, and testing supplies; occupational health and mental health support services. Lessons learned from recent pandemics should be used by Infection Prevention and Control and Occupational Health staff to refine preparedness plans to protect HCWs better.

Keywords: healthcare; workers; epidemics; COVID-19; Ebola; occupational diseases; pandemic.

INTRODUCTION

Healthcare Workers (HCWs) on duty during pandemics are often assumed to accept their increased biological risk of being infected as part of their chosen profession. “Nurses hold the

fort and they’re just expected to go on and on,” an HCW said about this common perception of frontline colleagues [1]. However, prolonged physical and mental stress, inadequate personal protective equipment (PPE) supply, and concerns about transmitting the infection to family members and patients pose challenges to HCWs who balance personal safety with professional and moral obligations [1, 2]. Derived from the review of the literature, multiple studies evidenced the biological risk assumed and their consequences during the Ebola epidemic and COVID-19 pandemic [1-75]. In this article, we compare strategies

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from recent, past and ongoing outbreak measures used to protect HCWs, including those facing additional challenges such as racial disparities, violence and stigmatization.

The approximately 59 million HCWs worldwide have been deemed “the most valuable resource for health” [3]. Modeling based on World Health Organization (WHO) Global Health Observatory health workforce data (1990-2013) predicts a net shortage of 15 million HCWs by the year 2030 [4]. The impact of a pandemic can quickly overwhelm public health and healthcare delivery systems worldwide and especially in nations already undergoing humanitarian crises due to war, tribal conflicts, economic failures, and other strenuous conditions that become exacerbated under an outbreak. While inadequate emergency response preparation causes global suffering throughout all occupations, HCWs suffer from higher infection and death rates during infectious disease outbreaks when compared to the general population, in addition to other physical and mental health effects [5-8]. Amnesty International (2021) estimates that as of March 2021, 17,000 HCWs died from occupationally acquired infection during the ongoing COVID-19 pandemic [9]. The Head of Amnesty International, Stephen Cockburn, stated that:

“Throughout the pandemic, governments have hailed health workers as heroes, but this rings hollow when so many workers are dying from a lack of basic protection. Every health worker has the right to be safe at work, and it is a scandal that so many are paying the ultimate price.” [10]

The WHO has published clear guidance on the rights, roles, and responsibilities of HCWs during the COVID-19 pandemic, including key considerations for occupational safety [11]. Without adequate support for front-line HCWs, health systems struggle even more as HCWs strike or decline to treat infected patients, become ill or die. Failure to protect HCWs also leads to worse outcomes as nosocomial infections spread to patients in hospitals or at long-term care facilities [12]. Close collaboration among public health, infection control, and occupational health specialists is vital to protect healthcare workers from harm during pandemics.

We review the physical and mental hazards and proposed solutions affecting HCWs during work in Ebolavirus (EVD) and SARS-CoV-1 outbreaks and the ongoing SARS-CoV-2 pandemic, focusing

particularly on proven strategies related to the biological hazards.

For this narrative review, we reviewed articles from Scopus, Web of Sciences, and PubMed, among other international sources.

HCWs are at increased biological risk of infection and death during pandemics

Emerging outbreaks typically originate with the introduction of an organism into humans from a wild animal reservoir, with subsequent human-to-human transmission [13]. Initial human cases have tended to be hunters or miners in rural locations. Transmission of illness to HCWs is an early harbinger of pandemics. For example, in the 2013-2016 EVD outbreak, one hospital ward saw 90% of its HCWs, predominantly nurses, fall ill [14]. In the three countries most affected during the West Africa EVD outbreak (Sierra Leone, Liberia, and Guinea) in 2014-15, HCWs were between 21 and 32 times more likely to be infected, resulting in 881 confirmed infections and 513 deaths among HCWs [15]. In 2003, during the SARS-CoV-1 epidemic, one index patient was found to infect 50 healthcare workers [16]. Of recorded SARS-CoV-1 outbreaks in Toronto, Hong Kong, Hanoi, and Taiwan, 36.7%, 20%, 63% and 19% of cases were in HCWs, respectively [8, 17, 18].

Medical personnel on the front lines of the SARS-CoV-2 pandemic were similarly at high risk for disease transmission, especially early in the outbreak when suspicion for occupational infection and use of appropriate preventive precautions were low. An early case review from a hospital in Wuhan, China, identified 29% of its infected patients as HCWs who acquired the infection occupationally, with ten of these infections linked to a single index patient [8]. A similar pattern of HCWs infections contributing to a large portion of all infections occurred during the emergence of SARS-CoV-2 in other countries. In April 2020, Italy reported 10% of SARS-CoV-2 infections in HCWs, while the U.S. reported 18% between February and July 2020 [19, 20]. Of the over 2 million people in the United Kingdom and United States using a COVID-19 Symptom Study mobile app March 24-April 23, 2020, front-line healthcare workers had at least a threefold increased risk of reporting a positive COVID-19 test compared with the general community. The highest risks were among HCWs working directly with COV-

ID-19 patients or without adequate PPE [7]. A living systematic review estimated the prevalence of SARS-CoV-2 infections in HCWs as of July 2020 to be 11% worldwide, with nursing staff predominantly infected [21].

Amnesty International (2021) estimates that as of March 5, 2021, at least 17,000 HCWs worldwide have died from COVID-19 infection [9]. In some countries, racial disparities associated with COVID-19 morbidity and mortality in the general population are also reflected in HCWs' fatality rates [20]. Reports from the United Kingdom and the U.S. indicated that Black, Asian, and minority ethnic HCWs accounted for 63% and 53% of HCW deaths in the early months of the COVID-19 pandemic, respectively [22, 20]. This increased risk of death may be partially due to risk factors affecting minority populations as a whole, such as increased predisposition for diabetes or increased likelihood of having public-facing roles. However, HCWs from these groups were also more likely to report reusing or having inadequate PPE [6]. *Recommendation:* Pandemic preparedness plans must address racial and ethnic disparities in the occupational health of HCWs, including plans to assure equal access to PPE and other protective measures.

As of June 02, 2021, according to the WHO Coronavirus-19 Dashboard (WHO 2020b), 170,812,850 SARS-CoV-2 cases and 3,557,586 deaths were reported to WHO worldwide [23]. Due to the morbidity and mortality of these infectious diseases and increased transmission rates in HCWs, protecting them must be a top priority.

Recommendation: Implementation of appropriate infection prevention and control (IPC) practices successfully reduces HCWs' infections [5, 24]. With access to appropriate protective strategies, HCW exposures become more controlled than that of the general population, and the risk of bringing illness home can become less than that of family members who have higher risk exposures through non-healthcare settings [25].

Adequate PPE supply, administrative, and engineering controls reduce HCW infection
SARS-CoV-2's heterogeneity and ease of transmission via droplets, contact, indirect contact, and aerosols promote widespread dissemination in healthcare settings [26]. Additionally, airborne transmission risk has been debated [27]. Risk

factors for transmission in healthcare settings include unprotected exposure, prolonged direct contact with a COVID-19 patient, exposure to bodily secretions, and specific events like aerosol-generating procedures.

Recommendations: To mitigate these types of risks, additional infection control measures beyond standard precautions must be implemented in all patient care settings.

Appropriate PPE for HCWs includes waterproof gowns or gowns with waterproof aprons, eye protection such as face shields or goggles, and respiratory tract protection via face masks or respirators. Water-repellent surgical masks prevent the transmission of large droplets, sprays, and splashes to the HCW and protect the patient from HCWs' respirations, as in surgery. They are loose fitting and disposable; they are not designed to protect HCWs from airborne infections [28]. *Recommendation:* Given the efficacy of masks in containing respiratory secretions, HCWs should wear masks and patients either masks or cloth face coverings at all times while inside any healthcare setting during the SARS-CoV-2 pandemic because infection can be transmitted by asymptomatic and pre-symptomatic individuals. Up to 40% of healthcare workers who tested positive for COVID-19 by reverse transcription-polymerase chain reaction (PCR) were asymptomatic [21].

For respiratory protection from aerosol-generating procedures such as tracheal intubation and airborne infection, a filtered face piece (FFP) respirator such as the N95 is required, which provides a tight fit to the face and filters 95% of airborne particles. Some organizational guidelines recommend the use of these respirators in the care of all COVID-19 patients; others allow or recommend waterproof surgical masks if no aerosol-generating procedures are involved [11, 28]. For HCWs who fail N95 fit-testing or must work for a prolonged time in a highly contaminated environment, another option is use of powered air-purifying respirators (PAPRs), which can filter nearly 100% of very small particles [29].

Appropriate environmental controls include the use of negative pressure rooms for aerosol-generating procedures, isolating confirmed and suspected cases to dedicated isolation wards, and securing adequate cleaning supplies required for hand hygiene and environmental decontamination. Open-air isolation wards using natural

or hybrid ventilation methods have also been proposed as an alternative to negative pressure rooms in resource-limited settings [30].

Shortages of PPE contribute to HCWs infections and deaths, and ultimately to health system strain and collapse. For example, during Ebola outbreaks, insufficient/inappropriate use of PPE was the most frequently cited exposure risk among HCWs. Lack of environmental controls, such as isolation wards, was another commonly cited exposure risk. In some settings, infection control was further hindered by lack of basic infrastructure such as running water, electricity, soap, and sharps disposal boxes that are integral to standard infection control for all healthcare environments [5]. The shortage and high cost of procuring PPE supply during the 2003 SARS-CoV-1 outbreak resulted in challenging circumstances in hospital settings [31]. In mid-March of 2020, as SARS-CoV-2 pandemic activity increased in many countries, shortage of PPE became a dire reality, notably N95 masks, but also gowns, face shields, and gloves [32]. Shortages of cleaning supplies such as bleach, hand sanitizer, and hand soap also occurred in health systems worldwide [33].

Increased demand for medical equipment far exceeded the supply of previously stockpiled equipment. In March 2020, the WHO estimated a need for 89 million medical masks and 76 million gloves monthly during the SARS-CoV-2 pandemic. Overall, the manufacturing of these supplies had to increase by 40%. The WHO urged governments and industries to increase PPE supply, calling for governments to provide incentives to industry to augment production while easing

restrictions on export and distribution of critical medical supplies [32].

Recommendation: National pandemic preparedness plans must therefore include strategies to address expected shortages of medical equipment, including PPE. The absence of a strategy to bolster production and distribute equipment to the most affected geographies led to detrimental competition between local governments/health systems for limited supplies in the U.S. [34]. Centralized planning helps mitigate these effects. In Taiwan, for example, the Central Epidemic Command Center (CECC) focused resources and set the price of masks using government funds and military personnel to rapidly produce and stockpile millions of masks and create over 1,000 negative-pressure isolation rooms by January 2020 [35]. Similar to historical wartime efforts that repurposed existing facilities for defense manufacturing, manufacturers typically outside the healthcare supply chain have been compelled to divert normal production in order to address deficits in PPE and other necessary supplies, *i.e.* distilleries producing alcohol-based disinfectants and hand sanitizers. Reuse of single-use, disposable PPE emerged as another strategy to address PPE shortages, notably N95 masks, during the SARS-CoV-2 pandemic. While extended use between multiple patients, reuse, and decontamination of single-use respirators is not consistent with the manufacturer and organizational guidelines for use, it can help alleviate supply shortages [36]. The US CDC offers guidelines to follow on safe reuse. This US CDC guidelines should be followed.

Figure 1 groups interventions according to the

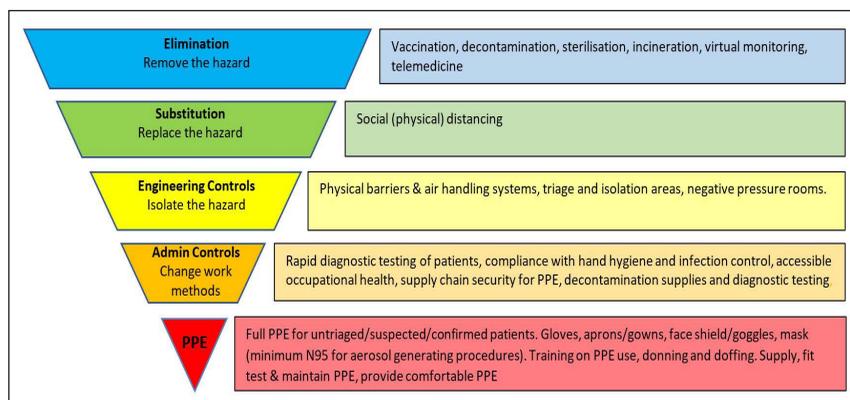


Figure 1 - Methods to address risk factors leading to Healthcare Worker Infection from Ebolavirus and Coronaviruses, according to the hierarchy of hazard control.

hierarchy of hazards controls. Provision of PPE and administrative controls such as training and behavioral modification rank lowest on the hierarchy compared to eliminating hazards and using environmental controls that depend less on individual behaviors. Technology has also created new environmental/engineering controls that can address HCWs' exposure risks. These protective measures, along with training in PPE use, should be prioritized for use by frontline healthcare workers. Prolonged exposure time is a risk factor for HCWs infection; however, reduced patient interactions can affect HCW-patient rapport, and ultimately quality of care. The same technology behind telemedicine and remote medical monitoring, which took on new prominence during the SARS-CoV-2 pandemic as a means to reduce exposure risk in outpatient settings, has also been adapted for use in inpatient settings to protect HCWs. Healthcare facilities have reported using equipment such as baby monitors, iPads, and Google Nest cameras to allow HCWs to monitor and interact with patients remotely. In addition to decreasing exposure time, the use of this technology and telemedicine conserves PPE supplies by lowering the number of times an HCW must enter and exit a patient's room [37]. Vaccines are another important protective biotechnology. HCWs were prioritised for vaccination in the U.S., and were among the first to receive either the Pfizer-BioNTech or Moderna vaccine. HCW prioritization for safe, effective vaccines will continue to be essential [38].

General ventilation as control strategy to all areas

Since mid-2021, airborne transmission (not just aerosol generated by certain clinical procedures) is accepted as a common method of SARS-CoV-2 transmission, requiring revision of earlier general measures in 2020 focused on droplet and fomite transmission. The gold standard prevention strategy for reducing airborne transmission is ensuring adequate ventilation in all areas of healthcare facilities. This is not included, and the recommendations are focused in 2020 general measures based in droplets and fomites thesis. Current evidence strongly suggests transmission from contaminated surfaces does not contribute substantially to new infections [76-86]. Transmission of the virus indoors can be reduced with good ventilation [87,88].

HCWs should use PPE and isolation rooms for all patients with characteristic symptoms and/or known exposure and testing results

Failure to recognize infected patients during an initial triage encounter is a commonly cited exposure risk during EVD and SARS outbreaks [5]. Mistriaging infected patients increases the number of HCWs with unprotected exposures and lead to nosocomial transmission of infection to other patients in their cohort. Delays in testing turnaround, limited testing availability, narrow epidemiological criteria for testing, and failure to screen for symptoms and signs of infection such as fever, cough, respiratory failure/hypoxia, vomiting, and diarrhoea all contribute to triage failures [5].

Development and distribution of rapid point-of-care tests are a crucial tool to protect front-line HCWs by helping to quickly identify patients who should be isolated, and allow for targeted use of isolation rooms and PPE.

Recommendation: National strategies to address production of medical equipment in pandemic planning should also ensure adequate production of supplies required for rapid tests. The shortage of any component of testing, from nasal/throat swabs to chemical reagents for testing, has been linked to delays in testing and obtaining test results [39].

Multiple factors can limit the real-world sensitivity of diagnostic tests, *e.g.*, as of April 2020 estimated sensitivity for SARS-CoV-2 was about 70% for RT-PCR tests commonly used to diagnose active infection [40]. Therefore, negative diagnostic testing should therefore not be the sole criteria for discontinuing precautions in patients presenting with typical symptoms and/or known exposure.

Training for outbreak-specific work and reduction of HCW fatigue help adherence to IPC protocols

Observations of HCWs providing care to patients on contact and droplet precautions in non-pandemic settings and HCWs donning/doffing in EVD-level PPE in experimental settings found that a majority of HCWs deviated from recommended techniques for donning/doffing PPE [41, 42]. During the SARS-CoV-1 outbreak in Singapore, HCWs infections occurred even with use of appropriate PPE. Improper use of PPE, including removing PPE unsafely, reusing single-use PPE, and having improperly fitted eye protection and

masks, were identified as contributing factors that may have led to these infections [31]. Similar risks, such as inadequate hand hygiene, are contributing to HCWs' infection risk in the SARS-CoV-2 pandemic, as well [43].

During the SARS-CoV-1 outbreaks in Toronto and Taiwan, HCWs were required to participate in rapid training to familiarize themselves with PPE. Taiwan also implemented training that was needed for families and hired caretakers who provided support in the hospitals [44]. Training HCWs in their community decreases fear and increases confidence in providing care for patients [45]. Training has the added benefit of teaching HCWs to recognise when standard precautions are sufficient in order to avoid depleting PPE supplies through inappropriate use [31]. In EVD outbreak settings, PPE monitors (buddies) were used to direct the doffing process [43].

After a series of what seems to be never-ending work hours, fatigued HCWs may be less likely to adhere to recommended IPC protocols and suffer from skin damage to the face and hands from PPE. Proposed solutions include full-face respirators and face shields, topical ointments and hand creams [46].

Face-to-face training may reduce errors in PPE use compared to written/video-based instruction alone, but overall, there is scarce data on the efficacy of different training methods. More research is needed in this area [47]. Simulation performed in advance of any outbreak situations can help identify lapses in preparation and training, provided the results of such exercises are publicised and acted on in preparation for future crises [48]. WHO has prepared COVID-19 simulation training exercises for all countries [49].

Government PR campaigns reduce violence against HCWs

During the 2013-2016 EVD pandemic, distrust of and violence against HCWs occurred due to misconceptions such as rumors that HCWs spread EVD [50]. In a village in Guinea, eight people from an Ebola outreach team comprised of HCWs, journalists, and local officials were killed [50]. While many nations applauded their healthcare workers during the SARS-CoV-2 pandemic, in some nations, HCWs were once again targets of violence. At least 44 attacks against HCWs were reported in Mexico [51]. The Indian government

had to enact a "zero-tolerance" policy making violence against HCWs a non-bailable offense after HCWs were attacked by mobs [52]. In the United States, public health officers recommending lockdowns and other public health measures faced harassment from laypersons and elected officials, including protests at their homes, vandalism, and threatening telephone calls and social media posts. Some officers required private security details for personal protection [53].

Recommendation: Pandemic preparedness programs should include resources for community outreach that help identify causes of community distrust of HCWs and correct underlying misconceptions about disease spread through targeted, educational public health campaigns. In all cases, provision of appropriate PPE, environmental controls, and IPC training also help address causes of violence by preventing HCWs infections and reducing community concerns that HCWs will bring infection home. Unfortunately, in many settings where HCWs requested safer work conditions, they were arrested or faced other forms of retribution, leading to further stigmatization. HCWs have the right to raise concerns about their safety to their employers and appropriate governmental authorities without fear of repercussions [10]. Efforts should be made by governments and local businesses to publicly support and thank HCWs to help counter negative attitudes publicly.

One concern about the narrative of HCWs being heroes or angels is that it suggests people do this work because they're unique, not because they're doing their job, for which they should be adequately paid and protected. "It's also been a real barrier to people (HCW) seeking help with their own problems, because they feel heroes don't struggle. An angel doesn't get PTSD." [54]. Feelings of stress, anxiety, depression, and post-traumatic stress disorder (PTSD), however, are common psychological effects that impact HCWs during pandemic situations. Comparing PTSD rates in HCWs in Singapore before and after the 2003 SARS outbreak showed a 20% increase in prevalence compared to 8% pre-SARS [55]. Among HCWs in or near Wuhan during the COVID-19 pandemic, over 70% experienced psychological distress, 50% experienced depression, 45% experienced anxiety, and 34% reported insomnia. Nurses and frontline HCWs who provided direct care

to COVID-19 patients were more likely to suffer from mental health symptoms [56].

Reports from past pandemics offer insight into the causes of psychological stress. In Toronto after the 2003 SARS-CoV-1 outbreak, causes of emotional distress included fear of personal infection, guilt about exposing family members to infection, voluntary 10-day quarantine, stigmatization from the lay community, and resentment over involuntary assignments to SARS patients. Accompanying symptoms included anxiety, fatigue, insomnia, irritability, and decreased appetite [57]. Rigid infection control procedures and meticulous personal protection equipment usage, though necessary, also increased HCWs' stress [55].

While the study from Wuhan during the COVID-19 pandemic found that frontline workers directly caring for infected patients experienced increased psychological stress, the study of Singapore HCWs during the 2003 SARS outbreak found similar rates of PTSD in HCWs regardless of actual exposure to SARS-CoV-1 patients or work areas [56]. Even in non-designated SARS hospitals, the pressure of diagnosing SARS-CoV-1 weighed heavily on the HCWs shoulders. Any delay or misdiagnosis caused an increased risk of anxiety due to possible infection of the HCWs themselves, their co-workers, and family members, in addition to a rebuke from health authorities [55]. An additional factor contributing to stress in non-frontline HCWs (and many frontline workers) is decreased income. During the EVD outbreak, patients avoided seeking healthcare because of fear of nosocomial infection, a phenomenon that recurred during the SARS-CoV-2 pandemic, when the volume of Emergency Room (E.R.) visits in the United States dropped by 50% [58, 59]. As income falls due to canceled procedures and patients avoid health systems, HCWs may find themselves working in a more demanding environment for less or no pay at all [5, 60]. During SARS-CoV-2, many HCWs not directly providing frontline care lost their jobs or experienced significant decreases in income [61,60].

In addition, memories related to human tragedy can lead to psychological distress during and after pandemic-related work [62]. HCWs responding to emergencies may have to provide care that runs counter to what they previously practiced as humane, ethical standards of care. Such "moral injuries" where people witness or are involved

in something that violates their moral code have been identified as contributing factors to PTSD in soldiers and may contribute to mental health problems such as anxiety, depression, and PTSD in HCWs [63, 64]. One example of a situation that can cause moral injury: the guilt of making life-altering decisions due to shortage of ventilators [65]. One young physician noted, "The most anxiety I have is around ventilator allocation. Seeing people die is not the issue. We're trained to deal with death. Nor is it the volume of people dying. The issue is giving up on people we wouldn't normally give up on" [66]. Another example: HCWs watching patients say goodbye to their loved ones without physical contact or not being able to say goodbye at all [67]. This was true for the first SARS outbreak, as well. An infectious disease physician remembers: "One of the nurses told her father goodbye on the phone because she had worked in a SARS-affected hospital. She couldn't go to the hospital where he was to visit him. So, it was a very sober time" [68].

Workplaces should anticipate and address HCWs' psychological distress

WHO guidance on the SARS-CoV-2 pandemic has emphasized that healthcare workers should focus on their mental health and physical health during this very stressful time [11]. Workplaces should anticipate feelings of stress, anxiety, and depression as a consequence of working in crisis settings such as pandemics and engage in strategies to mitigate this effect. Preparing workers for expected challenges can reduce the risk of mental health problems when practicing in difficult work environments. In outbreak settings, this includes training on physical hazards and methods to mitigate psychological distress and moral injury in outbreak settings.

Recommendation: All HCWs benefit from examples of healthy methods of decompressing and addressing stress that has worked for others. Table 1 summarizes strategies that have been used in various outbreak settings to support HCWs mental health [57, 69,70]. Specific attention should be paid to managing insomnia and identifying HCWs who are isolating/exhibiting avoidance, which is a sign of trauma and mental distress, and who may benefit from speaking with a mental health specialist [63].

Widespread closures of mass transit, schools,

Table 1 - Psychological Sequelae and Specific Stressors during Viral Outbreak Work.

| <i>Psychosocial symptoms</i> | <i>Interventions</i> |
|---|---|
| <ul style="list-style-type: none"> - Mental stress - Insomnia - Fatigue - Irritability - Changes in appetite - Moral injury - Depression - Anxiety - Post-traumatic stress disorder (PTSD) | <ul style="list-style-type: none"> - Stress adaptation model (normalisation/anticipation of stress) - Education on healthy coping strategies - Clear communication from supervisors/leaderships - 24/7 Crisis and Confidential telephone hotlines - Virtual support groups - One-on-one counseling sessions - Designated rest/break areas - Informal drop-ins with mental health professionals - Simulation exercises on ethical decision making. - Prompt psychiatry referral for clinical depression/PTSD - Journaling - Meditation - Yoga - Comedy/Humor |

stores, and restaurants pose additional challenges to HCWs who, in addition to new stressors at work, also face increased difficulty with transportation to work, finding care for dependent children, and obtaining meals. During COVID-19, some hospitals responded by arranging for services such as daycare, bringing food to HCWs staffing busy units, and offering free parking, bike rentals, and negotiating for reduced car rental rates [71, 72]. HCWs concerned about bringing infection home to vulnerable family members also benefit from provision of or assistance with finding new rest quarters where they can temporarily isolate themselves from family [70].

During pandemic work, continued clear communication from leadership of directives and precautionary measures was associated with lower rates of emotional stress and trauma [55]. HCWs in leadership positions can help staff prepare for and make sense of morally challenging situations; Greenberg et al. provide a list of such situations, such as having to decide which patients will receive limited resources [63].

Recommendation: Pandemic preparedness plans can use such lists to anticipate and create guidelines for morally challenging situations that allow

for consistent, ethical decision-making, rather than relying on actions by individual institutions or HCWs' approaches [73]. In interviews, a majority of HCWs in disaster settings have stated that prior training significantly affected ethical performance under duress. Reflective thinking and experience were similarly considered key factors in ethical performance, encompassing both personal trial-and-error experience and the shared experiences of other HCWs [74]. Simulations and other types of training instituted during "normal" times can therefore help prepare HCWs for the physically and morally challenging situations faced by HCWs in pandemic settings.

■ CONCLUSIONS

SARS-CoV-1, EVD and SARS-CoV-2 outbreaks exposed systemic weaknesses in HCWs' safety, infection prevention and control, and public health preparedness plans. HCWs have suffered from hazards such as infection, violence, mental stressors such as fearing for their own and their families' health, the financial impact of pandemics, and death. These stressors contribute to increases in anxiety, depression, and PTSD during pandemic work [7, 55]. Previous outbreaks and the current COVID-19 pandemic highlight the increased occupational risks HCWs face, especially among nurses and other frontline clinicians [86]. Strategies such as provision and training in the use of appropriate PPE, strict adherence to infection prevention and control protocols, and rapid testing and isolation protocols can increase HCWs safety and efficiency in current and future pandemics. Mental stress is an expected consequence of work in a pandemic setting and should be planned for accordingly, with additional resources made available to HCWs who develop clinically significant depression and PTSD from pandemic work. Clear communication from leadership can reduce psychological stress and trauma, as do coping strategies such as humor and restorative sleep [55]. During pandemics, HCWs benefit from having access to a range of mental health services.

Although many interventions can be deployed on an institutional or facility level, pandemics are large-scale crises requiring national-level responses. Pandemics are rapidly evolving situations that require aggressive, proactive public health strat-

egies, guidelines, contingency plans, and the implementation of a wide array of public policies. Fortunately for the HCW, the development and application of vaccines for SARS-CoV-2/COVID-19 drastically reduced the impact of pandemic, especially in mortality for most workers [89]. An effective pandemic response requires advance planning and infrastructure, including the ability to rapidly increase production and distribution of PPE and diagnostic testing supplies to reduce the effects of exposure to physical and mental health risks during an infectious disease outbreak. HCWs in many countries are in a more vulnerable position due to poverty, overcrowding, lack of utilities (water, electricity, internet connection, and sewage), armed conflict, food insecurity, and weak health systems infrastructure. These conditions limited pandemic preparedness levels prior to the emergence of COVID-19 [32]. However, many HCW infections from SARS-CoV2 were reported in several countries ranked “most prepared” or “more prepared” by the 2019 Global Health Security Index, including the United States and United Kingdom, which received the highest scores for pandemic preparedness [75]. Despite high preparedness scores, these countries grappled with PPE supply, delays in diagnostic testing, and other factors that led to high numbers of SARS-CoV-2 infections in HCWs. This highlights the numerous unmet challenges to protecting HCWs from infection in all geographies.

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