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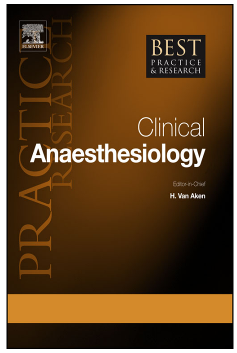

Considerations for acute care staffing during a pandemic

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Considerations for acute care staffing during a pandemic

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Summary

The increasing interconnectedness of the global population has enabled a highly transmissible pathogen to spread rapidly around the globe. In one year, the current COVID-19 (Coronavirus Disease 2019) pandemic has led to physical, social and economic repercussions of previously unseen proportions.

Health workers experience a significant burden during large-scale disease outbreaks. Working on the frontlines during a pandemic can have major consequences for their physical and mental health. Although recommendations for pandemic preparedness have been published in response to previous viral disease outbreaks, these guidelines are primarily based on expert opinion, and few of them focus on acute care staffing issues.

In this review we provide ideas for limiting staff shortages and creating surge capacity in acute care settings, as well as strategies for sustainability that can help hospitals maintain adequate

staffing throughout their pandemic response. Among these approaches are mathematical models, staffing algorithms, recruitment and redeployment of in-house staff, telemedicine, creation of temporary ICU's, communication, and leadership.

Although a health crisis has many negative consequences for our work environment, it also provides an opportunity for learning. Thoughtful collaboration within our healthcare institutions can allow us to develop viable strategies to meet acute care staffing needs in the future.

Abstract (126 words)

The increasing interconnectedness of the global population has enabled a highly transmissible pathogen to spread rapidly around the globe. The current COVID-19 (Coronavirus Disease 2019) pandemic has led to physical, social and economic repercussions of previously unseen proportions. Although recommendations for pandemic preparedness have been published in response to previous viral disease outbreaks, these guidelines are primarily based on expert opinion, and few of them focus on acute care staffing issues. In this review, we discuss how working on the frontlines during a pandemic can affect the physical and mental health of medical and nursing staff. We provide ideas for limiting staff shortages and creating surge capacity in acute care settings, and strategies for sustainability that can help hospitals maintain adequate staffing throughout their pandemic response.

Keywords
COVID-19, staff health, surge capacity, modeling, leadership, communication

Introduction

The past year has been strongly marked by the emergence of SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2). The global COVID-19 (Coronavirus Disease 2019) pandemic has had a catastrophic effect on life in countries around the world, with social and economic repercussions of unforeseen proportions. The increasing interconnectedness of the global population has contributed to the dramatic global spread of this highly transmissible pathogen [1]. Although infectious diseases with pandemic potential were already a major worldwide threat before COVID-19, the last century has seen several viral outbreaks affecting the respiratory tract. These outbreaks have demonstrated the complex interrelationships between animal and human hosts, and have highlighted the environmental factors that affect exposure and transmission [2].

Efforts to fight the COVID-19 pandemic have been multifaceted. Social distancing and lockdown measures aim to slow viral spread in our communities and healthcare centers. Increased testing capabilities have allowed experts to quantify and contain regional viral outbreaks. Hospitals have augmented acute care capability to handle the surge of critically ill patients during each wave of infections. In many countries, ensuring adequate staffing in the face of rapidly rising infection rates has been a major challenge since the start of the pandemic.

Acute care staffing during a pandemic can be problematic, as healthcare workers are affected both in their personal lives and at their places of work. They are additionally at risk of exposure and transmission when caring for infected patients. Infected staff initially quarantined at home may also need in-hospital medical care, placing a further burden on the healthcare system.

Moreover, health workers in acute care settings are highly specialized and cannot be easily replaced.

Specific guidelines for hospitals preparing for a pandemic have already been published after previous viral outbreaks [3–8]. Since the start of the COVID-19 pandemic, many authors have shared their personal experiences and proposed additional recommendations. Many contributions are based on expert opinion or have been published as editorials, offering comprehensive strategies for augmenting surge capacity in times of a health crisis [9–16]. For logistical and ethical reasons, there is little evidence in the form of randomized controlled trials.

Publications focusing solely on acute care staffing issues are limited [17–21]. Here we review the lessons learned from previous infectious disease outbreaks and the current COVID-19 pandemic, focusing primarily on strategies that can be used to improve acute care staffing. We discuss the implications of pandemic work for the staff's physical and mental health, and we provide ideas for limiting staff shortages and creating surge capacity in acute care settings. We also provide strategies for sustainability that can help hospitals maintain adequate staffing throughout their pandemic response.

Implications of pandemic work for staff health

Physical health and risk of infection

Health workers experience a significant burden during large-scale infectious disease outbreaks. This can have a profound impact on their physical and mental well-being. In addition, they account for a significant proportion of infections during a pandemic, and although illness severity is lower than in the general population, mental health issues such as depression and anxiety are common [22]. Previous experience from the outbreak of SARS-CoV-1 (Severe acute respiratory syndrome coronavirus) in 2003 has demonstrated the risk of transmission in healthcare settings and the subsequent vulnerability of health workers [23]. During the SARS-CoV-1 outbreak, the rate of infected health workers was 19% in China, 22% in Hong Kong, 20% in Taiwan, 43% in Canada, and 41% in Singapore [24]. In an early report from Wuhan, China, at the start of the SARS-CoV-2 outbreak, 29% of infected patients were health workers assumed to have acquired the infection while working in a hospital [25]. The Chinese Center for Disease Control and Prevention later reported that 3.8% of confirmed COVID-19 cases (1716 of 44,672) occurred in health workers, 14.8% of whom had severe or critical infections, and 5 of whom died [26]. Data collected by the World Health Organization (WHO), mostly in Europe and the United States, suggest that approximately 14% of reported COVID-19 patients are health workers [27].

During a pandemic, health workers can acquire an infectious disease at work through direct or indirect contact with patients and colleagues, or during their time off as a result of ongoing community transmission [28]. At work, staff are likely to come in contact with patients and colleagues who have subclinical infections but are still contagious [29]. There is a potential risk of transmission between health workers in places where social distancing measures are hard to apply, such as in common areas and break rooms [30]. Data suggest that COVID-19 infections are more likely to occur in staff who are not working directly with COVID-19 patients, because personal protective equipment (PPE) use may be less stringent [31]. Long-term care facilities have been identified as high-risk settings for severe outbreaks among residents and staff [32], as they may be built to resemble home-like environments where the ability to apply preventative measures may be compromised [28].

Health workers who treat patients with confirmed infectious diseases are at high risk of infection due to their close contact with patients' contaminated body fluids. Especially aerosol-generating procedures such as endotracheal intubation, non-invasive ventilation, and tracheotomy are associated with an increased risk of exposure and transmission [33]. Endotracheal intubation seems to be especially hazardous, with an odds ratio of 6.6 reported by a meta-analysis evaluating SARS-CoV-1 exposure and transmission to health workers [33]. Given that high viral loads of SARS-CoV-2 are found in sputum and upper respiratory secretions of patients with COVID-19, endotracheal intubation in these patients should also be viewed as a high-risk procedure for health workers [34].

Using a fluorescent marker during a simulation of intubation procedures, investigators were able to visualize deposition of respiratory secretions onto uncovered sites such as skin on the face and neck of the staff performing the intubations [35]. Although respiratory pathogens cannot initiate infection at these sites, they can be a potential source of self-inoculation. This underscores the importance of consistent adherence to hand hygiene at all times, including after removal of PPE [34]. A meta-analysis found that covering more parts of the body leads to better protection but usually comes at the cost of more difficult donning or doffing and less user comfort, which could actually lead to more contamination. More breathable types of PPE may lead to similar risks of contamination while having greater user satisfaction [36].

Preventing and managing infections in healthcare workers

Early detection of health worker infections is a key strategy to prevent secondary transmission to patients and other staff members during a pandemic. Hospital administrators are responsible for protecting their workforce, and thus have a responsibility to ensure the availability of adequate PPE. As we have learned from previous pandemics, it is paramount that hospitals maintain sufficient stocks of appropriate PPE for their workers [7,37]. Purchasing a PPE stockpile requires a sizable budget. A calculation system based on risk classification by type of health worker and type and number of PPE required per health worker per day could be helpful to hospital administrators [38].

In many countries, PCR testing during the COVID-19 pandemic has been limited to symptomatic individuals. Staff shortages during the COVID-19 pandemic have prompted calls for increased testing of asymptomatic staff. Such screening is suggested to mitigate workforce depletion through unnecessary quarantine and to reduce the risk of nosocomial transmission [39]. Although some studies show that testing health workers on a regular schedule is likely to identify an infection [40,41], clear intervals for routine testing have not been identified. Syndromic surveillance approaches using self-monitoring and reporting could be a more feasible alternative, but require a high level of communication between health workers and occupational health officers. Health workers might be reluctant to report mild symptoms due to concerns that they will burden the healthcare system [28]. Based on the available evidence, the WHO has issued recommendations for passive and active surveillance approaches and routine testing strategies in health workers, based on different transmission scenarios in acute care and long-term care settings [27].

A meta-analysis has shown that the sensitivity of antibody tests is too low in the first week after symptom onset to play a primary role in the diagnosis of COVID-19 [42]. There may be a complementary role involving the testing of individuals with a negative PCR test. Antibody tests are likely to be useful for detecting a previous SARS-CoV-2 infection if used 15 or more days after onset of symptoms, although the duration of antibody increase is currently unknown. As sensitivity has mainly been analyzed in hospitalized patients, it is unclear whether antibody tests are able to detect mild and asymptomatic disease [42].

In accordance with current WHO guidelines, a health worker who tests positive for a SARS-CoV-2 infection, with or without symptoms, should isolate at home or in a designated healthcare facility in accordance with their clinical condition. Symptomatic patients should remain in isolation for a minimum of 10 days plus 3 days without symptoms. Asymptomatic individuals can be released from isolation 10 days after they first tested positive [43]. There is considerable uncertainty about the relevance of PCR testing for redeployment of staff after a SARS-CoV-2 infection. A study comparing PCR testing and virus culture found that patients with mild symptoms could have positive PCR results for up to 28 days after diagnosis, although no infectious virus could be recovered after day 10 of symptom onset [44]. It is therefore suggested that a symptom-based algorithm be used to determine when staff can return to work [28]; for example, the one published by the Robert Koch Institute in Germany [45].

<u>Vaccination</u>

The normal development process of new vaccines is inherently long, and measures to streamline the production process are vital in response to an emerging pandemic [8]. Previous influenza pandemics have triggered calls for increased research aimed at more efficient production of influenza vaccines [46].

Tremendous efforts have been made by the scientific community in the race to safely develop a vaccine effective against SARS-CoV-2. There are currently more than 100 COVID-19 vaccine candidates under development, with a number of these in the human trial phase [47]. Although approval and deployment of certain vaccines therefore seems imminent, it will take time until a sufficient vaccine supply is available worldwide.

The WHO has set guidelines for vaccination priority and has provided a roadmap for different epidemiologic and vaccine supply scenarios [48]. In all scenarios, health workers at high risk of acquiring and transmitting the virus should be among the first groups to be vaccinated, along with older adults in the general population. The WHO’s staged vaccination program focuses on direct reduction of morbidity and mortality. As the vaccine supply increases, other demographic groups are to be included, such as people with underlying medical conditions.

Attention should be paid to equitable international distribution of the available supply. An ethical framework for global vaccine allocation has been proposed [49]. This model provides different phases to reduce premature deaths and end community spread of COVID-19. The distribution of vaccines would be linked to the expected effect of vaccination on specific metrics, such as standard expected years of life lost averted, declines in gross national income averted, or the ranking of different countries' transmission rates. During each phase, vaccines would be allocated to the countries where they are likely to have the most impact.

Mental health

The COVID-19 pandemic poses unique long-term stressors and risks to the mental and emotional well-being of health workers [50]. Pandemic situations generally require intense and prolonged responses from hospital staff, both directly (e.g., physicians and nurses) and indirectly (e.g., laboratory technicians, cleaning crews, administrative staff). This pandemic is different from previous disease outbreaks because of the successive waves of infections with short recovery times in between. Such a repetitive burden on health workers is unprecedented and has not been described in previous research.

Even in non-pandemic situations, evidence suggests that prolonged exposure to shift work has adverse effects on health [51]. Anesthesiologists rank among the workers most often affected by burnout [52], and generally speaking, 20% of all physicians will have a psychological health issue during their career. The lack of effective tools for managing stress and burnout in the medical profession is increasingly recognized as a problem [53]. The psychological impact on health workers is therefore an important consideration in acute care staffing during a pandemic.

A review analyzing 44 studies conducted during major epidemic and pandemic outbreaks (i.e., SARS, MERS, ebola, influenza, and COVID-19) has attempted to quantify the psychological impact on health workers [54]. Post-traumatic stress symptoms were reported in 11-73.4% of health workers across all disease outbreaks. Studies on the COVID-19 pandemic reported the highest prevalence rate (71.5-73%). Symptoms of depression and anxiety occurred in 27.5-50.7% of health workers across all disease outbreaks, again with higher rates in connection with the COVID-19 pandemic (50.4-50.7%). In addition, caring for patients during a pandemic seems to have a significant long-term psychological impact. In the years following the SARS-CoV-1 outbreak, health workers continued to report higher levels of burnout, psychological distress, and symptoms of posttraumatic stress compared to the general public and to staff who had not treated infectious patients [54,55].

In light of these results, hospitals should implement measures to support their staff early in the pandemic response. Hospital administrators need to actively consider health worker well-being. Possible strategies are listed in Table 1 [50,56,57].

Table 1. Strategies for actively promoting the well-being of health workers

Mitigate stressors, create a positive work culture, and build support measures

- Provide appropriate and timely preparation and training
- Reduce non-critical work activities and non-essential administrative tasks
- Anticipate family care issues and provide social support structures
- Encourage staff to openly discuss vulnerability
- Ensure that staff feels valued and heard

Promote self-care

- Ensure availability of food and drink during shifts

- Provide incentives for physical activity
- Aim for work schedules that permit good sleep hygiene
- Provide resources for mental health, mindfulness, and meditation
- Promote altruism as a protective psychological quality; e.g., programs to support the community through volunteerism and donations

Staff allocation and planning strategies for surge capacity

Staffing issues in a pandemic

There is abundant information in the literature on acute care staffing under normal circumstances; i.e., in non-pandemic times. These recommendations have mainly focused on economic aspects and patient outcomes based on different physician and nursing staffing models. Despite the potential clinical and economic implications, acute care staffing issues have not been studied using randomized controlled trials because of practical and ethical concerns [58].

The available evidence suggests that acute care staffing with intensivist physicians lowers hospital and intensive care unit (ICU) mortality and length of stay [58]. The availability of intensivist staff 24/7 can improve the care of critically ill patients by continuing therapeutic advances and facilitating timely diagnosis and resuscitation of deteriorating patients at night [51]. Such high-intensity physician staffing may be less critical in patients hospitalized in intermediate care (IMC) units [59].

Experience during the previous influenza and SARS-CoV-1 outbreaks has highlighted important staffing issues that occur in a pandemic. It has been estimated that as much as 40-70% of staff may not be able to work [4], not only due to illness but also because of family responsibilities, concerns for personal safety, and poor morale [7]. The number of available, skilled medical staff is dependent on local factors, such as hospital size and the number of ICU beds under normal circumstances. In addition, normal scheduling does not take into account the additional time needed for donning and doffing PPE, extra rest days to counter the effect of increased workload, variations in skill level of recruited staff with little ICU experience, and increased administrative burdens on senior staff [4].

In response to previous disease outbreaks, multiple guidelines have been published on the development of surge capacity to help hospitals deliver mass critical care in case of a pandemic or disaster [3–8]. Some have recommended that nursing staff be increased by 20-25%, even without an increase in the number of available beds [4]. In an ICU where a large proportion of the medical staff are inexperienced, there should be at least one ICU specialist present along with one junior ICU trainee or non-ICU physician for every 10-12 patients during the daytime and for every 18-20 patients at night [4]. A CHEST consensus statement from 2014 recommends planning for a surge capacity up to 200% above routine maximal capacity [6].

Most hospitals have limited reserve bed capacity (estimated at 25%) and a limited stockpile of equipment (usually lasting for roughly 14 days at normal demand) under routine circumstances [6,12]. The availability of trained nursing staff and ICU medical staff is also limited in most countries. A short-term increase in qualified staff is therefore complicated because an additional qualified workforce is not readily available. In addition, there are shortfalls in existing staff due to staff exposure and infection resulting in illness and quarantine. Lock-down measures such as school closures and a lack of childcare facilities can further limit staff availability [12].

Specific examples of the international COVID-19 response show that many healthcare systems were inadequately prepared to deal with the pandemic. One of the most affected regions was the Italian province of Lombardy. Under normal circumstances, the total ICU capacity in Lombardy is 720 beds for a population of just over 10 million inhabitants. These ICU beds usually have 85% to 90% occupancy during the winter months [60]. At the height of the first wave, ICUs had to hospitalize 1591 patients, 99% of whom required the support of a ventilator. ICU mortality was 26% [61]. In the UK, guidance for staffing of ICUs changed drastically during the first wave of the COVID-19 pandemic. It permitted specialist critical care nurse-to-patient ratios of 1:6 when there was support from non-specialists (normally 1:1) and one critical care consultant per 30 patients (normally 1:8 – 1:15) [39]. This is alarming, as patient care is increasingly compromised at higher ratios of patients to staff, with data suggesting a 7% increase in adverse outcomes for each patient above 1:4 in general medical or surgical care [62].

The predominant problem of the current COVID-19 pandemic has been the provision of mass critical care over an extended period of time. As pandemic resource requirements increase over months, some authors suggest that the specific challenges facing a hospital are comparable to running a sprint and a marathon – at the same time [63]. During the initial sprint, hospitals must respond to a rapidly changing environment in which critical decisions are made within hours and days. At the same time, they need to plan for the ensuing marathon of increased clinical care that will follow over the coming months, without fully knowing what the end looks like or when it will come. To develop surge capacity rapidly and efficiently, hospitals can obtain additional staff both from the hospital's existing internal sources as well as from external sources.

Internal resources: redeployment, recruitment, and restructuring

At the beginning of the COVID-19 pandemic, various authors in affected countries published management strategies that allowed their respective hospitals to mount rapid responses to the high influx of patients [9–11]. Specific recommendations on staffing were limited, but included allowing teams to have a two-week off-duty period after every period on the wards if manpower allowed [10]. Other publications soon followed as the pandemic progressed, providing more detailed recommendations on hospital preparedness and developing ICU surge capacity [12–16]. We provide a summary of recommendations in Table 2.

Table 2. Recommendations for augmenting staff capacity with internal hospital resources.

- Redeploy staff from administrative positions and/or from cancelled elective procedures [7]

- Redeploy research staff to clinical service unless they are doing pandemic-specific research [15]

- Off-duty staff can be integrated into a back-up pool to buffer a potential surge of patient admissions or staff shortfalls due to illness or quarantine

- Reassign nurses with previous critical care experience from the regular ward to IMC and ICU [12,13]

- Recruit and train nurse and medical staff from non-ICU specialties [7,12,13]. Critical care staff might need to take up a supervisory role and coordinate the efforts of non-intensivists. Buddy systems can be used to pair inexperienced with experienced staff members.

- Assign nurses and medical staff to roles making the best use of their most relevant skills [63]. Anesthesia providers can help with airway management, ventilation, and catheter access. Surgical teams can assist with procedures such as tracheotomy and thoracic tube insertion [64]. Perioperative nurses and operating room assistants can help with prone positioning and other forms of patient mobilization [21].

- Acknowledge support from non-clinical staff [15]. They are vital for maintaining rapidly expanding ICU capacity.

- Address social barriers that might prevent some staff members from being able to work. These include transportation issues and in-home care for family members such as children and elders [15].

Early adaptive measures to compensate for an increased need for staffing include adding shifts and increasing work hours, which can be planned in collaboration with the critical care staff. Staff on leave can be recalled to the hospital and vacations cancelled. Such an arrangement can suffice for treatment of an initial wave of patients and is estimated to expand ICU capacity by 20% to 50% [3]. However, such measures are not sustainable and are likely to rapidly deplete staff reserves [5].

When ICU beds are no longer available, critically ill patients might need to be hospitalized in temporary ICUs. A major challenge is organizing this increase in capacity in a way that allows step-by-step escalation [12]. Once elective procedures have been cancelled and staff redeployed, hospital discharge processes can be expedited to make additional space for patients who are well enough to be transferred out of ICUs [13,14]. Transferring patients to other hospitals can create additional capacity but poses important logistical challenges as well as a high risk of health worker exposure and contamination [65]. Options for creating additional ICU beds include emergency departments, IMC wards, post-anesthesia care units and recovery rooms, operating rooms, and intervention suites (such as endoscopy).

Whether cancelling elective surgery is an effective measure to increase ICU capacity has been questioned. In a retrospective study over a 5-year period, only 13.4% of ICU admissions were attributable to elective surgery. Just 6.4% of elective surgery admissions required mechanical ventilation [66]. Although the number of “saved” ICU beds is relatively small, there are other reasons to cancel elective surgery in a pandemic. These include freeing personnel to assist with other surge activities, decreasing pressure on limited PPE supplies, and protecting the well-being of frontline staff [67].

It is important to remember that not all patients will require advanced ICU care. A large part of the additional workload will fall to normal wards. This should be kept in mind when recruiting and redeploying non-critical care personnel to avoid staff shortages. A coordinated multidisciplinary approach is needed to avoid staff burnout or subpar clinical care in all areas [68]. Some authors have proposed that ambulatory surgery facilities (ASFs) may be able to assist acute care hospitals [69]. ASFs that perform only elective diagnostic and therapeutic procedures are likely to be closed during the height of a pandemic. Certain types of ASFs could help reduce the stress on hospitals by taking on selected essential (urgent and emergent) surgical procedures, such as minor trauma and obstetric patients. This would free up operating rooms, supplies, and personnel in acute care hospitals. ASFs which are not suitable for performing these procedures can still contribute by providing personnel and equipment to other institutions [69].

<u>External resources: augmenting the work pool</u>

In times of crisis, healthcare organizations must sometimes rely on external resources to expand their workforce. One such resource is the recruitment of medical students. This concept was already used during World War II, when medical schools enrolled and graduated students at non-traditional times and also shortened the time required to complete a medical degree [20]. During the COVID-19 pandemic, medical students in different countries have also been part of the international effort to curb staff shortages [70]. Universities have permitted voluntary early graduation of last-year medical students so they can begin internships ahead of schedule [16–18,20]. These early graduates can perform various clinical tasks to relieve the strain on front line clinicians. For example, they can assist with routine inpatient and outpatient care, triage and assess patients, collect and analyze data, and perform administrative tasks [19,71].

Although these reinforcements might be welcome at the height of a crisis, we must not forget to protect those involved. Governments, regulatory bodies, and medical schools have a responsibility to ensure that future doctors are sufficiently trained and supported to deliver patient care, even during a crisis [72]. This can be achieved by shifting teaching to digital platforms and integrating students' clinical placements and pandemic work into the teaching curriculum. Such a system offers an immediate response to the call for additional healthcare staff without necessarily delaying medical education [73].

Healthcare organizations can also expand their workforce by identifying health workers who have either retired or temporarily left the workforce and encouraging them to return to work. Using this strategy, many countries have been able to recruit significant numbers of retired physicians and nurses [17–19]. Healthcare professionals whose practices have closed during lockdown can be trained to conduct screenings, provide follow-up of quarantined people, collect epidemiological data, and provide community education. Such professionals include dentists, dental hygienists, physical therapists, optometrists, and hearing technicians [19]. Tragically, health workers rehired from retirement to help at the front line have commonly experienced the highest mortality when compared with their working-age counterparts [28,74].

Other vital services can be provided by volunteers with no significant healthcare experience. These services include delivering food and medicine, driving patients to appointments, and maintaining contact with people who have underlying health conditions and are self-isolating at home [17]. A network of screened volunteers can also provide options for in-home daycare for children or medical daycare for sick family members, which would free up staff who would otherwise need to remain at home [7]. Adequate training and legal protection should be provided for volunteers in such a scenario.

<u>Mathematical models and planning algorithms</u>

In light of the staff and equipment shortages that many hospitals have encountered during the COVID-19 pandemic, it has been recommended that healthcare institutions use predictive mathematical modeling to support their surge capacity planning [14]. Different simulation tools have been developed in response to previous influenza outbreaks, in an effort to quantify the impact of a viral disease outbreak. Initial modeling tools were designed to simulate a pre-defined pandemic scenario and estimate the expected rate of hospitalization and mortality when an influenza virus is transmitted in a population [75–78].

Precise planning with such models remains challenging, as these tools are characterized by high levels of uncertainty [7,8]. For example, early in a disease outbreak, the quality of data on infections and deaths can be limited by underdetection of cases, reporting delays, and poor documentation, all of which affect the quality of any model output. Predictive models for larger countries are problematic because they aggregate different local areas with heterogeneous population and disease transmission characteristics [79]. These models also do not estimate the impact of a pandemic on available healthcare resources. Newer simulation tools have tried to solve this problem by permitting the user to integrate different surge capacity strategies, such as increasing the number of available beds, permitting early discharges, and canceling elective surgery. The effects of different parameters on the availability of human resources can also be calculated [80,81].

Additional simulation models have been developed during the COVID-19 crisis. One model describes the maximum rate of COVID-19 patients which can be handled by a hospital for a given number of ICU beds, as a function of the arrival rate of new patients and their expected length of stay [82]. Another model allows the user to simulate the number of capacity-dependent deaths (i.e., deaths attributed to patients being unable to access the care they need due to lack of available capacity) as a function of various surge capacity measures implemented in different pandemic scenarios [83]. Although these tools offer comprehensive models to guide decision-making and planning in a pandemic, none of them can be applied directly to predict acute care staffing needs.

The COVID-19 pandemic has shown us that highly specialized anesthesia and ICU staff are not easily replaced. Adjustable staffing models could be used to ensure optimal planning of the limited human resources that are available. The University of Pittsburgh has developed an ICU staffing algorithm using a tiered healthcare provider strategy which incorporates non-critical care staff of all disciplines (physicians, nurses, medical assistants, and others) under the supervision of a trained critical care physician [84]. Using this model, one critical care physician could supervise up to four groups of 24 patients each, all requiring ICU-level care and/or mechanical ventilation.

Another staffing model has been proposed using disease-specific epidemiologic indices (incubation period and quarantine times specific to SARS-CoV-2) to limit healthcare worker infections during the COVID-19 pandemic [85]. The model compares a routine staffing schedule (five 8-hour shifts with two days off) to a pandemic staffing schedule (seven 12-hour shifts with 7 days off), as a function of different infection probabilities over time. The pandemic staffing schedule showed significant staff savings by limiting health worker infections in all simulation variations. Although such a schedule could protect health workers from exposure and infection, it is associated with a high burden for staff members due to the long working hours.

Telemedicine

The role of telemedicine as part of an integrated medical response to a disaster has previously been described [5,86]. Telemedicine is a technology that enables remote diagnosis and treatment of patients and can be used for long-distance clinical care, administrative tasks, and patient education [87]. Possible modalities include secured phone or video calls, text messaging, e-mail, mobile health applications, and remote patient monitoring [86,87]. Following the SARS-CoV-1 epidemic in 2003, China began exploring telehealth applications for use in similar situations in the future [88]. During the SARS-CoV-2 pandemic, the main application of telemedicine has been to assist in screening and triage of patients [19,89].

Triage and testing of patients is one of the key strategies used to limit the spread of any infectious disease. Telemedicine can help obtain a detailed medical history and evaluate the presence of symptoms. It could help to prevent the further spread of disease by isolating infected patients before disease transmission can occur [87]. A system that allows efficient screening is therefore not only beneficial to patients and their community, but also protects health workers [89].

Many countries struggling with the COVID-19 pandemic have entered a new phase where partial lockdown measures are again in place. Some but not all elective surgeries are being cancelled in response to new waves of SARS-CoV-2 infections. Telemedicine can assist perioperative teams in performing preoperative assessments and in coordinating diagnostic tests in an outpatient setting. Elective surgery patients can be informed about their upcoming anesthetic and surgical procedures and provide informed consent without physical contact [87]. Such strategies directly contribute to mitigating possible staffing shortages over the course of a pandemic.

The use of telemedicine in clinical work has been integrated into current COVID-19 management recommendations [14]. Telemedicine can be employed in the ICU for supervision purposes and can reduce the need for experienced critical care providers [14,84]. Medical decision-making can be assisted by providing rapid access to specialists without requiring their physical presence [89]. Temporary emergency facilities can be staffed by advanced practice providers, such as physician assistants or nurse practitioners, who are supervised by attending physicians via telemedicine. This allows capacity to be increased without necessarily increasing the number of shifts for medical personnel [90].

Although telemedicine is a promising tool which may help our response to public health emergencies, several barriers currently exist which result in its underutilization. These are summarized in Table 3 and should be addressed in the future for a more successful integration of telemedical applications.

Table 3. Barriers to the use of telemedicine in a pandemic.

Administrative barriers: licensing and credentialing [86,89]

- Regulatory structures and legal frameworks need to be put in place on local and national levels.
- Telemedicine programs need to be integrated into existing healthcare systems.

Technology and infrastructure [86,87]

- Systems that are not used on a daily basis rarely function during an emergency.
- Technological requirements must be ensured.
- Telemedicine needs to be included in training and education of the workforce.

Acceptance of telemedical applications, data security, and privacy issues [86,87,91]

- Patients and physicians need to be educated on the safety, privacy, efficacy and personal benefits of telemedicine.
- Instructional materials should be distributed to patients.

Funding issues [89]

- Reimbursement needs to be available through public and private healthcare insurers.
- Payment parity between in-person and telemedical services needs to be developed.

Strategies for sustainability

Ethical considerations

Healthcare professionals are being asked to provide care in environments that pose significant risks to their own health. During the COVID-19 pandemic, health workers have been expected to do their job without questions, because they are presumed to have a moral obligation to society and a duty to care for patients [92,93]. In addition, health workers have a contractual obligation to their employers. However, in response to previous disease outbreaks, it has been argued that a worker's obligation to treat should not outweigh duty to oneself and one's family in the face of increased personal risk [94]. This poses an ethical dilemma in staff reallocation, as healthcare needs to be provided during a pandemic but no individual in a healthcare role should be obliged to provide it [92]. Another ethical dilemma is the redeployment of health workers with significant comorbidities or meeting certain age criteria. Based on US data of the COVID-19 pandemic, 92% of fatal health worker cases were among those with an underlying medical condition. Deaths among health workers were also significantly higher in the age group over 65 years [95].

In reality, healthcare professionals around the world have continued to perform their work admirably under high workloads and increasingly difficult circumstances. The American Medical Association has published a code of medical ethics in an effort to provide foundational guidance for healthcare professionals and institutions [96]. These guidelines discuss how physicians may ethically decline to provide care if appropriate PPE is not available after considering the anticipated level of risk. Circumstances unique to an individual physician or other health worker, such as an underlying medical condition, may also justify a refusal to provide care.

Administrators and policy makers should therefore be mindful of those staff members being redeployed to high-risk roles. The necessary training and support should be provided in a timely fashion, so that the redeployed staff are sufficiently prepared for their new roles [92]. If scheduling allows, individuals with underlying medical conditions or meeting certain age criteria could be discouraged from clinical work that comes with a high risk of exposure and infection. Staff who cannot provide care to patients with an active infection can still contribute through telemedicine, teaching roles, patient follow-up, or coordination activities [93].

Maintaining education and training of staff

Education and training are essential for augmenting and sustaining a highly skilled workforce and implementing effective infection control measures. During previous coronavirus epidemics, education and training in infection control measures were consistently associated with a decreased risk of health worker infections [22]. Traditional teaching modalities can include online refresher courses, voice-annotated lectures, and instructional videos. The availability of such resources is essential and can be complemented by simulation drills. This provides hospital staff the opportunity to practice and assess their preparedness for real-life situations.

The integration of high-fidelity simulations is an effective way for institutions to create realistic challenges for their workforce and better evaluate emergency scenario preparedness [97]. During the COVID-19 pandemic, simulation training was also used to prepare healthcare workers. Simulation training can help participants recognize and address unexpected problems. In one example, cardiac arrest simulations revealed several violations of infection control measures during cardiopulmonary resuscitation [13]. In another example, a simulation course focused on pronation strategies for the critical care nursing staff [15]. Simulation and training courses could also be used to create dedicated teams. One study has reported a first-pass success rate of 88% in a cohort of 150 endotracheal intubations performed in COVID-19 patients by a dedicated airway management team [98]. Similar results were reported for another cohort in which a first-pass rate of 89.1% was observed in 202 COVID-19 patients [99]. Up to 14 days post-procedure, there was no evidence of cross-contamination in the physicians who intubated the COVID-19 patients, which was attributed to experience and training.

Leadership

During the COVID-19 pandemic, the need for effective leadership and guidance at all levels of society has become clearer than ever. Successful pandemic management relies on the concerted efforts of world leaders, policy makers, healthcare executives, and local medical staff.

Leadership behavior can be guided by best practice models and leadership strategies [100], with effective communication as an essential skill that can help clarify the situation, provide hope, and maintain transparency [63]. Valuable lessons can be learned both from the medical literature and from business and management publications. Despite its many challenges, the COVID-19 pandemic also offers an opportunity for learning and further development of strategies to be used in times of crisis. Through good leadership we can give our staff the support they need to become more vigilant, efficient, and resilient in their work [101]. Strategies for leadership behavior and effective communication are listed in Table 4 and Table 5.

Table 4. How to lead during a pandemic

Set up a task force or a command team [56,100,102]

- Establish a clear chain of command
- Members should include leaders from varied groups (clinical operations, quality improvement, education, research, and business)
- Strengthen connections to the front line to get regular situational assessments

Decide with speed rather than precision [102]

- Define priorities, name decision makers, and make smart trade-offs
- Embrace action and do not punish mistakes; failing to act is worse

Delegate responsibilities [63,100,102]

- Front line clinicians can take on responsibility in their areas of expertise

- Spread the workload to avoid burnout, build autonomy, and allow opportunities for personal and professional growth

Foster a culture of trust and engage with your team [101–103]

- Don’t overlook the power of collective intelligence
- Ask for help, recruit team members who are more knowledgeable than you are
- Create possibilities for staff feedback and listen to individual team members
- Allow employees to contribute to decision-making in the workplace

Build supportive measures and promote self-care [57,102]

- Aim for work schedules that promote physical and mental resilience; see also the section on mental health

Establish information and treatment protocols based on best-practice guidelines [37,50]

- Combine this with ongoing training opportunities

Table 5. Communication strategies for successful pandemic management

Create a team for centralized communication [56,104]

- Meet regularly to monitor the situation closely and give updates to the workforce
- Consider a centralized application or document for real-time feedback and sharing of questions to be answered

Provide a central source of information in a highly visible location [50,63,100,104]

- This can be a physical location or via intranet and e-mail

- Continually update and promote recommended guidelines and interventions
- Be succinct and give your sources of information

Openly communicate hospital metrics [37,56,100,104]

- Information includes the current number of cases, status of hospital capacity, and resource availability such as PPE
- Be as transparent as possible to help maintain confidence in the work environment

Include non-clinical staff in (virtual) information meetings [56]

- Make sure all team members' voices are heard and skill sets are utilized
- Acknowledge the flexibility and dedication that is required of staff

Make a point of thanking staff regularly for their hard work

Conclusion

Health workers experience a significant burden during large-scale disease outbreaks, with major consequences for both physical and mental health. The COVID-19 pandemic poses an unprecedented challenge because of successive waves of infections with short recovery phases. Strategies to prevent health worker infections should include staff education and the provision of appropriate PPE. Successful management of health worker infections is dependent on early detection through testing and thoughtful redeployment of personnel after infection. Hospital administrators should actively promote the well-being of their staff to avoid burnout and long-term mental health issues.

Surge capacity can be increased using both internal and external resources. Recruitment and redeployment of in-house staff can quickly increase the available staff but requires training and adequate supervision. Students and retired employees can also strengthen the available workforce, but special consideration needs to be given to ensure students' continued education and to protect retired health workers. Escalation strategies to create additional ICU beds are part of a comprehensive preparation plan. Mathematical models and staffing algorithms can provide guidance for optimal scheduling. This can protect health workers from infection and evenly distribute highly specialized personnel. Telemedicine can optimize staffing by limiting patient contact in some clinical activities, such as elective preoperative assessment, and by facilitating supervision of less experienced personnel in triage and acute care settings.

Exceptional leadership behavior and effective communication strategies are key components of a sustainable management plan in a pandemic. Although a health crisis has many negative consequences for our work environment, it also provides an opportunity for learning. Thoughtful collaboration within our healthcare institutions can allow us to develop viable strategies to meet acute care staffing needs in the future.

Practice points

- Acute care staff are at high risk of disease exposure and infection during a pandemic

- Successful staffing strategies consider both physical and mental health issues
- Surge capacity can be created using a hospital's internal and external resources.
- Mathematical models and planning algorithms can be used to increase staff safety and better distribute highly specialized personnel
- Telemedicine can reduce health worker exposure and optimize supervision of less experienced personnel
- Exceptional leadership behavior and effective communication are key components of a sustainable management plan in a pandemic.

Research agenda

- Future research on the mental health consequences of the repetitive burden during a prolonged pandemic response can improve understanding of health worker needs and provide specific planning strategies
- Further development of predictive modeling tools and planning algorithms should be encouraged to address specific staffing issues
- Equitable vaccination schemes should be promoted and implemented to increase the safety of healthcare professionals in the workplace
- Further discussion on ethical considerations will be beneficial to healthcare providers working in high-risk acute care settings with limited supplies of PPE

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Declaration of Competing Interests

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