ARCHITECTURE – A CRITICAL INGREDIENT OF PANDEMIC MEDICINE

AN OPEN LETTER TO POLICY MAKERS

William J. Hercules, FAIA, FACHA, FACHE; Diana Anderson, MD, ACHA; Marc Sansom, MBA
21 March 2020

The architecture of patient environments is a critical component of saving lives

The purpose of this paper is to identify and posit solutions for critical issues related to the care environments being considered by policy makers as the COVID-19 crisis continues to affect more citizens of the world, and what specific considerations relate to this architecture. History instructs, and more specifically, Florence Nightingale demonstrated that the built environment had more of an effect on wounded soldiers than their initial wounds.[1] **We argue that the built environment is a critical part of pandemic solutions and emergency preparedness.**

Most policy makers believe that any enclosed space may suffice, and **simplistically think that space is space, patient rooms are patient rooms, and widgets are widgets**. This is simply **NOT** the case. While the policy makers are wired for action and solutions, many simply don't know and haven't been properly advised. In fact, all of us are operating in a clumsy improvisational dance as we race against the calendar. **Improper environments of care may create many unintended consequences.**

Architects in general, and specifically board-certified healthcare architects[2] and certified health facility engineers[3], are **key and valuable resources** for rapid adjustments to current hospital and non-hospital infrastructure – repurposing old healthcare buildings, erecting temporary structures, and considering emergency preparedness in our building's codes and design guidelines[4]. **Current space utilization in hospitals can be quickly evaluated by these experts to maximize existing areas for use.**

- *The built environment is a critical part of pandemic solutions and emergency preparedness – consider Florence Nightingale's experience.*
- *Traditional capacity is limited, and expedient alternatives carry many challenges resulting in unacceptable unintended consequences.*
- *Policy makers must immediately convene a taskforce of qualified professionals to ideate acceptable and rapidly deployable solutions for housing the medical interventions necessary to combat this crisis and make those solutions available globally.*
- *Practical and rapid solutions are available based on current and emerging design and construction technologies.*
- *Urban designers, and architects must be leveraged and engaged to develop future-state solutions, so our current clumsy improvisational response is not repeated.*

With the rapid worldwide spread of the SARS-CoV2 virus and the resulting COVID-19 disease, leveraging all forms of professional expertise and specialties is paramount to a rapid resolution of the crisis, avoiding unintended consequences in the short-term, and embedding resilience in our health systems in the longer term. Given we have no current vaccine or effective treatment available, we must turn to non-pharmacologic means – including social

[1] *Florence Nightingale, Why Do We Remember Her?;* The National Archives of the United Kingdom; website accessed 20 Mar 2020
[2] Board-certified healthcare architects; American College of Healthcare Architect; website accessed 20 Mar 2020
[3] Certified Healthcare Facility Manager; American Society for Healthcare Engineering of the American Hospital Association; website accessed 20 Mar 2020
[4] *Adoption of the FGI Guidelines*; Facility Guidelines Institute; website accessed 20 Mar 2020

distancing, isolation, and quarantine – all of which depend upon the built environment. **Our homes, neighborhoods, healthcare settings, infrastructure and cities play a central role in emergency preparedness and response.** Harvard's Global Health Institute underscored the urgency based on current bed demand across the U.S. in several scenarios, concluding that "vast communities in America are not prepared to take care of the COVID-19 patients" [5,6] Space, as it relates to infectious disease epidemics **"isn't just about quarantine; it's also a design problem."**[7] In the face of airborne pathogens communicating to humans so freely, "…the only thing we have left is quarantine."[8] At least temporarily, "**We have to return to this kind of medieval spatial response to disease control, which means that architecture and urban design suddenly become medical.**"[9]

Specific Qualities of Space Enclosures for COVID-19

While the American Society for Healthcare Engineering (ASHE)[10] and others[11] have clarified the health facility related recommendations from the Centers for Disease Control and Prevention (CDC)[12], the devil is in the details to affect the range of patient conditions. **And these environments of care DO matter.** Architects are ready and positioned to emphasize the impact that the built space has on health outcomes and how care is delivered.

If patients require hospitalization according to emerging treatment modalities, they will need either a room with negative air pressure with respect to other nearby spaces, or increased isolation provided by an Airborne Infection Isolation Rooms (AIIRs), like the rooms to resist tuberculosis. **Both have specific air filtration and exhausting requirements to protect the patient within its enclosure, the caregivers, and others in adjacent spaces.** However, the ratio of both types of rooms is a very small in a typical hospital, and some hospitals may have neither.

Existing hospital rooms may be modified to accommodate these specific air pressure requirements, and ASHE and others have documented some of these concepts.[13,14] However, they will require rapid and concentrated physical and operational adjustments. Additionally, before each room is available to accept patients, the air balance must be tested and confirmed in order to manage contamination risks, which are numerous.

Scenarios for Housing COVID-19 Patients

Our number of acute and intensive care bed resources will be exhausted quickly by this coming infectious tsunami.[15] There are at least three types of environments of care that have various degrees of suitability to house this influx of patients: the current hospitals; homes, nursing homes, and hotels; quickly constructed alternative locations like

---

[5] Waldman A, Shaw A, Ngu A, Campbell S; *Are Hospitals Near Me Ready for Coronavirus? Here Are Nine Different Scenarios*; ProPublica; website accessed 20 Mar 2020
[6] Warner J; *Why We Are Not Doing Enough To Stop the Pandemic (in Simpler Math)*; Medium; 19 Mar 2020; website accessed 20 Mar 2020
[7] Budds D.; *Design in the Age of Pandemics*; Curbed; Vox Media; 17 Mar 2020; website accessed 20 Mar 2020
[8] Manaugh G, Twilley N; *Untitled Upcoming Book*; MCD Books; Spring 2021
[9] Manaugh, Twilley; ibid
[10] Flannery J, *Health Care Facilities & COVID-19 Safety; What You Need to Know*; American Society for Healthcare Engineering of the American Hospital Association; 17 Mar 2020; website accessed 20 Mar 2020
[11] Sheerin M; *COVID 19 Guidance*; American Society of Heating, Refrigerating and Air-Conditioning Engineers; Mar 2020
[12] *Interim Guidance for Healthcare Facilities: Preparing for Community Transmission of COVID-19 in the United States*; Centers for Disease Control and Prevention; website accessed 20 Mar 2020
[13] Flannery J; ibid
[14] Sheerin; ibid
[15] Waldman, et al; Warner; ibid

vacant spaces in office buildings, prisons, tents in vacant parking lots, etc. Each have their specific challenges from a life-safety and building services standpoint. ***Evaluating them will require careful triage by qualified professionals including architects, engineers, and rationing of available caregivers, therapies, environments, equipment, etc. which may evolve fluidly.***

Existing Hospitals are the best location for patients who need focused medical treatment for COVID-19 and have other medical comorbidities. Additionally, some of these conditions will trigger critical care, whereby highly specialized teams with specialized equipment are co-located. **These systems may or may not be quickly adaptable**, despite actual spatial capacity. Adjustments in this infrastructure will also include building support systems such as HVAC and power capacities, technology, etc. These are the most regulated of the environments of care, and while modifications may be allowable, **care should be taken to engage a credentialed healthcare architect to not adversely affect the other ongoing hospital operations**.

Homes, Nursing Homes, and Hotels may become alternative places for less critical patients to be treated. However, **such approaches are caregiver intensive and inefficient. The caregiver deployment systems do not currently exist, and the qualities of the care environments are diverse and are unlikely to meet reliability standards for consistent outcomes.** Specialized treatment equipment (ventilators, ECMO machines, etc.) are very unlikely to be available in this context. Personal protective equipment (PPE) must be managed, as well as the monitoring strategy and its associated equipment. While these spaces may be readily available, the supporting systems must be invented in real-time. Adequate and patient-appropriate life-safety, HVAC, normal electrical power (and perhaps emergency power), secure communications and data systems, etc. must be considered at each location.

If a home or a room in a nursing home is employed for acute care, a temporary High-Efficiency Particulate Air (HEPA) filtration machine will likely be required to cleanse the air surrounding a patient's bed. These machines have specific power requirements, require "make-up air", and are loud. Additionally, the bedroom door must remain closed, the existing air return grilles closed and sealed, and the entry used by caregivers in protective gowns should be sealed. These pressure differences will create difficulties with the rest of the HVAC system, and the bedroom door may be difficult to open or close if sealed.

Hotel rooms must be similarly equipped with HEPA filter machines, sealed, grilles and doors, etc. The life-safety systems must be capable of supporting patients who may not be able to evacuate the building on their own in the case of an emergency. We recommend that a floor or zone of a floor be designate for this use, as that floor or zone will be considered contaminated, limiting elevator access to caregivers only, and cordoned off from the remainder of the building. The HVAC system affecting this zone will likely need to be rebalanced. Patients with respiratory ailments generally require oxygen. While these can be supplied in portable tanks, concentrating a collection of portable oxygen tanks **represents a potentially explosive fire risk, beyond the construction type of normal hotels**.

Also, **hotels have different geometries than hospital inpatient units.** Hospital corridors are eight feet wide to facilitate beds passing and rotating a gurney to enter a patient room. Hotel corridors are five or six feet wide and have narrower doors. Housing patients is one thing. Having adequate space to support active nursing is another. A typical modern inpatient unit in a hospital requires about 1.5 times the amount of additional space to support the staff, supplies, and equipment. This means that hotel rooms will be converted to nursing stations, equipment storage, clean supply, soiled utility rooms, etc. Said another way, **a hotel with 24 rooms on a floor may be able to support only 10 – 12 patients**.

Alternative Places beyond traditional medical infrastructure must be approached carefully. Time is the enemy, and we simply can't pivot rapidly enough for a traditional building with special considerations nor will policy makers have the patience for such.

Temporary Construction must still meet life-safety requirements for patients who are incapable of self-preservation in a building emergency. Tent hospitals may be set up in parking lots, but they must also provide proper and protective air circulation for patients and caregivers and emergency egress.

Office Buildings may become available as temporary patient enclosures also, but the construction is typically not conducive for patient-appropriate life-safety, limiting the number of patients housed there. Adequate and patient-appropriate life-safety, HVAC, normal electrical power (and perhaps emergency power), secure communications and data systems, etc. need to supplement the existing thin infrastructure.

Prison Cell Blocks are currently being pressed into service as temporary patient enclosures in the US. We do not agree with this approach for many reasons, especially those within our knowledge domain. There is no evidence that we are aware of internationally where prisons are being considered as viable opportunities to increase health service capacity, due to existing overcrowding issues in the prison populations of many developed countries. In fact, concerns exist over the incubator potential of prison environments on prisoners and prison staff. While we describe these difficulties, we are concerned about the collateral effects of their use. There are much better and equally accessible solutions.

Cruise Ships have been offered by at least one cruise line operator as temporary hospitals. Again, we do not agree with this approach for many reasons, especially those within our knowledge domain. While we describe these difficulties, we are concerned about the collateral effects of their use. Purpose-built mobile hospital ships are exceptions to this stance. The geometries of a space-efficient cruise ships exacerbate the geometric discussions cited above. Stateroom doors are typically only two-feet wide, which won't allow a gurney to pass. The corridors are akin to economy hotels, which create substantial difficulties in maneuvering patients. Also, the furnishings are fixed, requiring renovation. Additionally, the yield may be only 1/3. With the one purpose-built exception cited above, these simply won't work.

While these options may be able to be converted in emergency situations while operating sub-optimally, our point is that these decisions will require professional council and guidance from experienced architects, AND will likely require construction intervention – **a process which takes more time than an emergency expects or allows**.

If policy makers insist on such solutions, they must also reach into their respective departments to make sure that authorities who have jurisdiction tasked with reviewing and approving these projects are technically capable of rapidly assessing design intent and the constructed result so that patients and caregivers alike remain safe and the primary problem of a patient's curative outcome is realized. We recommend engaging qualified board-certified healthcare architects[16] active in their knowledge community[17] to act as advisors.

Global Lessons and Observations

The 'surge capacity' of a health system at the workforce-equipment-facilities intersection is **a critical part of any resilience strategy, and architects and their associated design discipline professionals are essential to**

[16] *Certificate Holder's Directory*; American College of Healthcare Architects; website accessed 20 Mar 2020
[17] Academy of Architecture for Health of the American Institute of Architects; website accessed 20 Mar 2020

pandemic solution development. The pandemic has revealed a significant discrepancy in ICU bed numbers between different countries. The focus for years across most geographies has been on reducing bed numbers and diagnosing and treating in the community to keep people out of hospital. But in a pandemic situation, those beds need to be scaled up quickly in appropriate facilities. Stories of 'corridors' being redesigned as critical care wards in the space of a week are starting to emerge in Europe, as hospitals try to innovate to manage the problem.

We are learning from China's ability to build hospitals in a matter of days and to use all types of other facilities to house patients sets a pandemic design precedent. This was made possible because of planning and pre-establishing the supply chains. However, while no one imagines these hospitals would meet acceptable standards, **the flexibility to build and then commission a whole new hospital in such a short time to deal with a crisis and address the supply/capacity issues can educate others.**

Critically vital resources include equipment and staff, but infrastructure design and buildings need to be considered in tandem. From a broader public policy standpoint, will we design our cities differently in the future to manage risk in the face of future pandemics? This is a public health crisis that is rapidly becoming a healthcare/medical crisis, and **the built environment should be an important part of the solution**. Our healthcare systems need to be more resilient by encouraging digital technology in lieu of vehicles that accelerate disease transmission. We also need to make our cities and communities more resilient so we can cut such diseases off close to source before infecting the healthcare system.

Specific Recommendations for a Path Forward

Practical and rapid solutions are available based on current and emerging design and construction technologies.

- We recommend that policy makers **convene qualified professionals to ideate acceptable and rapidly deployable solutions** for housing the medical interventions necessary to combat this virus.
- Consider 3-D printed building modules.
- Consider modular buildings components.
- Consider converting over-the road trailers or cargo shipping containers placed in abandoned parking lots for the basic shelter, and then integrating and aggregating them into inpatient units.
- **At a public health level, we call for urban design, and architecture to be leveraged and engaged at the table developing future-state solutions.**

About the Authors:

William J. Hercules, FAIA, FACHA, FACHE is a board-certified healthcare architect, facility strategist, CEO of WJH Health, and a recent President of the ACHA
Orlando FL U.S.A.
Bill@WJH-Health.com
www.WJH-Health.com

Diana Anderson, MD, ACHA is an internal medicine physician, a board-certified healthcare architect and a current Fellow at the University of California San Francisco
San Francisco CA U.S.A.
Diana.Anderson@Dochitect.com
www.Dochitect.com

Marc Sansom, MBA is the Managing Director of Salus Global Knowledge Exchange, an international knowledge community at the intersection of designing for human and planetary health
London U.K.
Marc@Salus.Global
www.Salus.global