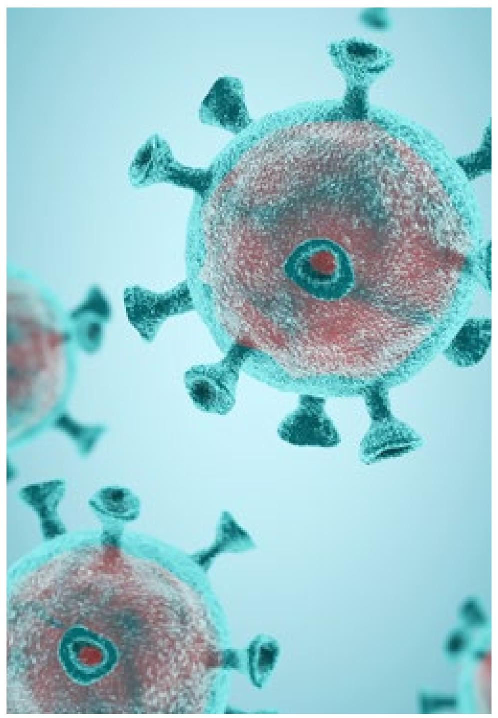
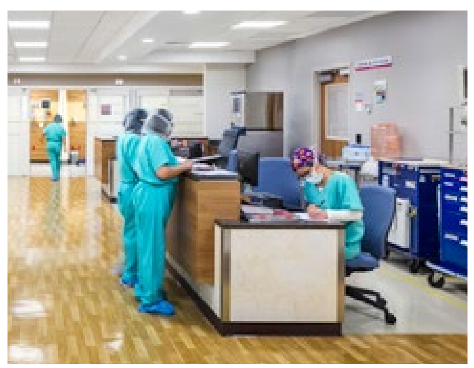
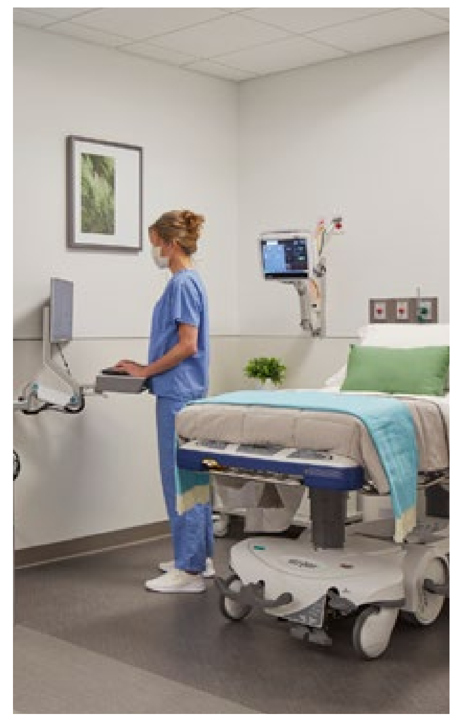
The Pandemic-Resilient Hospital: How Design Can Help Facilities Stay Operational and Safe

July 2021

HKS | ARUP | ASHE | American Hospital Association





ABSTRACT

As the SARS-CoV-2 pandemic is continuing to stress our health care system, it is hitting our hospitals especially hard. In this guide, we share actionable strategies for how hospital systems, large and small, can implement resilience strategies to support and maintain operations during a pandemic.

Contents

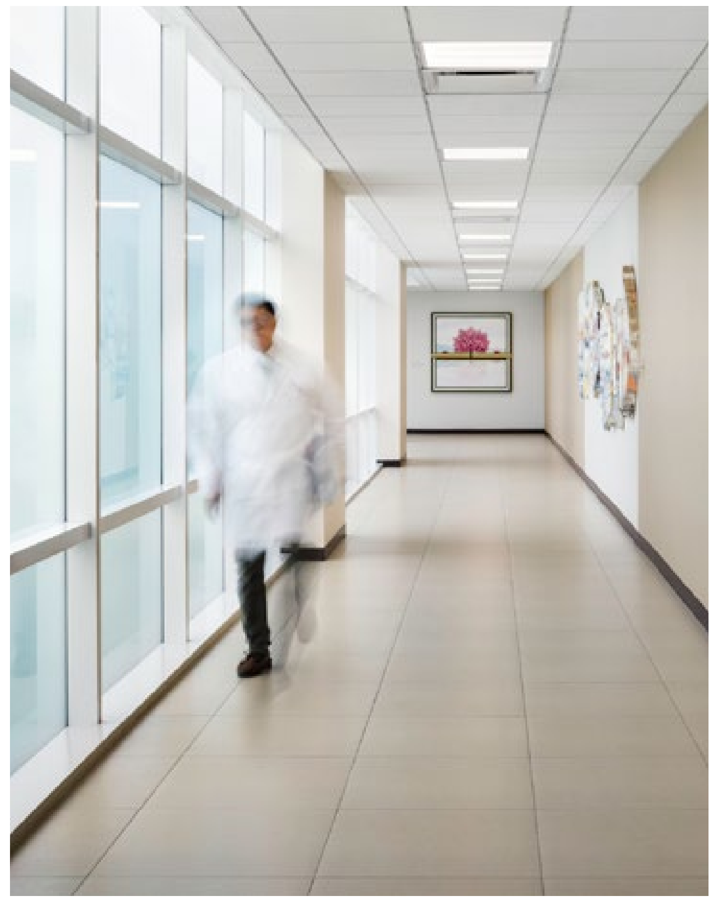
Introduction

THE PROBLEM

The SARS-CoV-2 virus has killed more than 2 million globally, 400,000 in the United States, and sent many more into hospital care. This pandemic has brought with it the unintended consequence of deferring an estimated 4 in 10 people from seeking care, temporarily shuttering surgery centers, and causing many hospitals – already with narrow margins – to implement wide layoffs, furloughs, or even shut down in some cases. The American Hospital Association estimates lost revenue has cost America's hospitals an average of $50.7 billion per month.

Infectious diseases are increasingly likely to arise and become more widespread in the future due to climate migration and the growing spread of zoonotic diseases, and the environments of care must be a part of the solution.

Creating facilities that are able to maintain operations during a pandemic is essential. Facilities need to be safe and demonstrate safety to foster public trust and a return to care. Without this, there will continue to be a monumental impact on our health care delivery system, and patients seeking care for conditions like heart disease, cancer, diabetes or a knee replacement.



THE CONCEPT

The following document is intended to help hospital executives, facility directors, and planners with facility investment considerations when designing and renovating spaces to address the current pandemic and increase resilience for the future. It is not meant to be a prescription or to give one answer, but rather to offer priorities and key considerations regardless of the space constraints and offer examples of what this could look like in action.

The **7 Principles for Pandemic-Resilient Healthcare Design** offer core considerations, providing a variety solutions based on a facility's unique situational needs.

THE APPROACH

This guide was created by an interdisciplinary team of architects, engineers, clinicians, and medical planners from HKS, a top global architecture firm, Arup, a top international engineering firm, and The American Society for Health Care Engineering (ASHE), the largest association dedicated to optimizing the health care built environment, with feedback in interviews from health care professionals across the nation.

We address design for long-range airborne infectious diseases and leverage synergies between infectious disease care and overall healthcare priorities, with the goal of creating a flexible and resilient hospital campus. Interviews with frontline clinical, administrative, and executive staff informed the design strategies. We recognize that no one strategy or modification has been a panacea, and each facility needs unique approaches based on their foundational infrastructure.

7 Principles for Pandemic-Resilient Healthcare Design

The following ideas for infrastructure and planning can support the maintenance of operations during a pandemic through the fostering of safety for patients, staff, and family, and the flexibility of a facility to respond to the changing needs.

01

Versatility

In addition to meeting pandemic needs, the design must work for everyday use and non-infectious patient care to be financially viable.

02

Surge Ready

The design needs to support an increase in the number of patients and patient severity on the existing footprint.

03

Supports Well-being

Pandemic care is extremely stressful on staff, patients, and families. The design needs to support spaces for respite, recovery and well-being.

04

Clean Air and Surfaces

Design to reduce the transmission of infectious particles, while supporting ease of maintenance and cleaning of air and surfaces.

05

Isolate, Contain & Separate

Facilitate the separation of infectious patient care to keep the rest of the patient and staff population safe and support continuity of operations.

06

Flow

The design supports clear channels for circulation and flow to support safe movement and minimize transmission risk.

07

Digital/Physical

We must design innovative, appealing spaces and places that allow for seamless transitions from the physical to the digital realm.

Heating, Ventilation, and Air Conditioning (HVAC) Considerations

The hospital air distribution systems play an essential role in protecting frontline essential workers and isolating infectious patients from the standard, non-infectious hospital operations. Risk-based, quantifiable targets should be established for the indoor air quality with the goal of **reducing the contaminated particulate concentration and increasing the dilution percentage** at the patient, room, and building levels. Wherever possible, treat the contagion source directly and shrink the containment zone to minimize risk to the bedside caregivers, reduce possibility of migration, and effectively address the contagion.

The following are **Key HVAC Considerations** for infrastructure investment to facilitate the safe operations during a long-range airborne transmission pandemic. Risk mitigation measures should be evaluated based on performance specific to each individual hospital application and is not meant to be prescriptive.

Ventilation (System Level)
Increase outside air to maximum design availability as well as exhaust to outside in order to increase the contaminant dilution percentage.

Total Air Changes (System Level)
Increase total supply and return/exhaust air to infected areas to reduce contaminated particulate concentration.

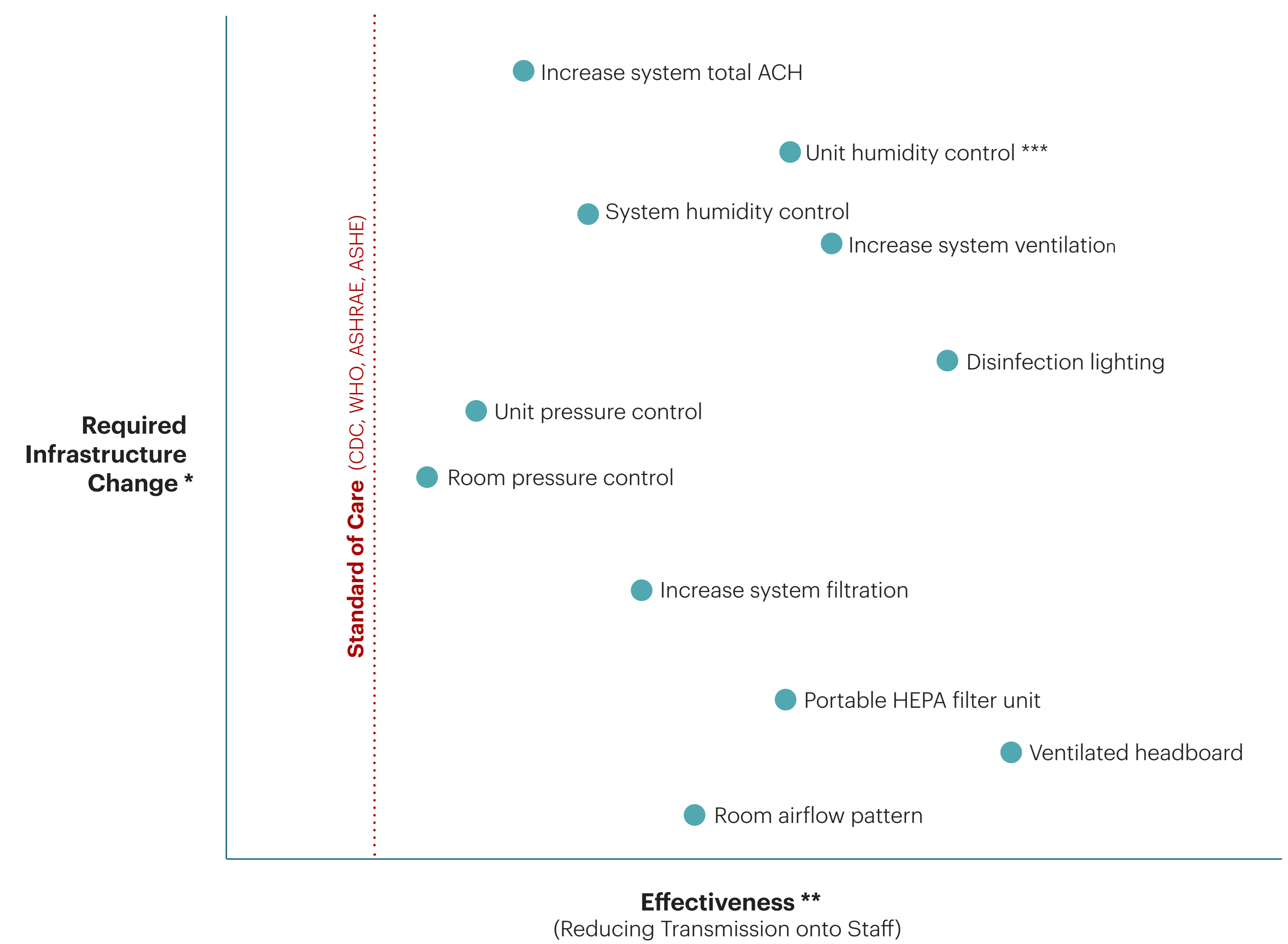
Air Treatment (Room and System Level)
Remove, capture or eradicate the contaminant locally or centrally with filtration and/or molecular modification technologies.

Pressure Control (Room and Unit Level)
Incorporate negative pressure relationships where isolation from its adjacent space is required.

Airflow Pattern (Room Level)
Configure placement of diffusers and grilles to allow air to flow from clean to less clean to protect the clinical staff.

Disinfection Lighting (Room-level)
Utilize upper air (indirect) UV-C lights in patient rooms and other strategic locations in concert with a complimentary HVAC system to kill airborne pathogens that remain in the room. Consider direct UV-C lighting for transient spaces.

INFRASTRUCTURE IMPACT ANALYSIS



* Infrastructure change will be based on existing system configurations and limitations.
** Effectiveness will vary based on the specific contagion and other variables.
*** ASHRAE/ASHE 170 currently recommends humidity control to improve effectiveness of reducing transmission to staff. Assess the relative humidity ranges in respect to the contagion's viability and incorporate necessary humidity control.

Case Study

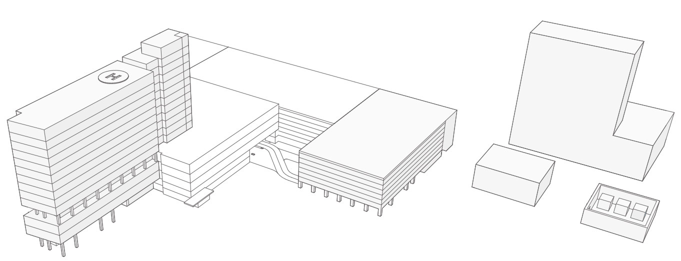
Hospitals come in many forms. To help facilitate the design principles outlined previously and provide tangible design strategies, we chose one case study on the following pages to exemplify these principles. What is provided is not meant to be a one-size-fits-all solution, but rather emblematic of how the design of space can help facilities to maintain operations during a pandemic involving long-range airborne transmission.

LEVEL CONSIDERATIONS

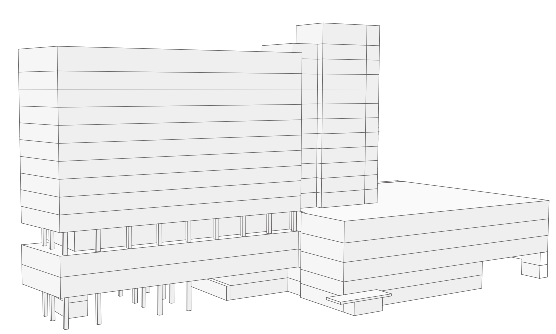
- Campus & System Level
- Building Level
- Unit Level
- Room Level

"Our facility's response to the COVID-19 pandemic was born out of extreme collaboration, interdisciplinary planning, rapid learning, and modularity based on constantly changing circumstances. These have been, and will remain, the keys to effective emergency response."

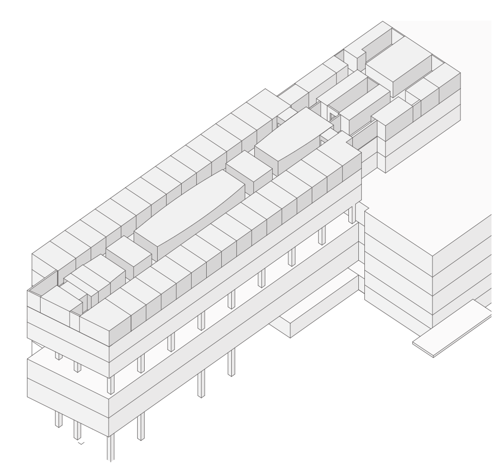
Mark Greenspan
Director, Construction Services
Memorial Healthcare System



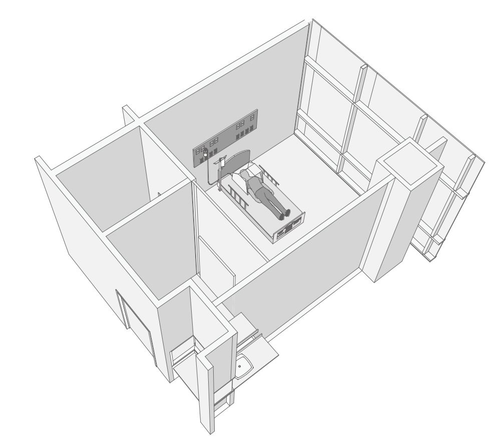
Campus & System Level



Building Level



Unit Level



Room Level

Campus & System Level

At a campus-wide level, considerations need to be given to how a patient arrives, is screened and tested, and is admitted to the hospital. There needs to be clear signage and communication at a campus level to facilitate this process.

Regarding patient transportation in most hospitals, one of the primary paths of travel tends to be from the Emergency Department (ED), where patients are first assessed and discharged or admitted. Buildings and units that have a shorter and more direct path of travel from the ED warrant greater consideration for designated infectious disease care.

Operational considerations such as bed capacity and staffing needs must be considered when choosing the location for a dedicated infectious disease unit.

> "Universal precautions were required for all patients. Splitting into clean and dirty did not work because symptoms were so varied, it was impossible to identify by physical exam and there was no immediate accurate testing."

Jim Augustine
MD US Acute CareSolutions, Serves 200 EDs in the USA

TECHNOLOGY HIGHLIGHTS

Robust Infrastructure

Remote telecommunication and electrical infrastructure extensions to quickly accommodate temporary setups for testing, triage and entry sequence.

Flexible Wireless Nurse Call

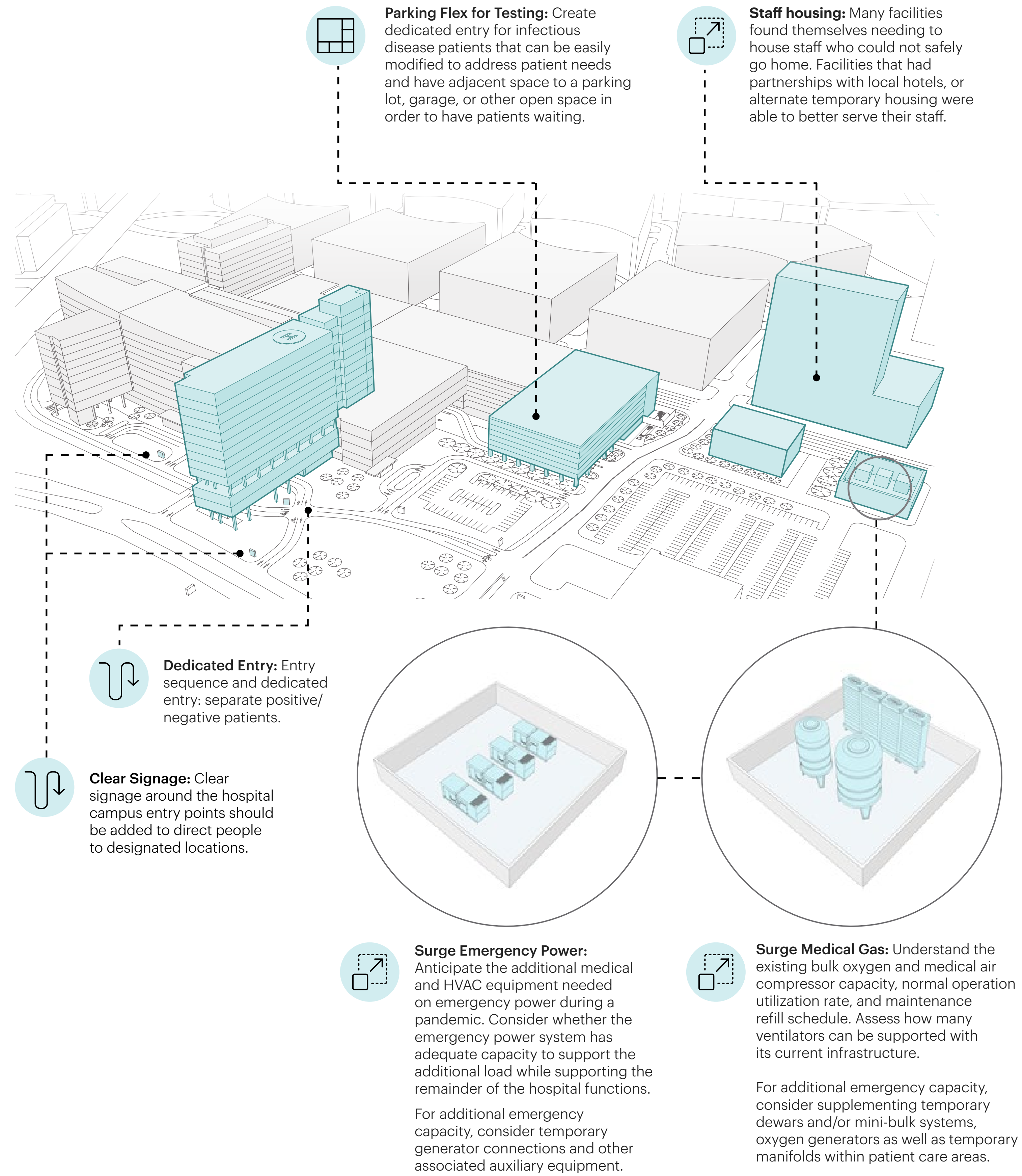
Consider nurse call "rapid response" kits that can easily expand and extend the existing nurse call system to serve temporary triage and bed units.

Location Tracking

Consider installing a campus-wide Real-Time Locating System (RTLS) to contact trace patients and staff and quickly identify and monitor exposure risks. RTLS technology can also assist in patient flow optimization, nurse call automation, and equipment tracking.

Staff Resourcing

Utilize integration resourcing tools to help allocate proper staffing, sustain operational efficiencies and to provide greater flexibility by allowing caregivers to float across departments and buildings when there are shortages of staff.



Building Level

At a building level, considerations need to be given to how an infectious patient can receive care safely and separately from non-infectious patients with their surgical, imaging, dietary needs, and more. As we think about patient transportation, we need to ensure separation of flows however possible.

HIGHLIGHTS

Versatility

Adding intentional details like pop up temporary walls, or fitting in clear dividers, etc. for the purpose of separating infected patients These temporary walls and devices need to be carefully balanced to ensure life safety and HVAC concerns are considered.

Surge Ready

Designated surge spaces for testing, triage, and care should incorporate necessary medical gas, telecommunication and critical power to support the surge conditions but be used for standard-care purposes.

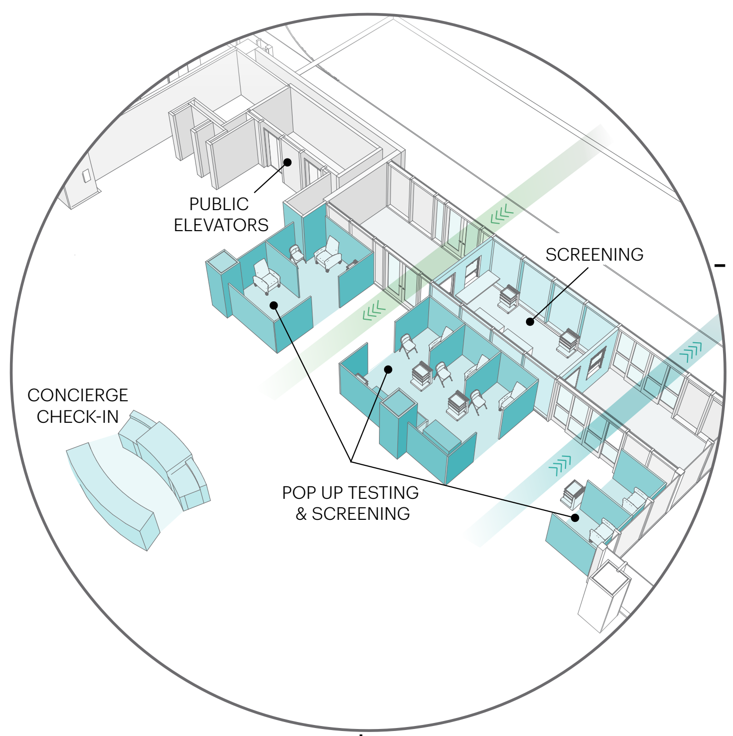
Well-being for Patients

Support the well-being of patients, and virtual/ physical interaction with loved ones.

Well-being for Staff

Plan for locations of respite where staff can safely relax, both within and outside the units.

HOSPITAL ENTRY



Lobby as Versatile Surge
Lobby space as flex space for testing, triage, and care for non-airborne infectious patients under surge conditions.

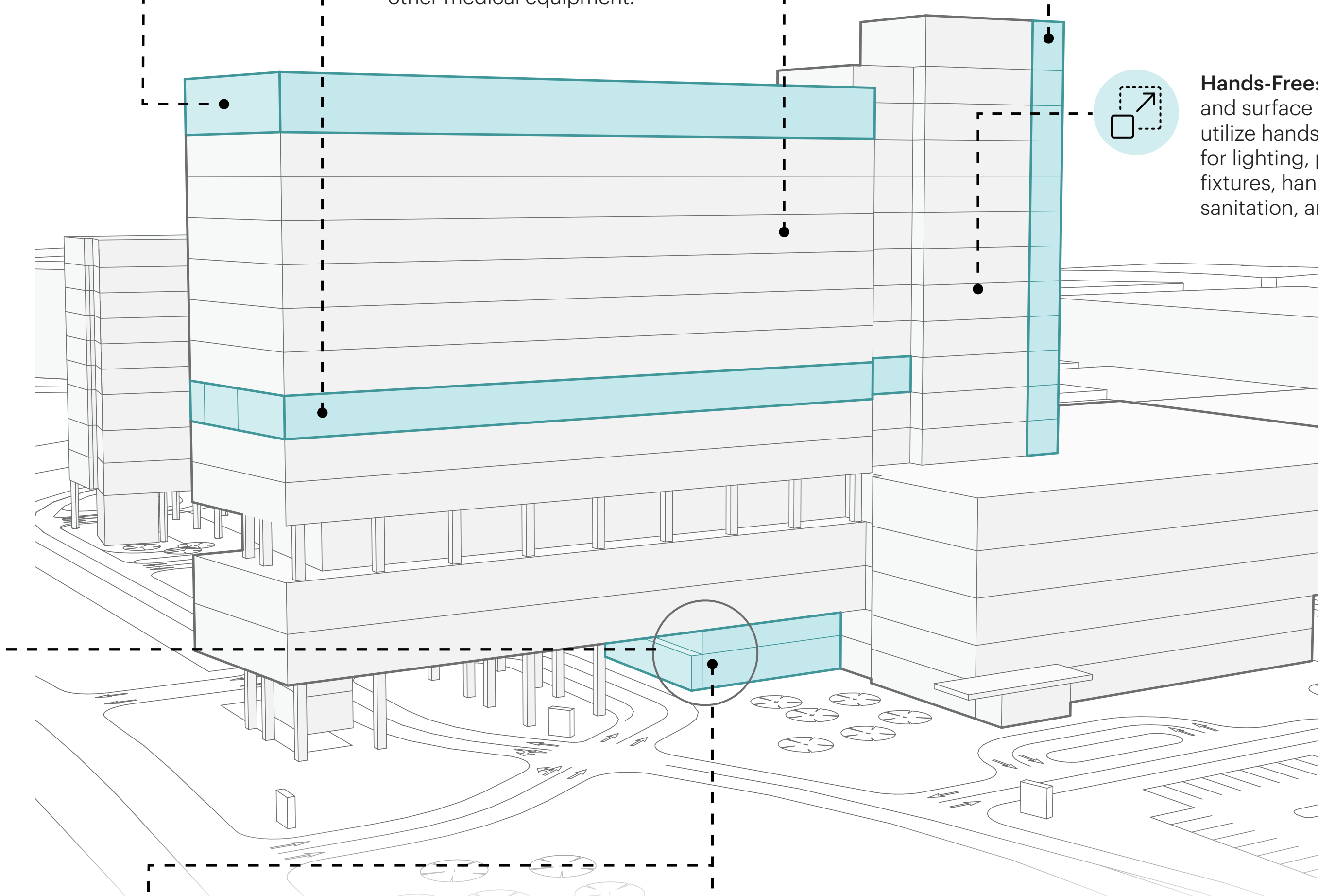
Safety: Evaluate the exposure risks of contagion unit exhaust discharge to facility, staff and/or public. Pre-engineer a solution to retrofit a bag-in/bag-out HEPA filtration for high exposure risk areas.

Versatility: Create an infrastructure system that can be modified in the future while limiting the needs to shutdown specific areas.

Surge Ready: Assess the medical gas, telecommunication, and electrical infrastructure risers and lateral mains to ensure designated surge areas can accommodate for the additional ventilators and other medical equipment.

Flow: As possible, do not use the trauma elevator for COVID patients. When possible use a single dedicated elevator and routinely clean it.

Hands-Free: Reduce human and surface contact and utilize hands-free technology for lighting, plumbing fixtures, hand drying, hand sanitation, and doors.



Dedicated Entry: Entry sequence shown from exterior signage and separate positive/negative patients prior to entry.

Increased Ventilation: Dilute particulate concentration in lobbies, waiting rooms and other high occupancy areas with the use of CO2 sensors.

Thermal Imaging: Consider an automated thermal imaging at all entrances and other strategic critical care entrance areas and integrating into the Building Automation System.

Unit Level

The majority of hospital clients that were interviewed had established at least one dedicated unit for COVID-positive patients. Many projects currently in design have modified their plans above mandated minimums in order to increase their future operational flexibility, this include an increased percentage of isolation rooms, and/or universal design rooms, which quickly can shift from acute to critical care.

> **"A guiding principle of our design is flexibility. Paramount in the design were additional handwashing sinks, negative pressure capability, re-configurable waiting space and additional restrooms and toilet facilities. We feel the new unit will be adaptable to unknown emerging healthcare issues in the future."**

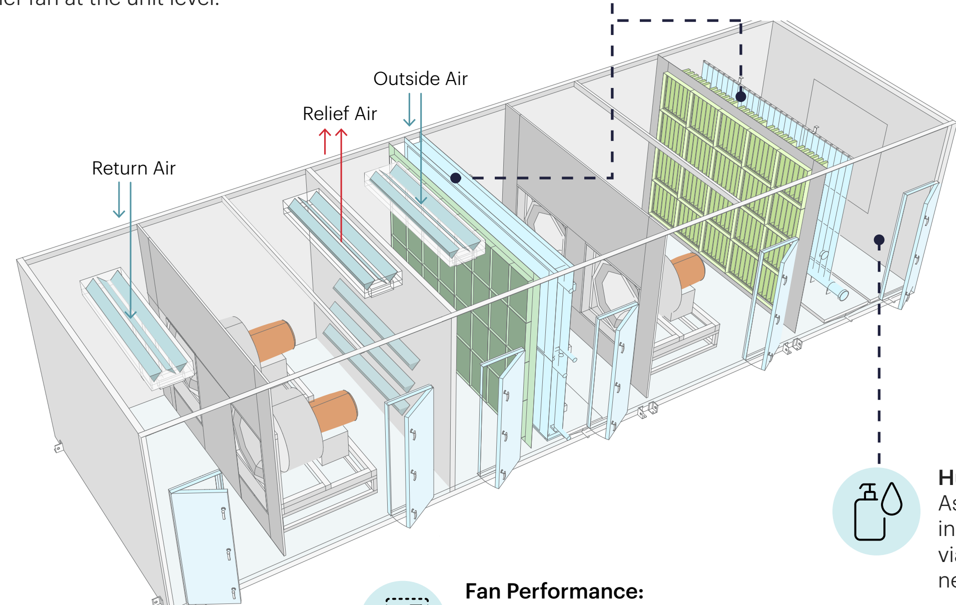
Karen S. Hill

DNP, RN, NEA-BC, FACHE, FAAN, Chief Operating Officer/ Chief Nursing Officer, Baptist Health Lexington.

AIR HANDLING UNIT

Economizer: Utilize the existing ductwork infrastructure and the economizer section with a supplemental heating/cooling coil, or preconditioned outside air, to serve 100% outside air to the contagion unit at peak design conditions. If an economizer is not present, incorporate a relief fan at the unit level.

Molecular Modification Technologies: Consideration of placement upstream and/or downstream of the final filter to deconstruct the DNA/RNA cell structure of the contagion still requires additional research for efficacy in air handler application



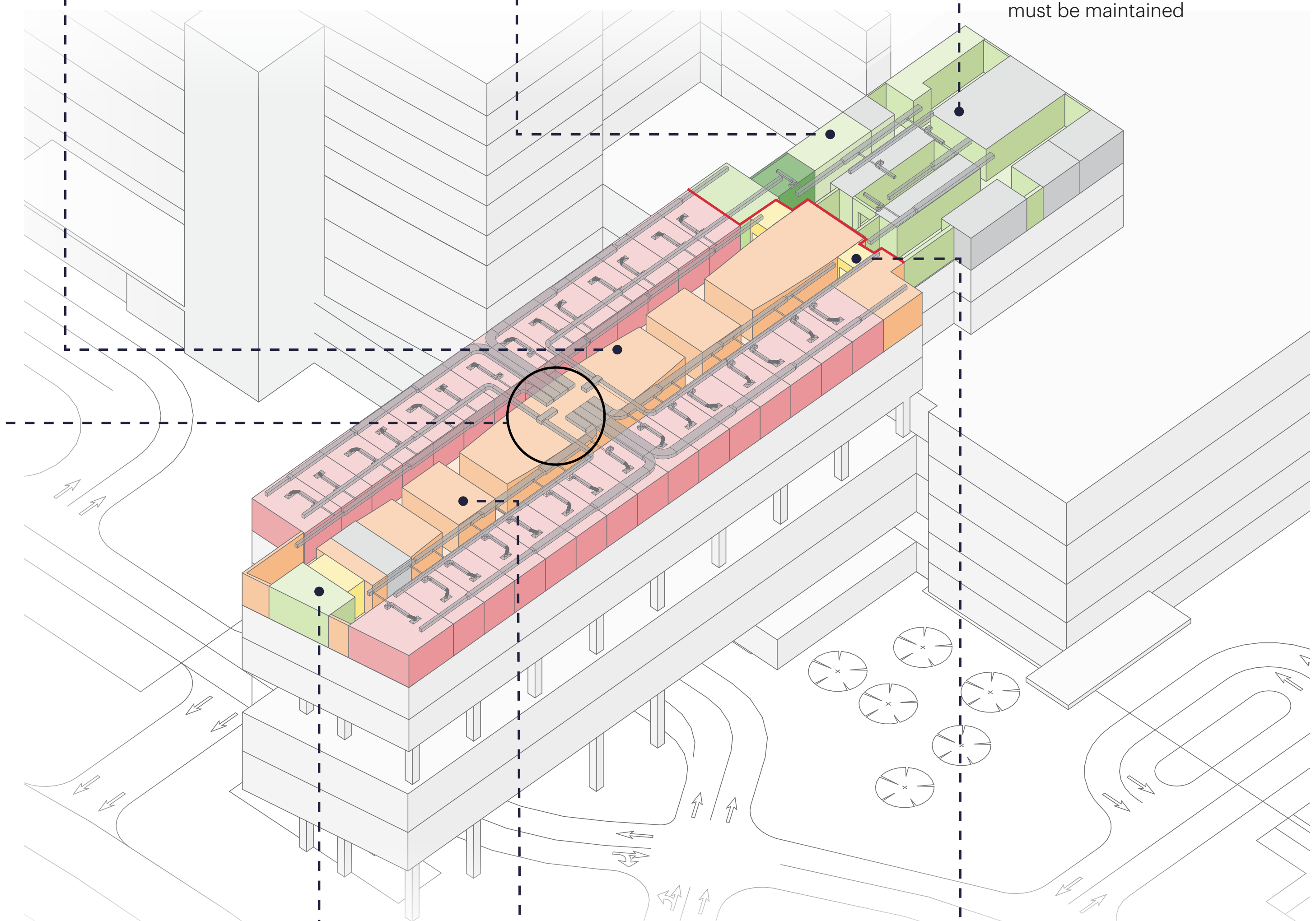
Humidity Control: Assess the relative humidity ranges in respect to the contagion's viability and incorporate necessary humidity control.

Fan Performance: Assess the fans' capabilities to sustain the pandemic mode operational requirements

Increased Hand Washing: Add hand washing sinks in strategic locations to enable hand washing before and after donning/ doffing of each patient visit

Disinfection: Consider upper air UVC lighting in staff respite, doffing areas, elevator lobbies and elevator cabs to eradicate the contaminants. Application must be coordinated with the HVAC design in each space

Elevator Pressurization: Consider pressure relationships between elevator shaft and elevator lobby and adjacent spaces on the designated contagion unit floors and eliminate cross contamination to other non-infectious floors. Elevator shaft pressurization is governed by codes and must be maintained



Staff Area Pressurization: Positively pressurize and incorporate differential pressure monitors to the staffing respite areas to protect the clinical staff

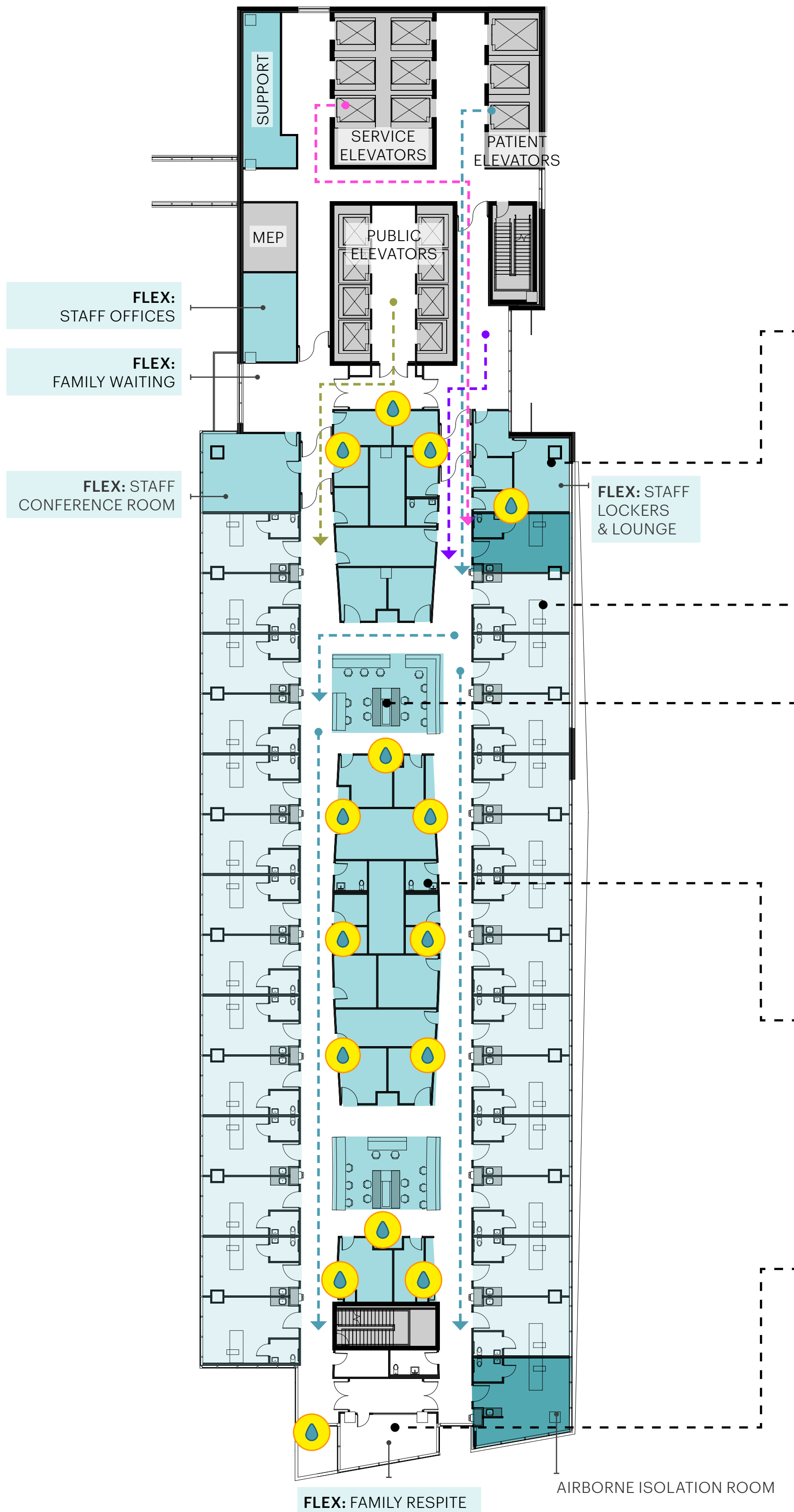
Team Station Airflow: Configure the placement of diffusers and grilles to allow air flow pattern to move from the team station to the corridor to protect the caregivers

Airlock for Unit: Incorporate temporary provisional considerations including a pop-up for airlock and differential pressure monitors to ensure the unit is negatively pressurized to the remainder of the building

Unit Level

NORMAL MODE

In normal mode, special consideration is given to areas that will need high future flexibility. Those spaces are designed here as flex spaces.



HIGHLIGHTS

Staff support:
- Staff lounge and locker room

Patient rooms:
- Neutral relative pressure to corridor
- 6 ACH minimum
- Return air patient room
- Maximum 60% Rh and MERV 14 minimum
- TAB: minimum and maximum set points

Nurse station, medication, corridors, clean support spaces:
- Neutral or positive relative pressure to corridor
- 2 total ACH outdoor air for nurse stations
- 2 ACH outdoor air and 4 total ACH for medication and clean support areas
- Return air rooms
- Max 60% Rh and MERV 14 minimum
- TAB: minimum and maximum set points

Toilets, soiled support spaces:
- Negative relative pressure to corridor
- 10 ACH minimum
- Exhaust air rooms
- NR Rh and MERV 8 minimum
- TAB: minimum and maximum set points

Flex family respite
- Flex space for use by families, or other staff needs

KEY

Recommended Staff Core Sink Location

FLEX — Multipurpose Flexible Room

Public Flow

Patient Flow

Staff Flow

Materials Flow

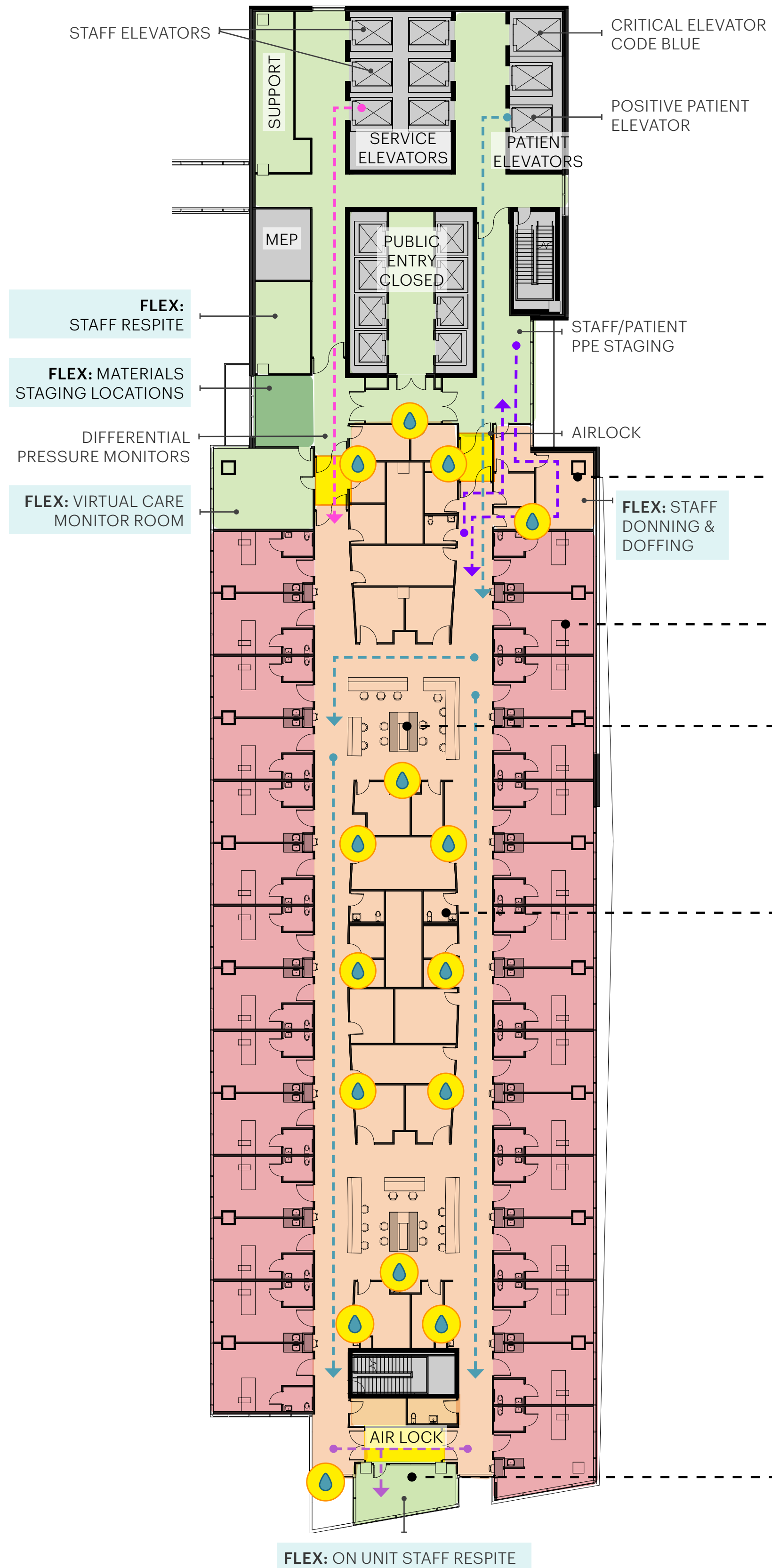
Patient Room

Staff Support

Isolation Room

- **ACH** - Air changes per hour
- **HEPA** - High efficiency particulate air
- **TAB** - Testing, adjusting, and balancing

Unit Level



PANDEMIC MODE

In pandemic mode, the built in flex spaces are converted to new uses such as materials staging and donning and doffing. In pandemic mode, the unit supports flow and process changes that help keep patients and staff safe.

HIGHLIGHTS

Staff support:
- Staff donning and doffing room

Patient rooms:
- Negative relative pressure to corridor
- 6 ACH minimum (12 ACH recommended)
- Relief/Exhaust air patient room
- Max 60% + MERV 14 minimum (HEPA preferred)
- TAB: min and max and Pandemic set points

Team station, medication, corridors, clean support spaces:
- Neutral or positive relative pressure to corridor
- Clean to less clean air flow pattern
- 2 ACH minimum
- Relief via economizer; exhaust via increased patient toilet or portable HEPA.
- 30% + 90% filtration minimum (recommend HEPA if recirculated)
- TAB: min and max and Pandemic set points

Toilets, soiled support spaces:
- Negative relative pressure to corridor
- 10 ACH minimum
- Exhaust air rooms
- 30% + 90% filtration minimum
- TAB: min and max and Pandemic set points

Flex staff respite
- Flex space is able to transition to safe on-site staff respite for smaller breaks

Upsizing medical gas for surge:
- Consider upsizing oxygen and medical air lateral mains to accommodate surge of ventilators. Eliminating diversity should be considered.

KEY

Recommended Staff Core **Sink Location**

FLEX Multipurpose Flexible Room

Public Flow
Patient Flow
Staff Flow
Materials Flow

Air Lock Vestibule
Clean Zone No PPE Required
Light Cool Zone 1 Layer PPE Recommended
Warm Zone 1 Layers PPE Required
Hot Zone 2 Layers PPE Required

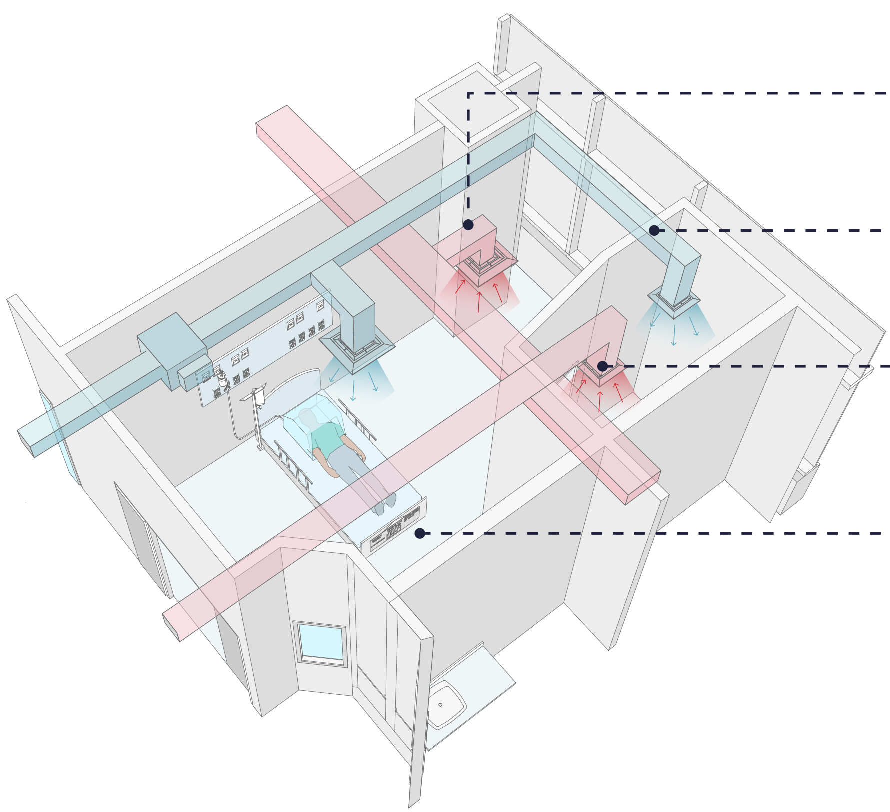
- **ACH** - Air changes per hour
- **HEPA** - High efficiency particulate air
- **TAB** - Testing, adjusting, and balancing

Room Level

At a room level, we need to consider how a room could quickly and safely flex into an isolation room, and adapt to provide higher acuity care, while keeping both the staff and patients safe. The entry into the room offers an important threshold to que behavior and the level of recommended precautions. This includes clearly marked donning and doffing zones at the door to the patient room with convenient access to PPE.

Different room configurations offer trade-offs in flexibility to support pandemic care. A bathroom adjacent to the corridor can create a natural area for a flex anteroom; however, the bathroom exhaust creates a negative pressure in respect to the patient room, in which case a bathroom on the external building wall can serve to better isolate infectious particles. However, either room type can be transitioned into an isolation room.

OUTBOARD PATIENT ROOM



Return Air
Less clean air is pulled to the far end of the room, away from corridor.

Clean Air Supply
Ensure airflow pattern is going from clean to less clean.

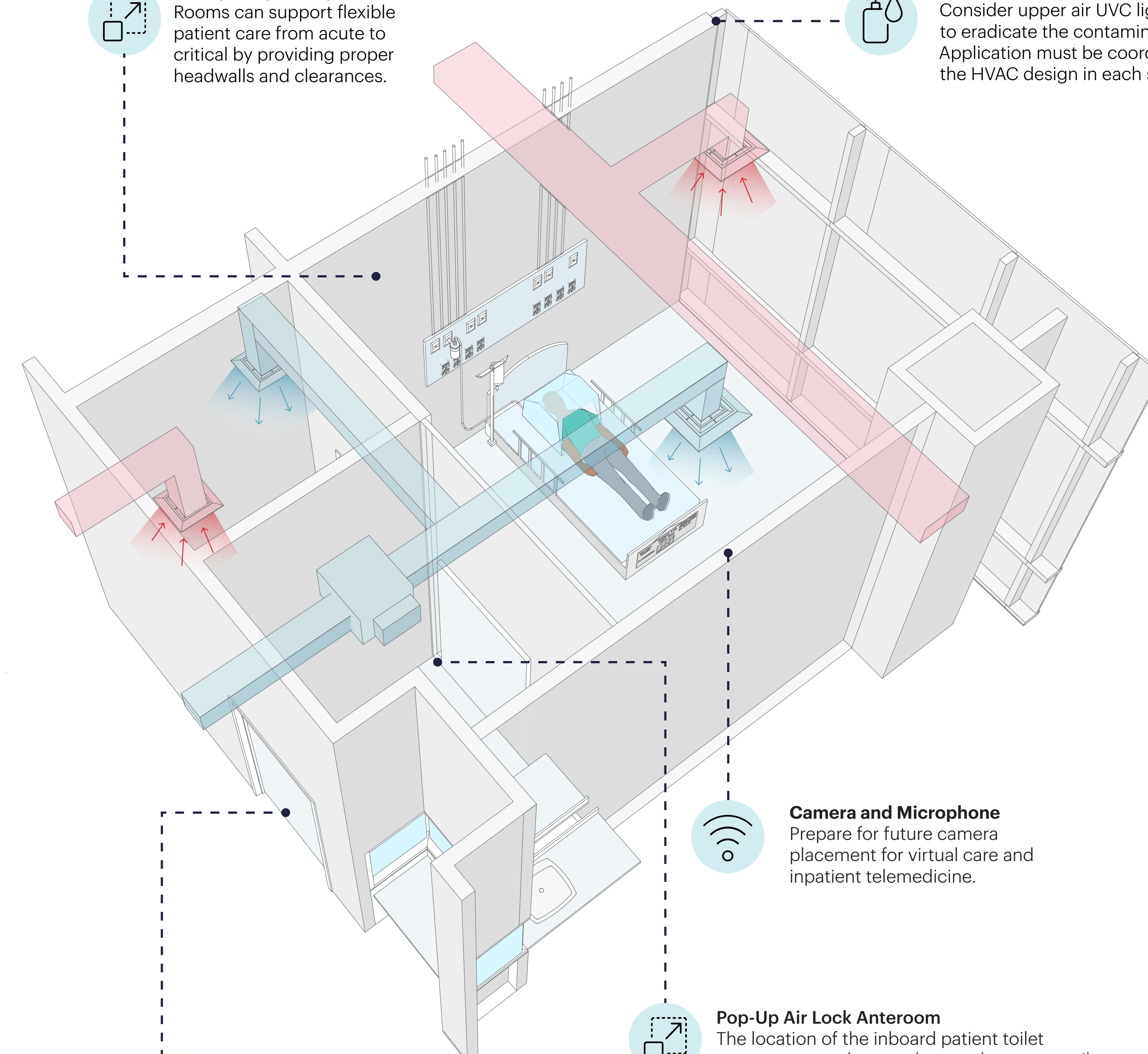
Increase Exhaust
Consider increasing patient toilet exhaust via variable-frequency drive (VFD) and high static fan.

Infection Control
Terminal clean and adequately ventilate the room prior to the reuse to ensure complete removal of all airborne contaminants. Follow CDC and ASHE air change clearance rates. Consider supplementing terminal clean with portable or upper room UVGI lights along with proper HVAC design.

INBOARD PATIENT ROOM

Acuity Adaptability
Rooms can support flexible patient care from acute to critical by providing proper headwalls and clearances.

Clean Air
Consider upper air UVC lighting to eradicate the contaminants. Application must be coordinated with the HVAC design in each space



Camera and Microphone
Prepare for future camera placement for virtual care and inpatient telemedicine.

Pop-Up Air Lock Anteroom
The location of the inboard patient toilet creates a natural space that can be temporarily modified as an ante-room for doffing.

The patient room should be negative in respect to the air lock and the air lock should be negative in respect to the corridor. Consider installing digital differential pressure sensors or magnehelic gauges within the temporary wall.

Pandemic Mode
Implement pre-engineered and pre-tested pandemic mode set points to allow negative pressure.

Room Level

Ideally hospitals would like to follow existing code, but during the SARS-CoV-2 pandemic many facilities needed to limit the amount of times that staff members have to go into the patient rooms, and thus use often-scarce PPE. Many hospitals have passed the cords under the door to be able to access regular-use equipment like IV pumps without entering. In this instance, it needs to be done on a multi-disciplinary team with leadership and management, and there needs to be clear visibility to the patient from outside the room.

HIGHLIGHTS

Treat the Source

Treat the contagion source directly and shrink the containment zone to allow the caregiver to be outside of the highly infectious and most susceptible area.

Staff Safety

Providing convenient access to PPE, clear donning and doffing spaces, and patient visibility without having to enter the room can help staff safety.

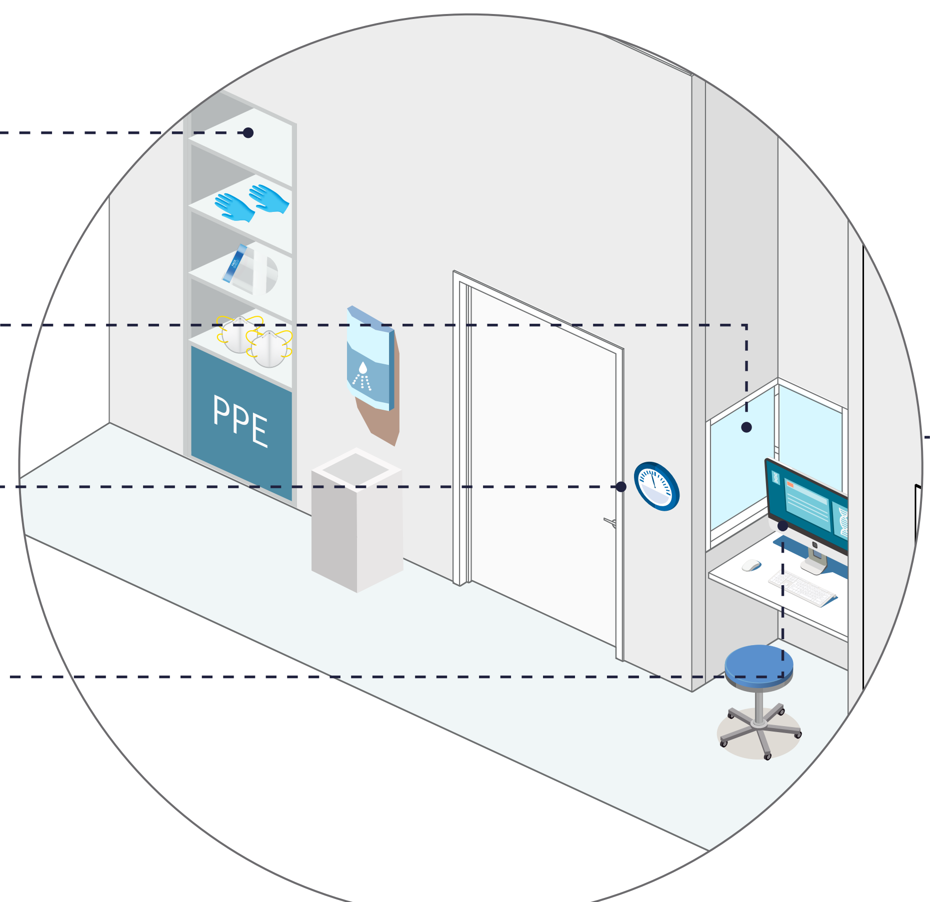
ROOM ENTRY

PPE
Easily accessible PPE storage outside of each room in storage cabinet, and trash can outside rooms for soiled PPE.

Patient Visibility
Window for patient visibility

Sensors and Gauges
Negative pressure to adjacent space. Consider installing digital differential pressure sensors or manual magnehelic gauges.

Virtual Monitoring
Create a virtual monitor and cameras to support virtual care and virtual ICU.



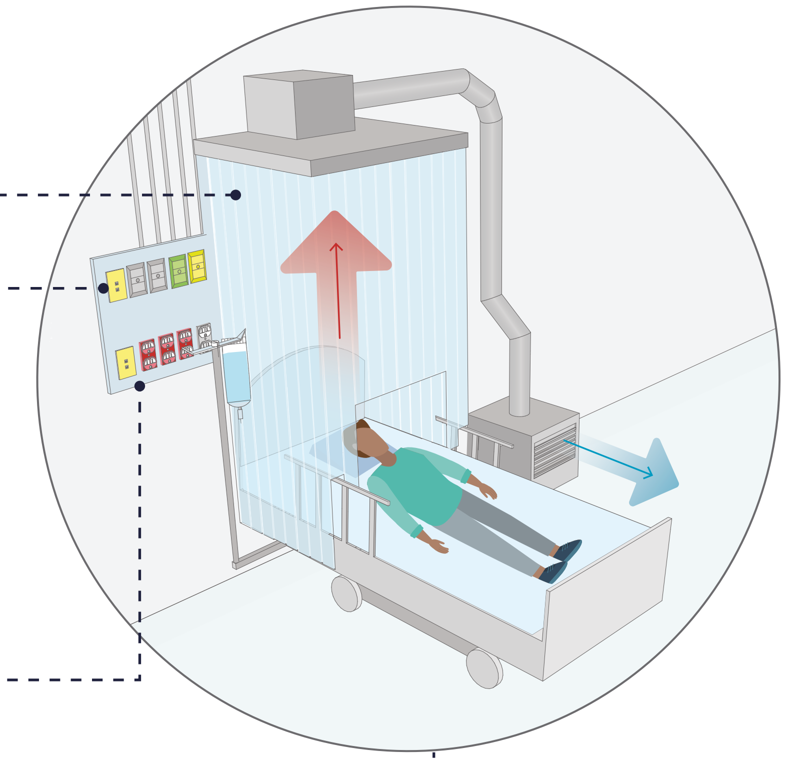
BEDSIDE

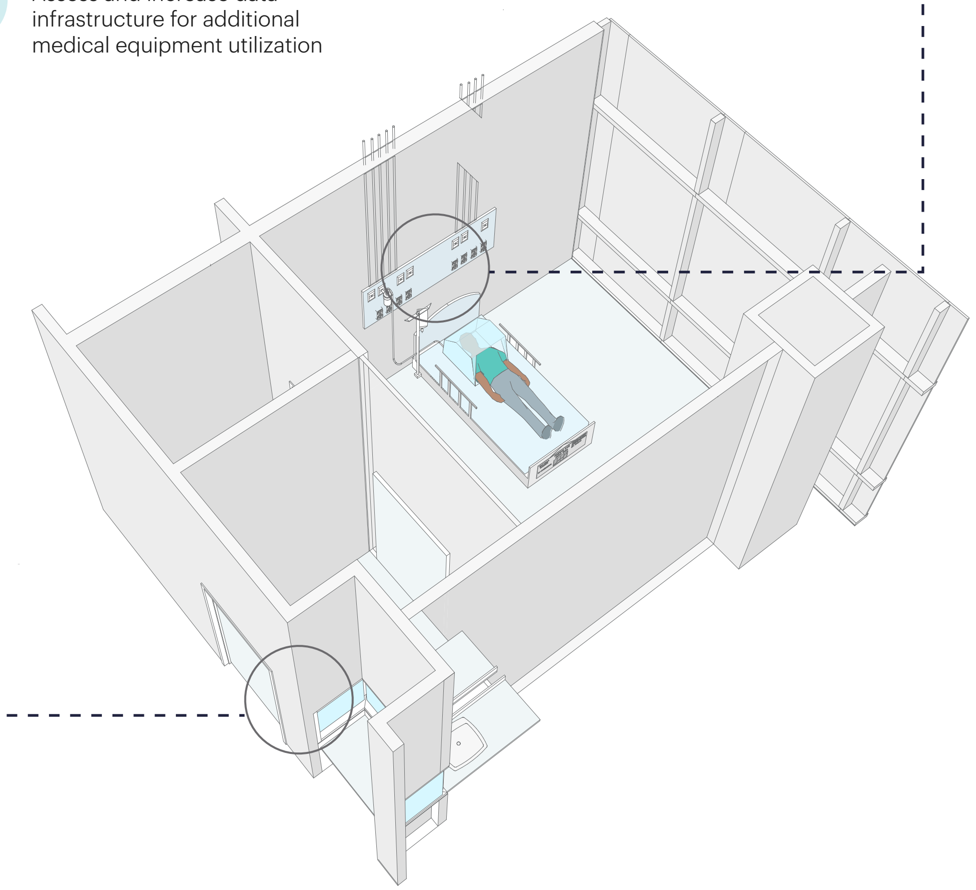
Ventilated Headboard
Considerations of a portable HEPA unit tied into a ventilated headboard over the patient bed should be made. Air will be exhausted from the headboard and passed through a HEPA filtration system before recirculating back into the patient room with clean air. Alternatively, the ventilated headboard air can be exhausted to the outside with a fully engineered solution

Medical Gas
Incorporate medical air infrastructure to allow use of ventilators

Emergency Power
Evaluate additional emergency power requirements for increased equipment use in the acuity-adaptable space

Data Infrastructure
Assess and increase data infrastructure for additional medical equipment utilization





Key Takeaways

- Continuity of operations and care is critical to our healthcare system and the health of patients, and the design of our healthcare facilities can help support this.
- Designing for flexibility, from acuity to isolation level, or the use of multipurpose or flex spaces, is essential in healthcare design going forward.
- Interventions at the facility level must consider the role of ventilation, power, medical gas and plumbing as a part of any solution to address infection control and pandemic response.
- The solutions to this challenge will look different for each facility. The below table provides a range of options for mechanical interventions and their relative level of cost and benefit.

LEVELS OF HVAC INVESTMENT

	HVAC Design Strategies			
	Applied to **Bedside Only**	Applied to **Room Only**	Applied to **Bedside + Room**	Applied to **Patient + Room + Unit**
Methodology	• Portable HEPA unit tied to a ventilated headboard • Appropriate airflow patterns • Enhanced filtration	• Stand-alone portable HEPA unit • Increase total air changes • Increase toilet exhaust • Upper-air UV-C	• Bedside + Room Level Strategies	• BAS Pandemic Mode • Humidity control • Unit-level negative pressure and 100% exhaust • System-level filtration and/or bi-polar ionization
Level of Protection (Staff + Hospital)	• Moderate to high	• Low to moderate	• Moderate to high	• High
Infrastructure Changes	• Low	• Low to moderate	• Moderate	• Moderate to high
Benefits	• Treats the source directly and positions caregivers outside the containment zone • Lowest infrastructure impact	• Contagion contained to patient room level • Reduces impact on adjacent connecting spaces	• Effective short-range aerosol control • Reduces risk for staff within the room	• Effective short and long range aerosol control within the unit • Unit effectively isolated from the remainder of the hospital • Reduces risk for all staff within the unit
Risks	• Staff's mobility around the ventilated headboard • All other areas at unit level are at risk	• Staff within patient room repains at risk • All other areas in unit are at risk	• All other areas at unit level are at risk	• Disruption to modify infrastructure • Longer preparation time • Highest energy utilization

SERVICE LINE CONSIDERATIONS

The bulk of this report focuses on inpatient environments; however, we recognize that many other spaces help to create a pandemic-resilient hospital. Below are lessons learned across critical hospital service lines from clients across the nation.

Surgical

Because operating rooms (ORs) are central to operational solvency, hospitals have paid special attention to the perioperative spaces, creating designated ORs with anterooms for COVID-19 positive patients separated from the rest of the surgical areas. For perioperative spaces, some new build facilities have decided to eliminate all open bay prep and recovery spaces, in favor of a three-walled solution, while increasing the number of four-walled isolation bays.

Imaging

For imaging, facilities have screening and masking protocols for all patients. Some facilities have increased the separation between patients by creating gowned-waiting cubbies (three walls with a curtain) or designated four-walled family waiting with a door. These interventions were not only to address COVID-19 but also seen as benefits to patient satisfaction and the ability to have mixed-gender gowned waiting.

Emergency Department

The Emergency Department (ED) offers the first line of defense for most facilities. Many EDs have expanded into adjacent parking lots or lobbies to increase triage and testing, and to separate patients to limit infectious disease spread. To learn more, reference our 2020 ER Contagion report.

Support Services

Support Services have always been critical but now this is even more true, everything from turnaround time of testing to the cleaning of care spaces and the movement of critical supplies, personal protective equipment (PPE) and clean supplies. These are often considered back-of-house processes, but they are on the forefront of being able to maintain and operate efficiently.

Registration and Pre-Admission Testing

For registration and pre-admission testing, the majority of facilities have expanded their use of online systems paperwork and many have worked to create individualization of spaces or do more in-room/in-bay registration.

Vaccine Storage & Distribution

Existing COVID-19 vaccines show a need for extremely cold temperatures for storage. Large-scale vaccination of staff can take place through employee health.

Project Status:
2015
Services:
Planning and Design
HKS

Engineering
Walter P. Moore

Orlando Regional Medical Center

Orlando, Florida

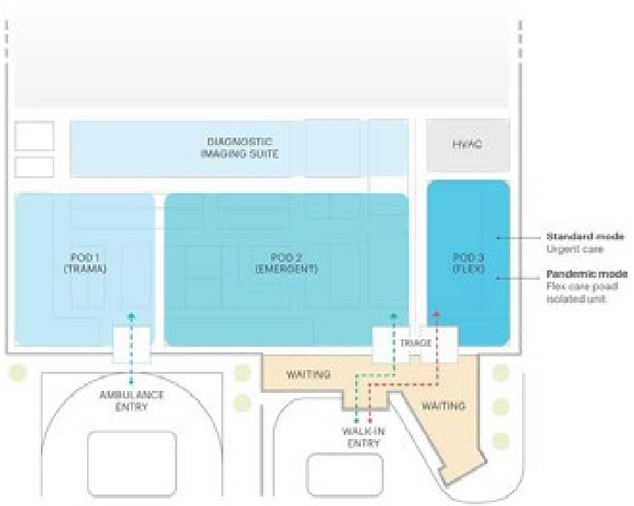
- The ED opened in 2015 and is a part of a larger hospital campus.
- Has a designated flex pod that serves for urgent care when in normal mode, and can flip to pandemic mode at the flip of a button. This has been throughout the current pandemic and has been reported to greatly increase staff comfort and safety.
- Each exam room has three standard walls, and a wall of glass with a door to maximize visibility while maximizing physical separation between patients.
- At the flip of a button, the unit can switch to negative pressure with 100% outside air in order to protect the staff and patients.
- When in pandemic mode, the pod has its own entry and waiting area to provide physical separation from the rest of the unit.

Project Status:
COVID-19 Response
2020
Services:
Planning and Design
HKS

Memorial Regional Hospital

Orlando, Florida

- The facility responded swiftly to pandemic threat, modifying and creating spaces to increase the safety of patients and staff while increasing capacity to handle potential surges in the demand.
- Conversion of trauma operating room into a dedicated COVID-19, airborne isolation operating room. Utilized temporary barriers to provide airlocks and increase safety.
- Utilized the ED canopy to create a covered entry into medical tents. Medical tents served to increase ED capacity for COVID-19 dedicated care and improve separation between patient populations.
- Large conference hall was converted into inpatient and observation surge beds with dividers between each bed.



Project Status:
Under Design
Services:
Planning and Design
HKS
Engineering
Arup

Baylor St. Luke's McNair Campus

Houston, Texas

- In the planning of a new construction, the facility is planning to invest in a number of MEP/IT features to harden the infrastructure and provide greater flexibility to overcome future challenges.
- Pre-engineered solutions to increase the ventilation rates of the patient bed tower and emergency department to 100% outside air while satisfying peak design conditions.
- Flexibility to enhance filtration to 99.999% HEPA filters safely and quickly in the future using an adaptable filter housing.
- Robust medical gas, electrical and telecommunication infrastructure at the system level and at strategic inpatient areas to support surge capacity demands.

Baptist Health Hamburg

Lexington, Kentucky

- The ED and Clinical Decision Unit are designed for flexibility and resilience. Examples of the facility strategies designed in include the following.
- The area is highly flexible to be used as a respiratory infection receiving unit, as a triage unit for our larger facility and to hold and stabilize patients in an overflow situation.
- Paramount were additional handwashing sinks, negative pressure capability, re-configurable waiting space, and additional restrooms and toilet facilities.

Southampton Hospital Association New Facility Stony Brook Southampton Hospital

Southampton, New York

- The facility responded swiftly to pandemic threat, modifying and creating spaces to increase the safety of patients and staff while increasing capacity to handle potential surges in the demand.
- Conversion of trauma OR into a dedicated airborne isolation OR. Utilized temporary barriers to provide airlocks and increase safety.
- Utilized the ED canopy to create a covered entry into medical tents to increase COVID-19 dedicated care and separation between patient populations.

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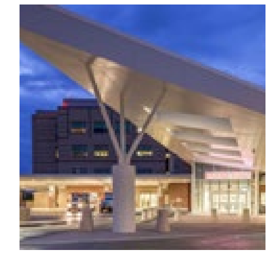

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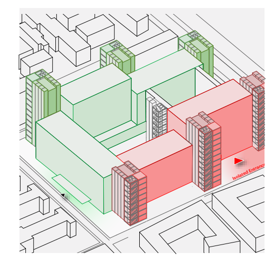
ER Contagion: 8 Ways to Beat the Second Wave



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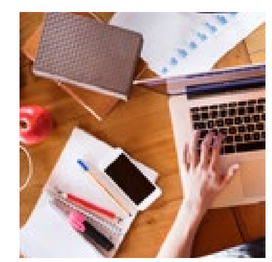
FLeXX Hospital: Surge Scenario



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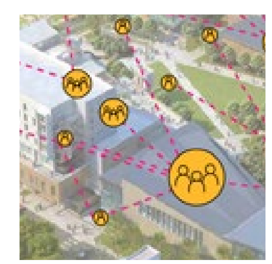
FleXX: A Study of Flexibility



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Community-BLOC: A Framework for Healthy and Pandemic-Resilient Communities

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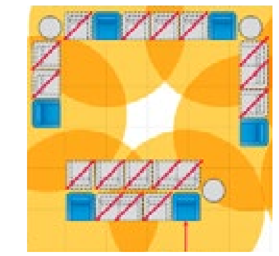
Reboot Readiness: A Primer on How to Design for Contagions



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