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COVID-19 Frontline Perspective

Design considerations to reduce risk and support patients and providers in facilities for COVID-19 care

Summary

Health care workers are on the front line of the COVID-19 pandemic. As such, they are at great risk and at the same time possess great knowledge of the effectiveness of health care settings, and what still needs to be addressed during these perilous times.

This white paper was written by the Front Line Working Group of the AIA COVID-19 Task Force in the early phase of the COVID-19 crisis from February to April 2020 for the American Institute of Architects (AIA), which established the AIA COVID-19 Task Force to explore the role of architects and the built environment during the COVID-19 crisis. Clinical, scientific, and subject matter experts at the interface of health care and design worked together closely to inform this document and the associated checklist tool. It reflects input from medical doctors, including specialists in emergency medicine, intensive care, anesthesiology, and gerontology; nurses; hospital administrators; researchers; and architectural designers. The document considers findings from a literature review of recent institutional reports, publications, and emerging findings.

The COVID-19 pandemic is novel, not just in terms of the SARS-CoV-2 outbreak itself, but also in how it differs from natural disasters or mass casualty events, which are typically more contained, static, or predictable. Knowledge of the COVID-19 disease, its pathogenesis, and treatment options are evolving daily, and the dynamic nature of the disease and its management ultimately determine space planning needs and design options. Further, insufficient supplies of essential equipment or inadequate health care spaces can directly impact space utilization and the delivery of care.

Therefore, clinicians at the front line and subject matter experts offer great value as essential partners to qualified health care architects and allied professionals seeking to circumvent the potentially overwhelming burden of disease stressing health system capacity and the health care workforce.[1]

Thus, the AIA COVID-19 Task Force's Front Line Working Group's goal is to assist in saving lives and reducing the transmission of COVID-19 disease by providing design guidance that considers the specific challenges imposed by this disease rather than utilizing public health, health care systems, or hospital disaster plans that address generic, smaller-scale, or localized community-based events. The focus considers all staff within health care settings, including clinicians, who are defined as anyone involved in direct patient care; surgeons; physicians; specialists; nurses; therapists; and social workers, among others.

Clinicians are essential partners to design teams seeking to circumvent the overwhelming burden of disease stressing health system capacity and the health care workforce.

Key messages

Alliance of Clinical, Subject Matter, and Design Experts. A deep working relationship between frontline health workers and experts is essential to understand the evolving knowledge of health conditions that informs design guidance for health care settings during pandemics, health emergencies, and public health crises.

Novel Coronavirus Imposes New Design Challenges. Clinical and subject matter experts offer critical information about the specific challenges that need to be met during space planning and design of health care facilities during the COVID-19 pandemic.

Front Line Informed Checklist for COVID-19 Care Facilities. Our initial findings are summarized in a checklist tool that delineates how providers' health and well-being, along with patient outcomes, are dependent on key elements in the environment and built conditions.

Background

Experience from clinicians at the front line

Health care workers at the front line of the COVID-19 pandemic can provide architects and designers critical perspectives on how hospital design is currently working (and what is sorely lacking) during this crisis. Although all hospitals and health care systems have disaster plans in place, the rapid deployment of these plans on the scale of this pandemic has never been tested. The unprecedented prevalence and spread of COVID-19 have placed health care systems and health care workers at tremendous risk.[2]

Hospitals and health care settings have found it necessary to adjust and adapt how spaces are used in order to deal with 1) the exponentially escalating number of patients, 2) the geographic and temporal spread of the disease, 3) the unique needs in the treatment of COVID-19 patients, and 4) the organizational changes in operations required to serve varying levels of acuity of the illness.

Health care workers encounter many hazards as they provide care, including exposure to pathogens, risk of infection, psychological distress, fatigue,

occupational burnout, stigma, and physical and psychological violence. Although many accept these risks as part of their chosen profession, they are also concerned about family transmission, especially to the elderly, the immunocompromised, and those with chronic medical conditions. Therefore, keeping patients, families, and frontline health care workers safe is a global priority.[3]

The Front Line Working Group was created to consider how the built environment can better support the provision of care and the providers themselves. Our initial findings reveal how protection of the providers' health and well-being are intertwined with patient outcomes and environmental conditions. This includes the provision of spaces which have direct impact on utilization and risk mitigation including 1) safe settings in which large-volume testing can rapidly identify infected patients, 2) adequate spaces for personnel as they put on and take off (donning and doffing) protective personal equipment (PPE) with team oversight, and 3) suitable settings for complex patient care. A variety of strategies are being adopted, which reveal the emergent needs for improved design. Innovations during a novel virus outbreak are important to safeguard health care personnel so that they can continue to deliver care to patients and their families.

Recently developed "workarounds" and the residual challenges identified offer possible solutions and reveal priorities that can be shared across facilities as they engage in readiness, response, and recovery from increasing patient volumes, depleting supplies, and changes in staff availability. In addition, the lessons learned can be translated into guidance to optimize safety and mitigate risk when evaluating and recommending physical facility changes at alternative care sites (ACS) and facilities in multiple scenarios and settings.[4]

Emergency medicine doctors in Bergamo, Italy, noted, "The single best way to save the most people and reduce morbidity is to be proactive. Those of us in the midst of this crisis wish we could have done things differently and implemented recommendations from the moment we encountered patient zero. Our lack of early testing and strict isolation run counter to what epidemiologists recommend to control infectious outbreaks. Please learn from our mistakes"[5].

The need

There is an urgent need for additional guidance on how health care facilities can function safely and effectively, and this information can then be used in new guidelines for the variety of care settings currently being established. The need applies across geographic locations, both urban and rural, in acute and longer-term care facilities, purpose-built facilities and alternate care settings (ACS), as they meet the surge in demand.

In addition, design features for infection control must consider the emerging data about how the virus spreads as people move along shared corridors and other spaces, or as staff rush from emergency settings to operating rooms, pharmacies, labs, etc.

Furthermore, guidance can inform the provision of settings to support the clinical team and staff who are exposed not only to infectious patients but also stressful situations over extended periods of time. The provision of spaces for collaboration and mentoring as well as spaces for rest, respite, and recovery are extremely important for providers' mental, behavioral, and physical health.

Process
In close liaison, frontline clinicians, scientists, epidemiologists, health care executives, public health and design professionals are developing new strategies for health care facility design. The Front Line Working Group continues to gather input to refine recommendations for the built environment.

Our findings inform priorities for design, planning, and programming of space utilization, including:

1. Patients: How and where should COVID-19 patients be assessed, transported, and located within health care settings?
2. Providers: What immediate actions are necessary for health care personnel's safety, and what support is essential for their health and well-being?
3. Places: What adaptations and improvements can be made to the built environment, equipment, and technologies to support care delivery, minimize risk, and optimize patient outcomes?

Now is our opportunity to use the insights from clinicians at the front line to make environments that better serve our care providers and their patients.

Problem statement
From both a public health and health care perspective, the novel COVID-19 pandemic has revealed unique critical problems that are unlikely to be addressed by traditional plans for emergency, disaster, or health care facilities.

Mike Leavitt, a former governor and secretary of the Department of Health and Human Services during the H5N1 epidemic, noted that although it is not possible to predict the future course of the outbreak, planning for a scenario in which many persons become ill and seek care at the same time is an important part of preparedness and can improve outcomes if an outbreak occurs. Therefore, it is paramount that design guidance changes to ensure preservation of a functional health care system and the health care providers themselves.[6] The solution to these challenges lies in using the deep knowledge of frontline experts with firsthand experience during the COVID-19 pandemic response. Their input can inform new design guidance for immediate deployment and for future outbreak cycles as we continue to battle COVID-19 in health care and community settings around the world.

Perspectives

Built determinants of pandemics
Pandemics and disasters teach us lessons about preparedness and response. Leavitt notes that pandemics change everything, including the politics, economics, and sociology of every culture they touch. The lessons learned when looking back are valuable and can powerfully shape the world, our health, and our societies.

Pandemics change everything; they change the politics, economics, and sociology of every culture they touch.

However, in the midst of a crisis, we do not have the luxury of time, and we must respond rapidly to the opportunities and challenges that place exaggerated demands on the health care delivery system and related facilities.[7] Medical, sociological, and public health research offer several examples of long-lasting strategies that successfully addressed diseases, such as improvements in water and sanitation in the 19th century. More recent efforts to reduce chronic and lifestyle diseases, such as diabetes, have utilized design to encourage walkable communities, healthy buildings, and ambulatory interiors.

During this pandemic response by exploring the integration of urban, architectural and interior design, along with technological and material choices the impact of this pandemic can be reduced. This is essential in a time when people travel extensively between communities and are more mobile inside of built settings. We must also consider how medical and scientific knowledge can be translated into design interventions that determine space utilization, and then inform design changes for the current or next outbreak cycles and future pandemics. The public health and care delivery strategies should consider how physical settings can be interconnected with health systems and integrated to provide screening, testing, triage, and patient care at local, regional, and international levels. The incorporation of the most valid, advanced, and available methods, including telemedicine and telehealth adds to the tools to be considered in how the built environment can support the health and well-being of patients and care providers.

Clinicians and designers' role in the physical determinants of health

Clinicians play both a central role and individual roles in health care. Disease prevention and health promotion benefit from perspectives from multiple disciplines including other specialties that consider the physical and social determinants of health. Clinicians and designers thus have a unique opportunity to help change the conversation by considering public health, urban and architectural opportunities to create forward-looking and innovative design solutions that can protect and restore health.[8]

Many lessons have been learned as clinicians planned to battle the disease by adapting their health care settings to prepare for and reduce the impact of the pandemic. The Centers for Disease Control and Prevention (CDC) has posted several guidance documents describing concepts and offering checklists regarding health care professional preparedness for transportation and arrival of patients with confirmed or possible COVID-19.[9] At the same time, it is critical for health care facilities to continue to provide care for all patients, irrespective of COVID-19 infection status, at the appropriate level (e.g., home-based care, outpatient, urgent care, emergency room, or hospitalization). Facilities may need to respond to a surge in patients requiring care.[10] Concentrated efforts will be required to mobilize all aspects of health care to reduce transmission of the disease, direct people to the right level of care, and decrease the burden on the health care system.[11]

The World Health Organization (WHO) states that a defining feature of COVID-19

regional outbreaks is the significant stress placed on health systems and health workers due to the large proportion of COVID-19 patients who require extensive clinical care. Outbreaks place acute burdens on staffing levels, availability of equipment, and crucial supplies, such as medical oxygen, ventilators, and PPE. It is essential, according to the WHO, to establish effective patient flow (through screening, triage, and targeted referral of COVID-19 and non-COVID-19 cases) at all levels. Even very robust health systems can be rapidly overwhelmed and compromised by an explosive COVID-19 outbreak. Contingency planning should include extreme scenarios, such as the need to rapidly and completely reconfigure or largely repurpose the entire health sector let alone individual hospitals or ACS. Difficult decisions must be made to respond directly to COVID-19; at the same time, strategic planning and coordinated action are critical to maintain essential health service delivery while mitigating the risk of system collapse.[12]

SARS-CoV-2 transmission

The consequences of delayed recognition of a person with SARS-CoV-2 pose a serious risk to patients and providers. While hospitals and health care settings routinely set up protocols for working with patients with infectious diseases, the unique aspects of this novel virus impose new design considerations and spatiotemporal requirements for airborne and contact isolation protocols.

Current research demonstrates that SARS-CoV-2 virus is spread through direct person-to-person contact with an infected symptomatic person, by droplet or contact transmission with fomite surfaces that have been in the environment of an infected individual, or via airborne droplet or aerosols transmission when performing or assisting with high-risk aerosol-generating medical procedures.[13] Epidemiologic, virologic, and modeling studies support the possibility that SARS-CoV-2 can be transmitted from those who are pre-symptomatic (SARS-CoV-2 detected before symptom onset) or those who are asymptomatic (SARS-CoV-2 detected but symptoms never develop).[14,15]

The risk of passing the virus to other patients, staff, and health care workers depends on multiple factors. Research to establish the survival of the SARS-CoV-2 virus in a variety of conditions indicates that it may remain viable for hours to days on different surfaces or materials. Person-to-person airborne transmission can occur via respiratory droplets produced when an infected individual speaks, coughs, or sneezes and exposes the mouth, nose, or eyes of another person. The infectious droplets can be inhaled into the lungs of those within close proximity or be transmitted if droplets land on surfaces or objects such as tables, doorknobs, privacy curtains and handrails that are touched by others who in turn touch their own eyes, nose, or mouth.[16] Droplets may also sink to the ground and spread as people walk into or through the environment.

Small infected droplets can remain in the air for periods of time and be transmitted to others over greater distances. The virus can be spread in a range of airborne and droplet sizes, particularly in health care settings where clinicians are routinely face-to-face with an infected patients or persons. Several procedures performed on patients with COVID-19 are known to generate infectious aerosols. Therefore, the CDC's infection and control recommendations include special precautions for spaces where aerosol-generating procedures (AGPs) are performed.[17] Where aerosolizing procedures take place, "super-spreading" events occur in health care

settings, such as emergency rooms, intensive care units, operating rooms, medical wards, and dialysis centers, among other settings.[18]

Implications for COVID-19 care environments

Environmental factors, such as the choice of materials and built dimensions, will affect the degree of protection afforded. The risk for infection is highly dependent on the distance to the infected individual as well as the type of personal protective equipment (PPE), face mask and eye protection worn, and human interactions. Putting on, removing, and disposing of PPE is a particularly high-risk activity for spreading the SARS-CoV-2 virus; therefore, health care teams need appropriate and generous space to oversee each other in their use of PPE.

Such space needs to allow for the separation of individuals, clean and contaminated circulation paths, and appropriate cleaning procedures to assist in the reduction of viral spread.[19] The positioning of additional handwashing and hazardous waste disposal facilities near the infected patient bed, directly outside of the patient room, and near clinical stations reduces risk and the amount of PPE needed for care in complex and crowded clinical settings. These hygiene facilities should be provided in addition to PPE, hand washing and footwear cleaning stations at the entry points and exits from a COVID-19 units or wards. Provision of staff-only handwashing and shower facilities nearby to COVID-19 care units and PPE stations and nearby staff toilets should also be considered to minimize transmission as gastro-intestinal symptoms have been reported.

Currently, it is unknown how long the air inside a room occupied by someone with confirmed COVID-19 remains potentially infectious, although a systematic review and meta-analysis of SARS-CoV-2 transmission found RNA in some air sampling studies.[20] Measures to improve ventilation in an area or room where someone was ill or suspected to be ill with COVID-19 will help reduce risk and shorten the time it takes for respiratory droplets to be removed from the air. Facilities should therefore consider factors such as the size and use of the room, activities in adjoining spaces, and the potential for room-to-room transmission when designing or modifying ventilation systems for airborne precautions. The relative pressure between rooms, flowrate and air changes per hour, and the location of supply and exhaust vents will determine how long it is necessary to close off rooms or areas used by ill persons before beginning disinfection and readying such places for the next patient.[21]

Existing evidence and emerging data can inform considerations of how architecture, materials, and utilization plans can directly influence patient and provider outcomes. In addition, the environmental or urban context of each care setting, and its proximity to a network of care resources, should inform the physical design. By increasing the distance between patients, visitors, providers, and staff, airborne or contact transmission may be reduced.

Space planning should consider how to rapidly triage and separate patients with symptoms or those under investigation (with or without symptoms) from the general population until they can be placed in the appropriate isolation rooms. Ideally, the lowest-acuity patients should be managed outside of the emergency department. If there is not adequate room to triage the number of patients presenting to the ED, temporary structures (e.g., tents or fabric structures) may be considered for those waiting to be tested, with separate areas and circulation

paths for those who are confirmed positive cases. Registration kiosks, plexiglass barriers, and physical distancing strategies have been utilized to protect patients and staff. Privacy curtains may also play a role in separating individuals, although staff routinely touch the curtain before, during, and after procedures, and contamination of curtains has been demonstrated.[22] Therefore, cleaning protocols and the choice of materials should be carefully considered.[23]

Strategies for COVID-19 planning and design

The strategies and lessons learned by physicians in Northern Italy who were at the front line during the initial COVID-19 outbreak in that country are reflected below and are consistent with our findings[24]. These are more fully described in the AIA COVID-19 Task Force Front Line Checklist.[25]

- Set up a network of facilities, experts and advisory panels to consider the distribution of staff, resources, and care facilities from institutional, local, regional and national perspectives
- Create emergency management disaster plans that address pandemics, over-capacity patient volumes, and potential staffing shortages, and be ready to adjust the spaces and the resources to accommodate the flow of incoming patients many times during the day.
- Maintain flexibility in space utilization planning in the layout of the emergency department (ED) and triage places to accommodate changing dynamics as the disease spreads through the community and potentially overwhelms the traditional ED flow patterns.
- Create plans to expand the availability of negative pressure rooms where possible while prioritizing the needs of COVID-19 patients as appropriate.
- Consider one-way circulation to divide “clean” from “contaminated” flow of staff and supplies.
- Provide spaces for personnel to help manage the flow throughout the facility.
- In larger hospital systems, designate units for treatment of COVID-19 patients to streamline the use of resources and prevent nosocomial spread of SARS-CoV-2, and be prepared to change space utilization accordingly.
- Provide appropriate spaces for environmental services, supplies, and workers that will be needed to expedite the turnover of beds in the ED and around the hospital. An unclean isolation room during a pandemic risks COVID-19 transmission and infection throughout the facility.
- Provide spaces for staff teamwork, mentoring, processing and managing the traumatic experience of this disease.
- Prepare psychological support for the staff early.

“Prepare psychological support for the staff early. You will need it.”

Conclusions

Clinical, scientific, and subject matter experts provide critical information about how planning and design can measurably impact care outcomes during the COVID-19 pandemic. Research continues in order to determine the many environmental factors that influence viral spread, including the risks associated with air flow, temperature, relative humidity, distance, materials, and other physical characteristics of built settings. Ongoing collaboration with clinical experts, infection control specialists, scientists, epidemiologists, health care executives and public health professionals will be important to translate the emerging knowledge into the most effective design guidance. In the context of this pandemic, architecture and design professionals may consider interventions that adopt a precautionary principle, taking reasonable action to reduce risk while awaiting greater scientific certainty.

The following design guidance provided by the AIA COVID-19 Front Line Checklist[26] summarizes strategies, considerations, and some concrete design solutions to meet the challenges that come from surges in patient numbers and the range of procedures required for different levels of acuity. Further, it considers how staffing, the availability of PPE, and the medical equipment necessary to combat this disease may inform the dimensions, layout, equipment, adjacencies and clinical spaces required.

Many of the concepts outlined in this White paper and Checklist were based on existing but incomplete knowledge about the novel SARS-CoV-2 virus during the early phase of the pandemic. Clinical teams continue to modify their facilities as new findings are released by the WHO, CDC, and research teams across the globe who continue to study how the virus is spread (via air, water, surfaces, etc.), and the disease should be treated. Ultimately, evidence-based studies by a consortium of clinicians, health care executives and epidemiologists along with architects, engineers, designers, and planners can inform facility guidance and alter codes and recommendations for current and future events.[27]

The interdependence and intertwining of environmental and built conditions with patient and provider outcomes are in evidence as frontline health workers adapt their care settings to make them more efficient, effective, and supportive. The burden of the COVID-19 crisis on clinicians has been highlighted by reports of suicide and depression. Architects' social responsibility to create spaces that care for patients as well as caregivers must not be overlooked. 'Clinicians for Design' continue to gather health care workers' experiences of the direct impact of the environment on the health, safety, and well-being of all patients, clinicians, staff, and visitors. These in-depth collaborations between clinicians and designers aim to save lives by design.[28]

COVID-19 Front Line Checklist Tool

Design considerations to reduce risk and support patients and providers in facilities for COVID-19 care

Purpose

The purpose of the AIA COVID-19 Front Line Checklist is to gather the insights and experience of clinicians, researchers, administrators, and staff in order to describe how the built environment may influence their workflow, operations, clinical management and care of patients during the COVID-19 pandemic.

The following describes a consensus of the Front Line Work Group and interviews with expert clinicians, scientists, and health care design professionals. This checklist reflects how health care settings have been modified or could be adapted to address COVID-19 care and offers guidance on important features to be considered within a variety of health care or alternate care site (ACS) facilities.

Continued collaboration with clinical specialists and scientists is warranted in order to translate emerging knowledge and research findings into the most effective and up to date design guidance.

Method

The lessons learned within existing hospitals in the early phase of the pandemic (February-April 2020) inform guidance for facilities that care for COVID-19 patients with different levels of acuity and need, and can be considered for a variety different health care settings. In addition, information is included from publications during the early phase of the 2020 pandemic.

The Front Line Checklist adapted the format used by the CDC (Centers for Disease Control and Prevention) Comprehensive Hospital Preparedness Checklist for Coronavirus Disease 2019 (COVID-19) and the AIA ACS Preparedness Assessment Tool.

Clinical considerations

Patient categories

Several patient cohorts exist within the outbreak cycles of this pandemic response. Each patient cohort influences the care required and the essential spatial features needed in different care settings. Therefore, patient status will determine the appropriate design features, type of facility or alternate care setting that is suitable for varied levels of acuity and health care needs. As research continues to reveal a greater understanding of COVID-19 transmission and the health care procedures required for each cohort, advice on the different patient categories and separation into different settings will likely change. The categories below may also be grouped into those in whom antibodies to SARS-CoV-2 have been detected or not detected. Additional cohorts may include children, elderly patients, and people with behavioral health conditions, among others.

Patient cohort	Definition
1. SARS-CoV-2 virus detected with symptoms	Symptomatic & positive tested COVID-19 patient
2. SARS-CoV-2 virus testing in process	PUI (patients/persons under investigation)
3. SARS-CoV-2 virus no longer detected in previously positive patient	Recovering COVID-19 patient
4. SARS-CoV-2 virus detected without symptoms	Asymptomatic person with positive test
5. Sars-CoV-2 virus negative with other medical condition(s)	Patient with an illness other than COVID 19; false-negative possible

Clinical management

Different patient populations and varying levels of disease acuity require different care spaces. Each of the following scenarios indicate a variety of space planning considerations.

1. Spaces for symptomatic patients of varying levels of acuity
2. Spaces for persons under investigation (PUI)
3. Spaces for recovering patients
4. Spaces for asymptomatic or pre-symptomatic virus-positive patients
5. Care spaces for vulnerable populations
6. Spaces for long-term care facility patients with special needs
7. Spaces for patients suffering from illnesses other than COVID-19, such as outpatient surgical or gastro-intestinal procedures
8. Community spaces to isolate people who are positive for COVID-19 and well but cannot afford to self-isolate. These people can propagate the virus and need to be isolated to protect the community at large (such as the use of TB sanitoriums in the past).

Facility considerations

Proximity of health care settings

- Consider proximity to hospital and specialty facilities particularly for COVID-19 patients with moderate or higher levels of acuity; remote facilities must have resources for rapidly changing symptoms, including resuscitation and/or critical care.
- Consider easy and appropriate transportation from the COVID-19 facility to a hospital with ICU facilities.

- Consider options for placing low acuity/other care services at locally designated public health or community care settings to reduce the burden on COVID-19 care facilities and transportation to such sites.
- Consider a network of facility types and scenarios dependent on location and resources, including:
  - » Ancillary isolated sites for highly contagious care
  - » Separate sites for noncontagious patients to reduce patient numbers at overburdened facilities
  - » Distributed regional facilities to reduce traffic that may disrupt ambulances or first responders at urban sites
  - » Place ACS or non-COVID care facilities in local communities to minimize overburdening facilities in the regional network.

Arrival, triage, entry, and testing

- Accommodate medical transportation, vehicular and individual queuing, outdoor field hospitals, modifications to entry ports, and triage stations positioned outside of the building.
  - » Determine a process (e.g., queueing by mobile phone) to allow patients to wait in a personal vehicle or outside the health care facility until it is their turn to be evaluated.
- Set up separate, well-ventilated triage areas for the capacity and level of acuity in each facility and associated health system resources.
- Create entry, triage, and waiting areas with well-ventilated spaces, separating people by six feet or more and with easy access to hygiene supplies.
- Implement infection source control for everyone entering a health care facility (e.g., health care personnel, patients, visitors) regardless of symptoms.
- Create separate reception, waiting and test areas using physical barriers such as glass or plastic windows or screens, with controlled spaces for fever testing, viral tests, and one-way corridor flow.

Figure 2: Applying the hierarchy of controls for COVID-19 (adapted from NIOSH)

Flexible facility utilization

- Map movement of patients through the entire facility and plan for multiple changes in facility utilization as patient volumes, acuities, and conditions change.
- Consider designating entire units within the facility or designate an entire facility to care for patients with known or suspected COVID-19. This strategy may limit the total number of health care providers exposed, conserve PPE used, or support staffing efficiencies.
- Allocate areas for symptomatic, asymptomatic, and patients under investigation for COVID-19.

- Patients with different respiratory pathogens might be housed on the same unit. However, only patients with the same respiratory pathogen may be housed in the same room.
- Minimize room transfers for patients with known or suspected COVID-19; As possible, patients should be housed in the same room for the duration of their stay, with procedures or tests performed in the same room.
- Provide access to toilets in resuscitation and other areas.

Set up facility strategies for isolation

- Ensure facility policies and practices are in place to minimize exposures to respiratory pathogens including SARS-CoV-2.
- Implement measures for controlling the spaces each patient uses for the duration of their visit, and room cleaning and disinfection.
- Protect individuals at increased risk for adverse outcomes from COVID-19 (e.g., older individuals, those with comorbid conditions), and health care professionals who are in a recognized risk category.
- Cancel elective procedures to increase bed capacity and reduce transmission risk.
- Set up a strategy for direct bedding or discharge of patients upon positive or negative diagnosis, which can minimize the need for separate patients waiting areas.

Health care personnel considerations

Personal protective equipment (PPE)

- Provide adequate protected space in convenient locations for safe donning and doffing of PPE.
    - » Clinicians need adequate space and furnishings for team members to observe or assist each other when putting on or taking off PPE.
- Provide PPE to patients to help minimize transmission to providers and reduce viral spread as patients move throughout the facility.
- Provide PPE to visitors who are allowed to sit with patients and comfort them at critical events during the caregiving process.

Personnel Protection

- Protect health care personnel from infection transmission.
- Allow for separate entry and exit from COVID-19 or other spaces known to accommodate patients with communicable conditions.
- Implement standard infection control procedures, including eye protection, contact and airborne precautions.
- Provide barriers that control or limit contact with patients where people enter, are triaged, receive testing, receive care, and are discharged.

- Provide a gateway sinks at the entry and exit to areas, units or wards with beds for COVID-19 patients.
- Install additional handwashing sinks for providers to use before, during, and after PPE use. These should be placed within the patient room, directly outside of the patient room, and near clinical or procedure stations.
- Provide frequent locations for hand sanitizer and wipes for surfaces to ensure general cleaning and disinfection procedures can take place regularly and in addition to shift change or patient relocation.
- Install decontamination shoe baths and use cleanable footwear protocols rather than relying on shoe covers (e.g., booties) to minimize infection transmission from droplets on the floor and to minimize slips, slides and falls.
- Ensure adequate areas and receptacles for contaminated waste.

Staff ratios and teams

- Patient-to-staff ratios and caregiving strategies impact space utilization.
    - » Consider the locations and dimensions of workstations, team rooms, and unit layout to allow doctors, nurses, therapists, specialists, resuscitation teams, and other clinical team members to collaborate and discuss patient conditions.
    - » Consider clinician's physical distance, proximity to the team and patients, sightlines, care models and management, and distance from specialty and support services.
    - » Consider parameters and materials used at staff workstations: sound (speech intelligibility, speech privacy, noise absorption and distribution); sight (electrical and day lighting, visual accuracy, visual privacy and views); physical comfort, movement, and safety (physical separation and distance, ergonomics, thermal comfort, relative humidity, ventilation).
- Plan to adjust patient-to-staff ratios and space utilization to accommodate staff shortages due to exposure, illness, or time off, while increasing numbers of patients with higher levels of acuity arrive.
    - » Develop space options for multiple layouts and arrangement of patient beds with clear sightlines between care team members. Sharing of rooms may be required depending on patient numbers, resources and staff ratios.
- The layout and arrangement of telemedicine screens can support observation, clinical teams, and family interaction.
    - » Robust Wi-Fi and high-quality audio and video transmission are vital for remote telemedicine and tele-diagnostics.

Care settings

Empathetic considerations for respite and end-of-life care

- Create respite areas for patients, visitors and for providers to respond to the stress experienced during high-volume, complex, critical, and difficult care situations, including end-of-life care.
- Create spaces to celebrate patient and provider successes.
- Provide spaces for rest, respite and recovery for the clinical team and staff.
- Provide settings for mental and behavioral health challenges and for family members or companions in distress.
- Provide spaces for staff to provide emotional support or palliative care.
- Provide space for family members at the patient's bedside or within view of the patient.
    - » Include spaces for visitor donning and doffing of PPE under the supervision of clinicians.
    - » Provide acoustic privacy for one-to-one conversations or via telecare, phone, or mobile technologies.
    - » Allow if possible, one family member using appropriate infection control procedures and PPE to join patients during end-of-life circumstances.

Implement separation and circulation controls

- Install physical separators or adapt spaces to reduce or eliminate exposures from infected individuals.
    - » Examples include the placement of physical barriers or partitions to guide patients through triage areas, along corridors, and through shared or specialty care settings.
    - » Curtains between patients may be useful compared with no separation. However, curtains are easily contaminated before, during and after patient interaction, and must be frequently washed/cleaned.
    - » Consider antimicrobial materials such as complex element compounds (CEC).
- Move patients to isolation beds or treatment spaces as soon as possible.
- Limit transport and movement of the patient outside of isolation rooms to medically essential purposes.
    - » Consider portable technologies such as X-ray equipment in patient cohort areas to reduce the need for patient transport.
- Plan movement paths and one-way circulation strategies to minimize the distance traveled and exposure of staff who move between critical care, labs, specialty areas, etc.
    - » Consider the difficulty of maintaining physical distance where two-way

gurney traffic with accompanying clinical teams occurs.

  - » Consider the actual corridor clearance dimensions, taking into account the positioning of required equipment outside of or near patient or treatment rooms, and equipment stored in corridors.
  - » When laying out "clean" or "infected" circulation paths, plan the most appropriate, direct, and rapid pathways for teams to move between the pharmacy, operating rooms, blood banks, and other departments. Thoughtful planning can minimize the need for PPE changes along such paths.

- Elevators may be designated separately for "clean" or "infected" persons, but ensure circulation paths are effective for critical access to care or supplies.
  - » Ensure gurneys, medical teams, and equipment can fit within the elevator, with room to turn the gurney to enter in the preferred direction.
- Provide donning and doffing spaces for PPE with adequate room for movement without touching surfaces in corridors or shared spaces.
  - » Areas designated by tape or marks on the floor that divide corridors into two paths or into designated areas for donning and doffing may be compromised as patients on gurneys, in wheelchairs, or on foot move through the space.

COVID-19 care rooms or bays

- Consider creating "universal" rooms to minimize patient transfer from one location to another unless necessary. This reduces the risk of infection transmission, the number of PPE changes required, and cleaning or disinfection activities.
  - » Plan for multiple adaptations to rooms and spaces for increased patient volumes, changing cohorts or levels of acuity.
  - » Provide handwashing, hygiene and waste facilities near to each patient room.
  - » Include equipment and spaces to process soiled, hazardous, pharmaceutical, and medical waste.
- Allow additional space for large clinical teams and complex interventions, procedures, and care.
  - » Consider room for large patient beds for high body mass index (BMI), and to accommodate patient positioning (proning), physical therapies, or clinical procedures.
  - » Allow area around the bed to accommodate six or more staff working together on proning or other procedures.
  - » Allow area around patient bed to accommodate four to six resuscitation 'code' team members who must interact and bring in and out equipment within the same space as the patient's team.

  - » Allow area for staff to pass equipment in and out without contamination or requiring deep cleaning.
  - » Allow area for equipment such as ventilators, dialysis, ECMO, infusion pumps, crash carts, portable imaging, etc.
- Provide places that support peer-to-peer provider collaboration at bedside, outside of the isolation space, and at clinical stations.
  - » Provide space for staff to move through or near COVID-19 rooms considering infection control protocols and the sequence of team interactions by the bedside, with teams at other clinical stations, via runners, and to "clean" or "infected" areas.
  - » Environmental and technological features for communication, collaboration, supervision, education, and focused work.
- Arrange room layouts and ward or unit modules so that there are good sightlines and rapid access to the patient, to the monitoring equipment, and among team members.
  - » Provide protected access of the clinical team to the patient and equipment.
  - » In COVID-19 units serving large numbers, minimize the distance from clinical stations to the patient's bedside.
- It is preferred that patients with suspected or confirmed COVID-19 be placed in private rooms with private bathrooms.
- Room doors should be kept closed except when entering or leaving the room, and entry and exit should be minimized.
  - » Consider vision panels in the door or remote video monitoring to provide sightline to patients, clinical teams, and equipment.
  - » Change doors or insert view windows for sightlines or communication with clinicians posted at the bedside. This strategy can reduce the number of PPE changes required by staging the flow of staff interaction.
  - » In order to manage staff-to-patient ratios and limit exposure, some facilities have positioned medical equipment such as medication pumps and intravenous drip poles outside of the room in order to monitor care while doors remain closed.
- Provide convenient access to restrooms in resuscitation and other areas.

Clinician stations

- Physicians, nurses, and all members of the care team need the ability to be near each other yet also need to allow for at least six feet of physical distance while being able to hear one another.
- Create a dedicated and assigned desk space for each health care worker to decrease the spread of contagion. At a minimum, staff should wipe down individual workstations at shift change.

- Consider clear plexiglass/glass to create mini cubicles in a common documentation desk to separate staff using the station.
- Consider localized sound amplification where needed, including at clinician stations and within crowded locations where equipment noise and alarms make communication difficult and increase the risk of miscommunication.
- Include shredders for destroying confidential documents.
- Provide remote telemedicine capability for clinicians to confer with each other, patients, and families.

Telemedicine

- Increased use of telemedicine, supported by recent changes, offers a new opportunity to provide care safely and remotely.
- Telemedicine and remote care have the benefit of reducing the amount of PPE required.
- Remote care providers need high-quality video, audio, internet, and power connections to engage in tele-diagnostics.
- Provide monitoring systems, room alarms, and pulse oxygenation screens to detect hypoxia, heart rate change etc., from a central location.
- Telemedicine systems can be distributed within the hospital, a health system network, to communities and patient homes.
- Provide technologies for remote patient and visitor interactions, including video-calls, cell phones or tablets.

Air handling:

Implement air-handling rooms, zones, or floors for infection isolation

- Air exchange, filtration, cleaning, and disinfecting should follow recommended environmental infection control procedures that also consider aerosol transmission and manage airflow from positive pressure rooms such as operating rooms.
- Air-handling systems with appropriate directionality, filtration, exchange rate, etc., that are properly installed and maintained are important for managing all spaces and settings in the facility.
- Many health care settings do not have an adequate number of negative-pressure rooms with filtered air flow to meet patient demand. Engineers should consider modifying existing HVAC system or adding new zones or individual room ventilation systems.
    - » In some cases, negative-pressure or negative-"flow" zones can be created to serve multiple patients who are all COVID-19 positive. Depending on the patient numbers, cohorts, and resources, entire floors or entire buildings can be converted for only COVID-19 patients.
    - » Create negative-pressure airborne infection isolation rooms

- Airborne infection isolation rooms (AIIR) are required for patients with or suspected of COVID-19 who are undergoing aerosol-generating procedures. (See below.) AIIRs are at negative pressure relative to the surrounding areas, with a minimum of six air changes per hour (a minimum of 12 air changes per hour are recommended for new construction or renovation).
- Rooms that require more frequent turnover, such as in an emergency department, may consider more frequent air exchanges to clear out pathogens faster and allow for quicker decontamination.
- Air from these rooms should be exhausted directly to the outside or be filtered through a high-efficiency particulate air (HEPA) filter directly before recirculation.
- Facilities should monitor and document the proper negative-pressure function of these rooms.

Create spaces for aerosol-generating procedures (AGP)

- Take special precautions in spaces where AGPs are performed.
- Some procedures performed on patients with COVID-19 could generate infectious aerosols (such as during intubation).
- Procedures posing such risk should be performed cautiously for patients with suspected or confirmed COVID-19 or for patients with other infections for which respiratory protection is strongly indicated (e.g., tuberculosis, measles, varicella).
- Nebulizers, high-flow oxygen, and non-invasive ventilation techniques create effluent and need closed systems to evacuate the aerosolized virus.
- Operating rooms and other spaces with positive pressure are locations where AGPs occur for COVID-19 and other patients, making airborne transmission possible.
- Consider positioning anterooms for both infection control and as areas for team supervision of safely donning and doffing PPE.
- Consider air-handling systems with the ability to switch from negative to positive air pressure to enable facilities to more rapidly respond to fluctuation in patient numbers, acuity, and care conditions.
- The ability to revert from positive to neutral airflow would be useful following resuscitation procedures.
- Monitor relative humidity to maintain conditions in the range considered to minimize microbial/virus growth or survival.

Environmental and infection control considerations:
Follow institutional, local, regional, and national infection control codes, regulations, guidance or recommendations. Refer frequently to recent research and expert clinical and scientific panels for updates and recommendations and regulations that address the unique circumstance and challenges imposed by the SARS CoV-2 outbreak.

While this document does not replace that guidance, the following planning and design features should also be considered.

- Create spaces that allow environmental cleaning and disinfection procedures to be followed consistently and correctly.
- Provide facilities and workflow for separation of clean and contaminated spaces for management of equipment, supplies, pharmaceuticals, laundry, food services, etc.
- Provide spaces for hazardous and medical waste to be dealt with in accordance with infection control procedures.
- Provide water systems for medical procedures such as dialysis, etc.
- Provide spaces and equipment for terminal cleaning of equipment, rooms, and PPE.

Emerging challenges and opportunities
- This AIA COVID-19 Front Line Checklist was developed from February through April 2020 during the early phase of the SARS-CoV-2 outbreak. Therefore, information about the disease and the potential impact of design was limited to the existing knowledge at that time.
- As new findings emerge, continued efforts will translate findings into up to date design principles, leveraging consultation among clinicians, scientists, epidemiologist, health care executives, public health specialists, users, and the design team.

In the context of this pandemic, architecture and design professionals may consider interventions that adopt a precautionary principle, taking reasonable actions that reduce risk while awaiting greater scientific certainty.

Author contributions

Contributors to Frontline Work Group, White Paper and Checklist
(EE) Eve Edelstein, PhD, MSc, M.Arch, F-AAA (Working Group Chair) | Co-Founder, Clinicians for Design

RF) Ruth Fanning, MBBChBAO, MRCPI, FFARCSI | Clinical Professor of Anesthesiology, Perioperative and Pain Medicine, Stanford University

(JR) John Riordan, MD, MS | Associate Professor Emergency Medicine, Vice-Chair Clinical Operations, School of Medicine, University of Virginia

(MW) Marvina Williams, RNBSN, Lean Black Belt | Associate Principal, Senior Medical Planner, Perkins & Will

(DA) Diana Anderson, MD, ACHA | Co-Founder, Clinicians for Design

(AH) Anita Honkanen, MD, MS, FAAP | Clinical Professor of Anesthesiology, Stanford University School of Medicine

(IB) Ilene Brenner MD, MS, FACEP | Attending, Tanner Health Care, Georgia and Alabama

(KW) Kirsten Waltz, AIA, ACHA, EDAC, LEED AP | Director of Facilities Planning & Design, Baystate Health

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COVID-19 Front Line White Paper and Front Line Checklist Tool
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Members of the AIA Task Force
(MS) Molly M. Scanlon, PhD, FAIA, FACHA — Chair

(DA) Diana Anderson, MD, ACHA

(EE) Eve A. Edelstein, PhD, MArch, Assoc. AIA, EDAC, FAAA

(JF) John Fowler, AIA, EDAC, LEED AP

(WH) William Hercules, FAIA, FACHA, FACHE

(EP) Erin Peavey, AIA, EDAC, LEED AP

(YS) Yiselle Santos, AIA, LSSYB, WELL AP, LEED AP

(ET) Ellen Taylor, PhD, AIA, MBA, EDAC

(KW) Kirsten Waltz, AIA, ACHA, EDAC, LEED AP

(MW) Marvina Williams, RN, BSN, LSSBB

(FZ) Frank Zilm, DArch, FAIA, Emeritus FACHA

(DP) Doug Paul, AIA staff

Meetings
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Important reader note

Health Impact Briefing in the context of the AIA COVID-19 rapid response is a summary of the best available information on the date of release using evidence-based best practices or policy analysis (guidelines, standards, or code initiatives) for a public health pandemic response to the challenges emerging in the built environment that affect the health, safety, and welfare of the public, notably the building occupants, such as patients, frontline health care staff, caregivers, families, and support staff.

This Health Impact Briefing represents the work of the AIA COVID-19 Task Force to educate and inform architects, health care practitioners, public health professionals, and authorities having federal, state, and/or local jurisdiction within the pandemic response. This Health Impact Briefing in no manner represents or is intended to replace existing applicable laws, regulations, or standards.

1 Li R, Rivers C, Tan Q, Murray MB, Toner E, Lipsitch M. The demand for inpatient and ICU beds for COVID-19 in the US: Lessons from Chinese cities. medRxiv. 2020: preprint. doi:10.1101/2020.03.09.20033241. Accessed April 1, 2020.

2 Adams JG, Walls RM. Supporting the health care workforce during the COVID-19 global epidemic. Journal of the American Medical Association. March 2020: E1-E2. doi:10.1001/jama.2020.3972. Accessed April 1, 2020.

3 World Health Organization. Coronavirus Disease (COVID-19) Outbreak: Rights, Roles and Responsibilities of Health Workers, Including Key Considerations for Occupational Safety and Health. 2020: 1-2. Accessed April 1, 2020.

https://www.who.int/publications/i/item/coronavirus-disease-(covid-19)-outbreak-rights-roles-and-responsibilities-of-health-workers-including-key-considerations-for-occupational-safety-and-health

4 The American Insittute of Architects. AIA COVID-19 Task Force 1: Health Impact Briefing #1. COVID-19 alternative care sites: Addressing capacity, safety, and risk challenges for our nation's hospitals during a public health pandemic response. 2020; 1-14. Accessed June 2, 2020.

http://content.aia.org/sites/default/files/2020-04/KC20_AAH_C-19_Alt-Care-Sites-Whitepaper_sm_v03_FINAL.pdf.

5 Giwa AL, Desai A, Duca A. Novel 2019 coronavirus SARS-CoV-2 (COVID-19): An overview for emergency clinicians. Pediatric Emergency Medicine Practice. May 2, 2020; 17(5): 1-24. Pub Med ID: 32207910. Accessed April 1, 2020.

6 Bauchner H, Leavitt M. Coronavirus Q&A: Former Utah Governor and HHS Secretary Mike Leavitt. JAMA Network. April 2020. Accessed April 8, 2020.

https://edhub.ama-assn.org/jn-learning/audio-player/18437848.

7 Bauchner H, Leavitt M. Coronavirus Q&A: Former Utah Governor and HHS Secretary Mike Leavitt. JAMA Network. April 2020. Accessed April 8, 2020.

https://edhub.ama-assn.org/jn-learning/audio-player/18437848.

8 Bauchner H, Galea S. The Role of Physicians in Addressing Social Determinants of Health. JAMA Network. April 2020. Accessed April 2, 2020.

https://edhub.ama-assn.org/jn-learning/audio-player/18408822.

9 Centers for Disease Control and Prevention. Healthcare Professional Preparedness Checklist For Transport and Arrival of Patients With Confirmed or Possible COVID-19. Accessed April 6, 2020.

https://www.cdc.gov/coronavirus/2019-ncov/hcp/hcp-personnel-checklist.html

10 Centers for Disease Control and Prevention. Coronavirus Disease 2019 (COVID-19): Healthcare Facility Guidance. (20200421). Accessed April 6, 2020.

https://www.cdc.gov/coronavirus/2019-ncov/hcp/guidance-hcf.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fhealthcare-facilities%2Fguidance-hcf.html

11 Centers for Disease Control and Prevention. Interim Infection Prevention and Control Recommendations for Patients with Suspected or Confirmed Coronavirus Disease 2019 (COVID-19) in Healthcare Settings. Accessed April 13, 2020.

https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-recommendations.html

12 World Health Organization. COVID 19 Strategy update 14 April 2020. Accessed April 14, 2020.

https://www.who.int/docs/default-source/coronaviruse/covid-strategy-update-14april2020.pdf?sfvrsn=29da3ba0_12&download=true

13 Lockhart SL, Duggan LV, Wax RS, Saad S, Grocott HP. Personal protective equipment (PPE) for both anesthesiologists and other airway managers: principles and practice during the COVID-19 pandemic. Published online ahead of print, April 23, 2020. Canadian Journal of Anesthesia. 2020; 1-11. doi:10.1007/s12630-020-01673-w. Accessed April 23, 2020.

14 Furukawa NW, Brooks JT, Sobel J. Evidence supporting transmission of severe acute respiratory syndrome coronavirus 2 while presymptomatic or asymptomatic. Emerging Infectious Diseases. 2020; 26(7). doi: 10.3201/eid2607.201595. Accessed May 4, 2020.

15 Lee S, Meyler P, Mozel M, Tauh T, Merchant R. Asymptomatic carriage and transmission of SARS-CoV-2: What do we know? Canadian Journal of Anaesthesia. 2020. doi:10.1007/s12630-020-01729-x.

16 Centers for Disease Control and Prevention. Interim Infection Prevention and Control Recommendations for Patients with Suspected or Confirmed Coronavirus Disease 2019 (COVID-19) in

Healthcare Settings. 2020. Accessed April 6, 2020.

https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-recommendations.html.

7 Centers for Disease Control and Prevention. Interim Infection Prevention and Control Recommendations for Patients with Suspected or Confirmed Coronavirus Disease 2019 (COVID-19) in Healthcare Settings. 2020. Accessed April 6, 2020. https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-recommendations.html.

8 Chu DK et al. Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: A systematic review and meta-analysis. The Lancet. 2020. doi: 10.1016/ S0140-6736(20)31142-9.

https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)31142-9/fulltext

9 Centers for Disease Control and Prevention. Cleaning and Disinfection for Community Facilities. 2020. Accessed April 6, 2020.

https://www.cdc.gov/coronavirus/2019-ncov/community/organizations/cleaning-disinfection.html

20 Chu DK et al. Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: A systematic review and meta-analysis. The Lancet. 2020. doi: 10.1016/ S0140-6736(20)31142-9.

https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)31142-9/fulltext

21 Centers for Disease Control and Prevention. Interim Infection Prevention and Control Recommendations for Patients with Suspected or Confirmed Coronavirus Disease 2019 (COVID-19) in Healthcare Settings. 2020. Accessed April 6, 2020. https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-recommendations.html.

22 Schweizer, M, et al. Novel hospital curtains with antimicrobial properties: A randomized, controlled trial. Infection Control & Hospital Epidemiology. 2012; 33(11). doi: 10.1085/668022.

23 Centers for Disease Control and Prevention. Healthcare Infection Prevention and Control FAQs for COVID-19. 2020. Accessed April 6, 2020.

https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-faq.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Finfection-control%2Finfection-prevention-control-faq.html

24 Giwa AL, Desai A, Duca A. Novel 2019 coronavirus SARS-CoV-2 (COVID-19): An overview for emergency clinicians. Pediatric Emergency Medicine Practice. May 2, 2020; 17(5): 1-24. Pub Med ID: 32207910.

25 The American Institute of Architects. AIA COVID-19 Task Force 1: Health Impact Briefing #1. COVID-19 Alternate care sites: Addressing capacity, safety, & risk challenges for our nation's hospitals during a public health pandemic response. April 6, 2020. Accessed June 14, 2020.

http://content.aia.org/sites/default/files/2020-04/KC20_AAH_C-19_Alt-Care-Sites-Whitepaper_sm_v03_FINAL.pdf

26 The American Institute of Architects. AIA Coronavirus Disease 2019 (COVID-19) Alternate Care Sites Preparedness Assessment Tool V2.0. April 6, 2020. Accessed June 14, 2020.

http://content.aia.org/sites/default/files/2020-05/KC20_AAH_C-19_PreparednessChecklistV2.pdf

27 WHO R&D Blueprint. 2019 novel Coronavirus Global research and innovation forum: towards a research roadmap. A Coordinated Global Research Roadmap. Feb 12, 2020. Accessed June 14, 2020.

https://www.who.int/blueprint/priority-diseases/key-action/Roadmap-version-FINAL-for-WEB.pdf?ua=1

28 Anderson DC, Pang SA, O'Neill D, Edelstein EA. The art of medicine: The convergence of architectural design and health. The Lancet. Dec 8, 2018; 392: 2434-2433.

1 Li R, Rivers C, Tan Q, Murray MB, Toner E, Lipsitch M. The demand for inpatient and ICU beds for COVID-19 in the US: Lessons from Chinese cities. *medRxiv*. 2020: preprint. doi:10.1101/2020.03.09.20033241 Accessed April 1, 2020

2 Adams JG, Walls RM. Supporting the health care workforce during the COVID-19 global epidemic. *Journal of the American Medical Association*. March 2020:E1-E2. doi:10.1001/jama.2020.3972. Accessed April 1, 2020

3 WHO Communications Team. Coronavirus Disease (COVID-19) Outbreak: Rights, Roles and

Responsibilities of Health Workers, Including Key Considerations for Occupational Safety and Health. Geneva, Switzerland: The World Health Organization (WHO); 2020: 1-2. Accessed April 1, 2020

https://www.who.int/publications/i/item/coronavirus-disease-(covid-19)-outbreak-rights-roles-and-responsibilities-of-health-workers-including-key-considerations-for-occupational-safety-and-health

4 The American Insittute of Architects. AIA COVID-19 Task Force 1: Health Impact Briefing #1. COVID-19 alternative care sites: Addressing capacity, safety, and risk challenges for our nation's hospitals during a public health pandemic response. 2020; 1-14. Accessed June 2, 2020.

http://content.aia.org/sites/default/files/2020-04/KC20_AAH_C-19_Alt-Care-Sites-Whitepaper_sm_v03_FINAL.pdf.

5 Giwa AL, Desai A, Duca A. Novel 2019 coronavirus SARS-CoV-2 (COVID-19): an overview for emergency clinicians. *Pediatric Emergency Medicine Practice*. 2020;17(5):1-24. Published 2020 May 2. Pub Med ID: 32207910. Accessed April 1, 2020

6 Bauchner H, Leavitt M. Coronavirus Q&A: Former Utah Governor and HHS Secretary Mike Leavitt. JAMA Network. April 2020. Accessed April 8, 2020.

https://edhub.ama-assn.org/jn-learning/audio-player/18437848.

7 Bauchner H, Leavitt M. Coronavirus Q&A: Former Utah Governor and HHS Secretary Mike Leavitt. JAMA Network. April 2020. Accessed April 8, 2020.

https://edhub.ama-assn.org/jn-learning/audio-player/18437848.

8 Bauchner H, Galea S. The Role of Physicians in Addressing Social Determinants of Health. JAMA Network. April 2020. Accessed April 2, 2020.

https://edhub.ama-assn.org/jn-learning/audio-player/18408822.

9 Centers for Disease Control and Prevention. Healthcare Professional Preparedness Checklist For Transport and Arrival of Patients With Confirmed or Possible COVID-19. Accessed April 6, 2020.

https://www.cdc.gov/coronavirus/2019-ncov/hcp/hcp-personnel-checklist.html

10 CDC Coronavirus Disease 2019 (COVID-19): Healthcare Facility Guidance. (20200421). Accessed April 6, 2020.

https://www.cdc.gov/coronavirus/2019-ncov/hcp/guidance-hcf.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fhealthcare-facilities%2Fguidance-hcf.html

11 CDC Interim Infection Prevention and Control Recommendations for Patients with Suspected or Confirmed Coronavirus Disease 2019 (COVID-19) in Healthcare Settings. Atlanta, United States: Centers for Disease Control and Prevention; 2020. Accessed date: April 13, 2020.

https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-recommendations.html

12 WHO COVID 19 Strategy update 14 April 2020. The World Health Organization. Geneva, Switzerland. Accessed April 14, 2020.

https://www.who.int/docs/default-source/coronaviruse/covid-strategy-update-14april2020.pdf?sfvrsn=29da3ba0_12&download=true

13 Lockhart SL, Duggan LV, Wax RS, Saad S, Grocott HP. Personal protective equipment (PPE) for both anesthesiologists and other airway managers: principles and practice during the COVID-19 pandemic. Published online ahead of print, 2020 Apr 23. *Canadian Journal of Anesthesia*. 2020;1-11. doi:10.1007/s12630-020-01673-w. Accessed April 23, 2020.

14 Furukawa NW, Brooks JT, Sobel J. Evidence Supporting Transmission of Severe Acute Respiratory Syndrome Coronavirus 2 While Presymptomatic or Asymptomatic. *Emerging infectious diseases*. 2020; 26(7). doi: 10.3201/eid2607.201595 Accessed May 4, 2020.

15 Lee S, Meyler P, Mozel M, Tauh T, Merchant R. Asymptomatic carriage and transmission of SARS-CoV-2: What do we know?. *Canadian Journal of Anaesthesia*. 2020. doi:10.1007/s12630-020-01729-x

16 CDC. Interim Infection Prevention and Control Recommendations for Patients with Suspected or Confirmed Coronavirus Disease 2019 (COVID-19) in Healthcare Settings. Atlanta, United States: Centers for Disease Control and Prevention; 2020. https://www.cdc.gov/coronavirus/2019-ncov/hcp/

infection-control-recommendations.html. Accessed April 6, 2020.

17 CDC. Interim Infection Prevention and Control Recommendations for Patients with Suspected or Confirmed Coronavirus Disease 2019 (COVID-19) in Healthcare Settings. Atlanta, United States: Centers for Disease Control and Prevention; 2020. Accessed April 6, 2020. https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-recommendations.html.

18 Chu DK et al. Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis. *The Lancet*. 2020. doi: 10.1016/ S0140-6736(20)31142-9

https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)31142-9/fulltext

19 CDC. Cleaning and Disinfection for Community Facilities. Atlanta, United States: Centers for Disease Control and Prevention; 2020. April 6, 2020.

https://www.cdc.gov/coronavirus/2019-ncov/community/organizations/cleaning-disinfection.html

20 Chu DK et al. Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: a systematic review and meta-analysis. *The Lancet*. 2020. doi: 10.1016/ S0140-6736(20)31142-9

https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(20)31142-9/fulltext

21 CDC. Interim Infection Prevention and Control Recommendations for Patients with Suspected or Confirmed Coronavirus Disease 2019 (COVID-19) in Healthcare Settings. Atlanta, United States: Centers for Disease Control and Prevention; 2020. Accessed April 6, 2020. https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-recommendations.html.

22 Schweizer, J, et al. (2012) Novel Hospital Curtains with Antimicrobial Properties: A Randomized, Controlled Trial. *Infection Control & Hospital Epidemiology* 2012;33(11):000-000. DOI: 10.1085/668022.

23 CDC Coronavirus Disease 2019: FAQ on Infection Control. Healthcare Infection Prevention and Control FAQs for COVID-19, Accessed April 6, 2020.

https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-faq.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Finfection-control%2Finfection-prevention-control-faq.html

24 Giwa AL, Desai A, Duca A. Novel 2019 coronavirus SARS-CoV-2 (COVID-19): an overview for emergency clinicians. *Pediatric Emergency Medicine Practice*. 2020;17(5):1-24. Published 2020 May 2. Pub Med ID: 32207910

25 AIA COVID-19 Task Force 1: Front Line Checklist. American Institute of Architects. Washington DC. June 20, 2020. www.AIA.org

26 AIA COVID-19 Task Force 1: Front Line Checklist. American Institute of Architects. Washington DC. June 20, 2020.www.AIA.org

27 WHO R&D Blueprint: 2019 novel Coronavirus Global research and innovation forum: towards a research roadmap. A Coordinated Global Research Roadmap. Feb 12, 2020. Accessed June 14, 2020.

https://www.who.int/blueprint/priority-diseases/key-action/Roadmap-version-FINAL-for-WEB.pdf?ua=1

28 Anderson DC, Pang SA, O'Neill D, Edelstein EA. The art of medicine: The convergence of architectural design and health. *The Lancet*. Vol 392. Dec 8, 2018. (Pp. 2434-2433).

The American Institute of Architects
1735 New York Ave., NW
Washington, DC 20006
aia.org