PANDEMIC RESPONSE

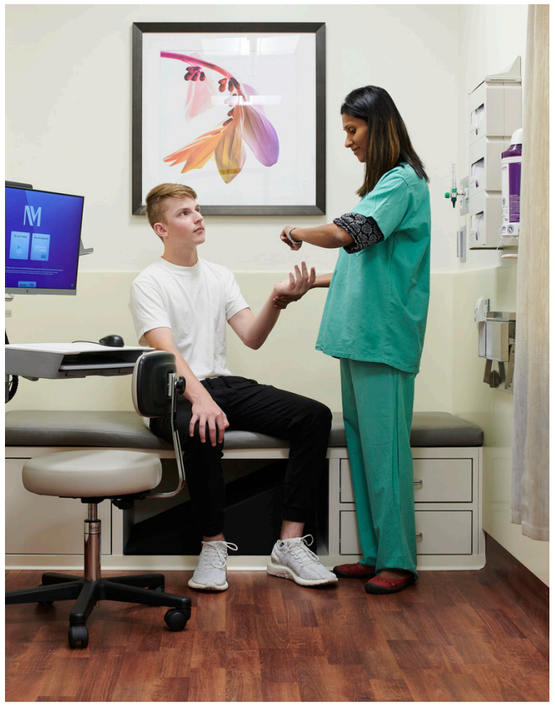
POSSIBILITIES TO COPE WITH THE
GAPS IN INFRASTRUCTURE

LIMITLESS.

Finding answers to tomorrow's questions means searching beyond the known and embracing the possible. We strive, test, discover and reinvent to imagine a future with limitless possibilities.

Saint Luke's Medical Center
Pasig City, Philippines

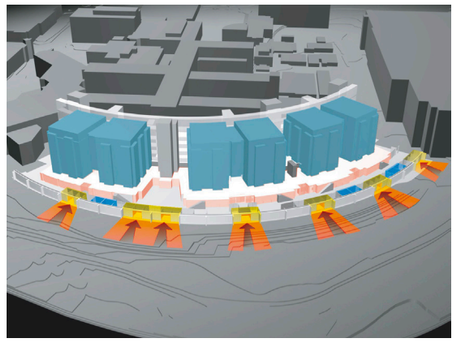
Designing our front-line of defence against outbreaks of pandemic diseases while minimizing impact of existing operations is key.

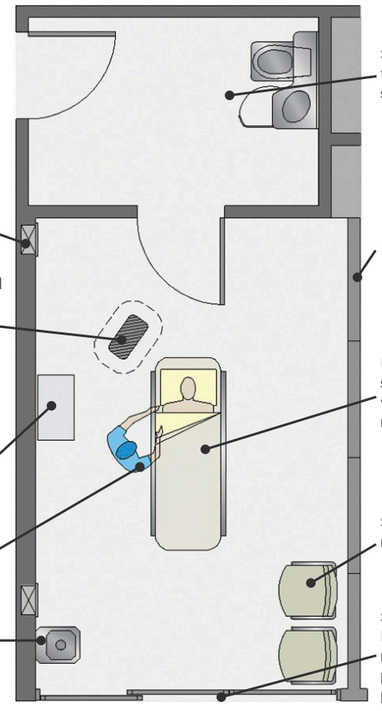


MedStar Washington Hospital Center ER One
Washington, D.C.

The recent media exposure around the worldwide COVID-19 crisis has only highlighted the need for sophisticated solutions effecting infection control operations and facility designs to support the operations. HKS has been at the forefront of emergency preparedness issues and its impact on facility design for the last decade. Many of the ideas that were conceived in the design concepts of the Washington Hospital ER One project in Washington, DC are still being implemented and improved upon today. Project ER One was the first of its kind in the United States and was on the leading edge of design for the time.

The ER One concept focused on three goals: scalability that conforms to fluctuating patient volumes, medical consequence management to allow continued operations in the midst of unknown events, and threat mitigation to help prevent and mitigate the effects of intentional harm or adverse natural events. Each of these concepts have been influential in helping to define how we begin to consult with our clients on the design of facilities and how these design solutions can promote safety, efficiency and complement the efforts of the care givers during difficult emergency scenarios.



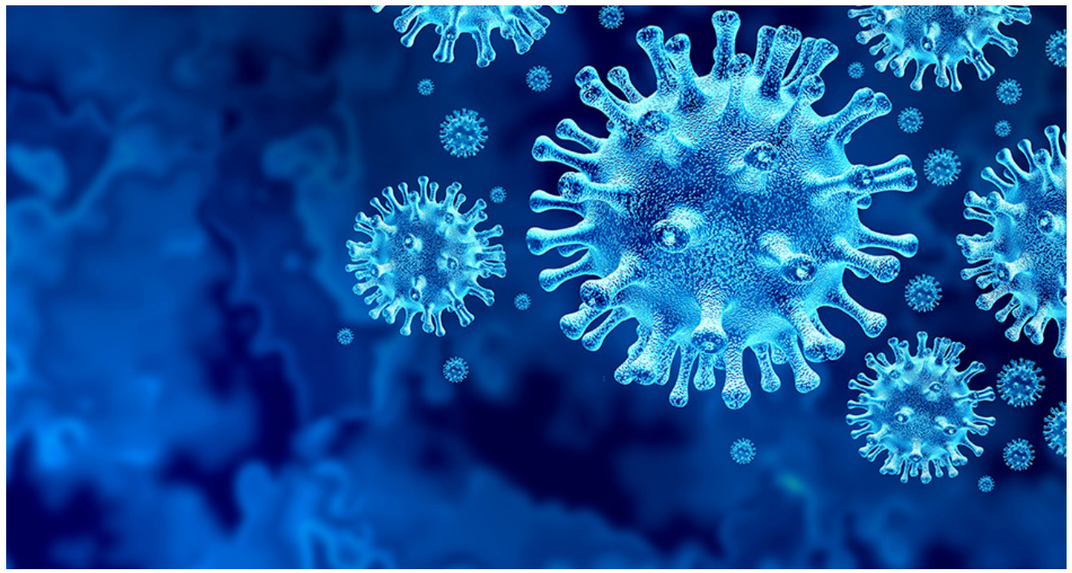


HKS is at the front-line of emergency and disaster preparedness, with a spotlight on pandemic outbreaks around the globe.

Health systems across the globe are challenged with emergencies and pandemics that are becoming increasingly common. These outbreak events over the course of the last decade, including H1N1, SARS and the current COVID-19 crisis, have a significant impact on large segments of the world's population.

The medical world has considerable concerns about how to control and isolate patients with potentially highly contagious diseases. It has highlighted the need for sophisticated solutions for infection control operations and facility designs to support these operations.

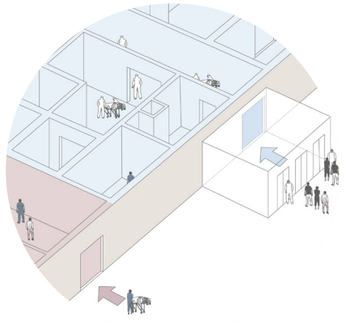
The Centre for Disease Control (CDC), World Health Organization (WHO) and other worldwide health agencies have helped to define recommended protocols[1] that establish infection control measures for varying levels of health-related transmittable contagions and diseases. New recommendations are released daily to respond to the constantly evolving COVID-19 virus as knowledge gained from the treatment of infected patients.



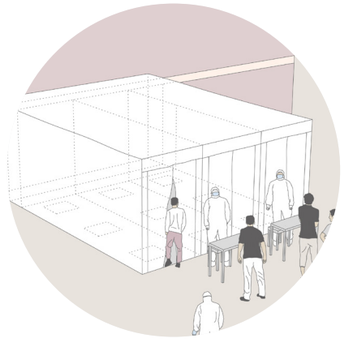
[1] Pandemic Preparedness Resource. (2020, February 15). Retrieved from https://www.cdc.gov/coronavirus/2019-ncov/php/pandemic-preparedness-resources.html

Key Design Elements

01
Departmental Compartmentalization



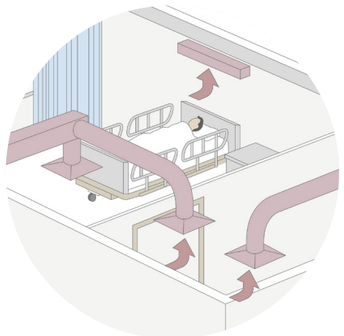
02
Expandable/ Convertible Exterior Space



03
Dedicated Patient Transfer Elevators

04
Mass Casualty Decontamination Design Solutions

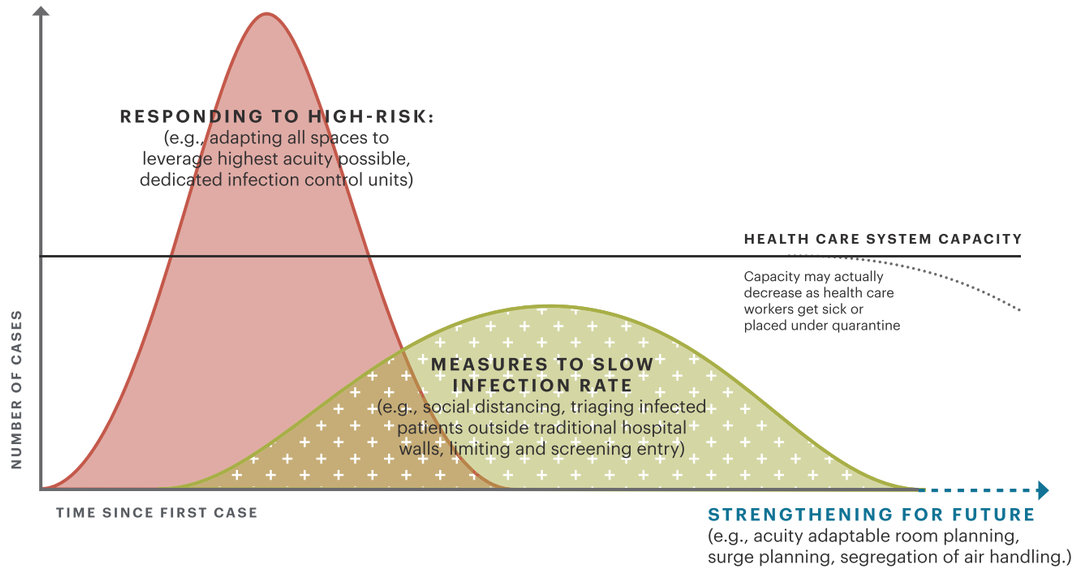
05
Mechanical System Infrastructure (Seasonal/Pandemic Exhaust Design)



06
Emergency Observation Unit Conversion to Pandemic Isolation Floors

How Health Care Systems and Designers Can Tackle a Public Health Crisis Together

As the novel coronavirus sweeps through countries around the world, many hospitals and other medical providers are rushing to treat patients while taking constant inventory of their own resources: Where can patients come in safely? Are there enough beds for critical care? Are there enough beds for everyone else who needs one? How can they stop contagion within their own walls, including keeping their own staff healthy?



Adapted from: CDC. Interim pre-pandemic planning guidance: community strategy for pandemic influenza mitigation in the United States—early, targeted, layered use of non-pharmaceutical interventions. Atlanta, GA: US Department of Health and Human Services, CDC; 2007. https://stacks.cdc.gov/view/cdc/11425.

We know from COVID-19's rapid spread throughout the world that hospitals should expect a surge in patients, which could lead to a shortage of supplies and critical care rooms. A sharp jump in demand for limited resources could stretch caregivers in unprecedented ways. But the health care and design industries can draw on a wealth of emergency preparedness best practices, and as designers, we can offer guidance on how to adapt spaces to respond to a public health crisis like the one we're facing.

The coronavirus has upended life across continents and forced us to keep our distance from each other, but we can still communicate and help. To that end, this is about what health care providers and designers can do to mitigate the spread of infectious diseases such as COVID-19 and how we can make our communities more resilient.

Flattening the curve

We can't stop the pandemic, but we can stop people in our communities from getting sick all at once and overwhelming our health care systems. Here are some strategies deployed by hospitals:

Drastically reduce the number of entries into buildings or campuses while mandating visitor screening at the entry points. MD Anderson Cancer Centre has stationed public safety officers at six designated entries at its Houston campus to screen incoming patients. Employees are screened at separate entrances.

Prohibit non-essential staff, vendors, contractors and consultants from entering clinical areas. Many hospitals are only allowing a limited number of adult visitors on their campuses. Children are reportedly getting only mild symptoms of COVID-19, which might allow them to go through screening undetected even though they're contagious.

Implement drive-through testing to keep infectious people from walking into a medical campus and spreading the disease. Hospitals in many cities are launching a drive-through coronavirus testing site for its current patients, health care workers and first responders.

Preparing for the surge

When disaster strikes, health care providers and their communities must be ready. This is how health systems and others can brace for the anticipated influx of coronavirus patients:

Explore options for surge capacity by installing temporary structures within parking garages and shell spaces or erecting tents in open spaces adjacent to major hospital facilities. Several hospitals are setting up tents near their emergency departments so they can screen patients for respiratory illness and separate them from the other hospital patients.

Create airborne isolation units and isolation floors that are dedicated for patients that have tested positive for COVID-19. This will reduce the need for caregivers to don and doff personal protective equipment and lower the chance of transmission to patients without the virus.

Look for unconventional partners that have resources to help in a crisis. LVMH, the owner of French luxury brand Louis Vuitton, is using its perfume factories in France to make hand sanitizer to prevent a nationwide shortage. The hand sanitizer will be distributed to French hospitals for free.

Increase the ranks of nurses and doctors who will be on the front lines fighting the disease. Colorado and New York are expediting the licensing of health care professionals so that retired nurses and doctors will consider returning to the field to help with the surge.

Toughening for the next time

This crisis will pass, and then another one will hit. It's inevitable. But we can get better at how we respond.

Continue to design for acuity adaptability and keep it top of mind, providing standard patient rooms that can be quickly transformed to serve critical care needs. These rooms would allow caregivers to modify them quickly to serve this new process. Other spaces in your hospital can also be designed for flexibility but might require your facilities staff to convert to a new use. Our research team partnered with the non-profit CADRE and furniture provider Steelcase Health to analyse four attributes of flexibility in health care facilities, defining the level of effort, agency and expense required to adapt a space under each attribute. This framework helps health care providers understand the spectrum of flexibility so they can plan their facilities according to their needs.

Think ahead about where you can place drive-through testing sites or triage tents on your campus in case of an outbreak or mass-casualty event. Also consider pairing with non-traditional partners such as hotels to expand bed capacity in case of a catastrophe.

Take stock of your social network. This is for all of us. "Social distancing" and self-quarantining have prompted many of us to reflect on how much we depend on one another. In some cities, residents are picking up groceries and medicine for older neighbours who are quarantined. We should get to know the people on our block, on our street, in our city. Whom can you lean on next time there's a crisis, and do your neighbours and friends know they can count on you?

How does our need for flexibility get driven during a pandemic?

How surge capacity is required in response to a contagion different from (or similar) to other disaster preparedness scenarios

According to the World Health Organization, a pandemic is declared when a new disease for which people do not have immunity spreads around the world beyond expectations.

"Emerging infectious diseases (EIDs) such as Ebola, influenza, SARS, MERS, and, most recently, coronavirus (2019-nCoV) cause large-scale mortality and morbidity, disrupt trade and travel networks, and stimulate civil unrest.

When local emergence leads to regional outbreaks or global pandemics, the economic impacts can be devastating. The processes that drive disease emergence risk interact with those necessary to achieve multiple societal goals."

*Source: https://www.pnas.org/content/117/8/3888.short

Because pandemics, especially like the ones we are facing today, have an incredible spread rate, it requires us to increase our surge response in operations and buildings rapidly. This rate of change, escalating daily, is also distinct to a pandemic compared to a natural disaster where you experience the conditions once- and then deal with the aftermath. The issue of flow, and the rapid surge capacity growth, make pandemics need a unique kind of flexibility.

When we respond to EIDs in the short term our environments have to flex to first Contain the epidemic and manage in the following ways.

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

When we respond to EIDs in the short term our environments have to flex to:

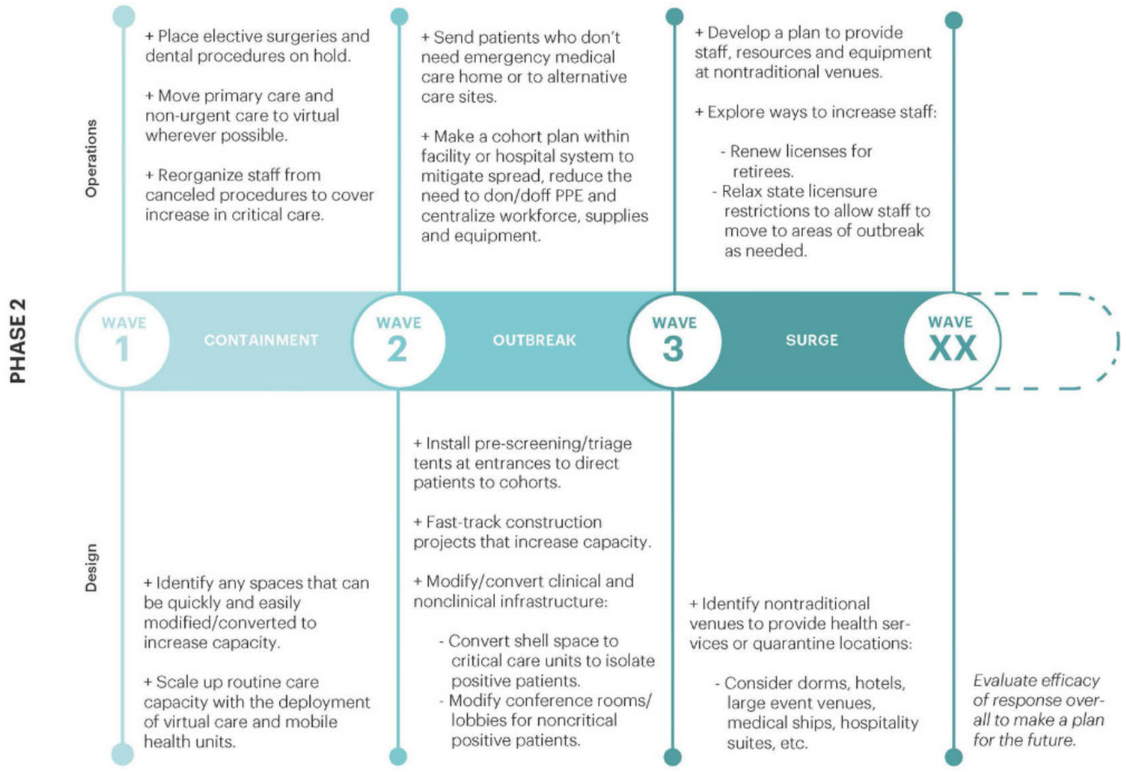
1. **Limit how germs can enter the facility.** Cancel elective procedures, use telemedicine when possible, limit points of entry and manage visitors, screen patients for respiratory symptoms, encourage patient respiratory hygiene using alternatives to face masks (e.g., tissues to cover cough).

   From a planning perspective, this translates to clear demarcation with screening capabilities at entry and exit points. Leveraging the thresholds of buildings like parking lots to create pop-up spaces. And ensuring that thresholds are manically monitored, so the isolated areas can stay so and limit the spread. Versatility and modifiability of public areas can be leveraged- and rapidly deployed structures- such as triage tents, cleanable partitions, mobile units all become viable to keep as much traffic out of the hospital as possible.

2. **Isolate symptomatic patients as soon as possible.** Set up separate, well-ventilated triage areas, place patients with suspected or confirmed COVID-19 in private rooms with door closed and private bathroom (as possible), prioritize AIIRs for patients undergoing aerosol-generating procedures.

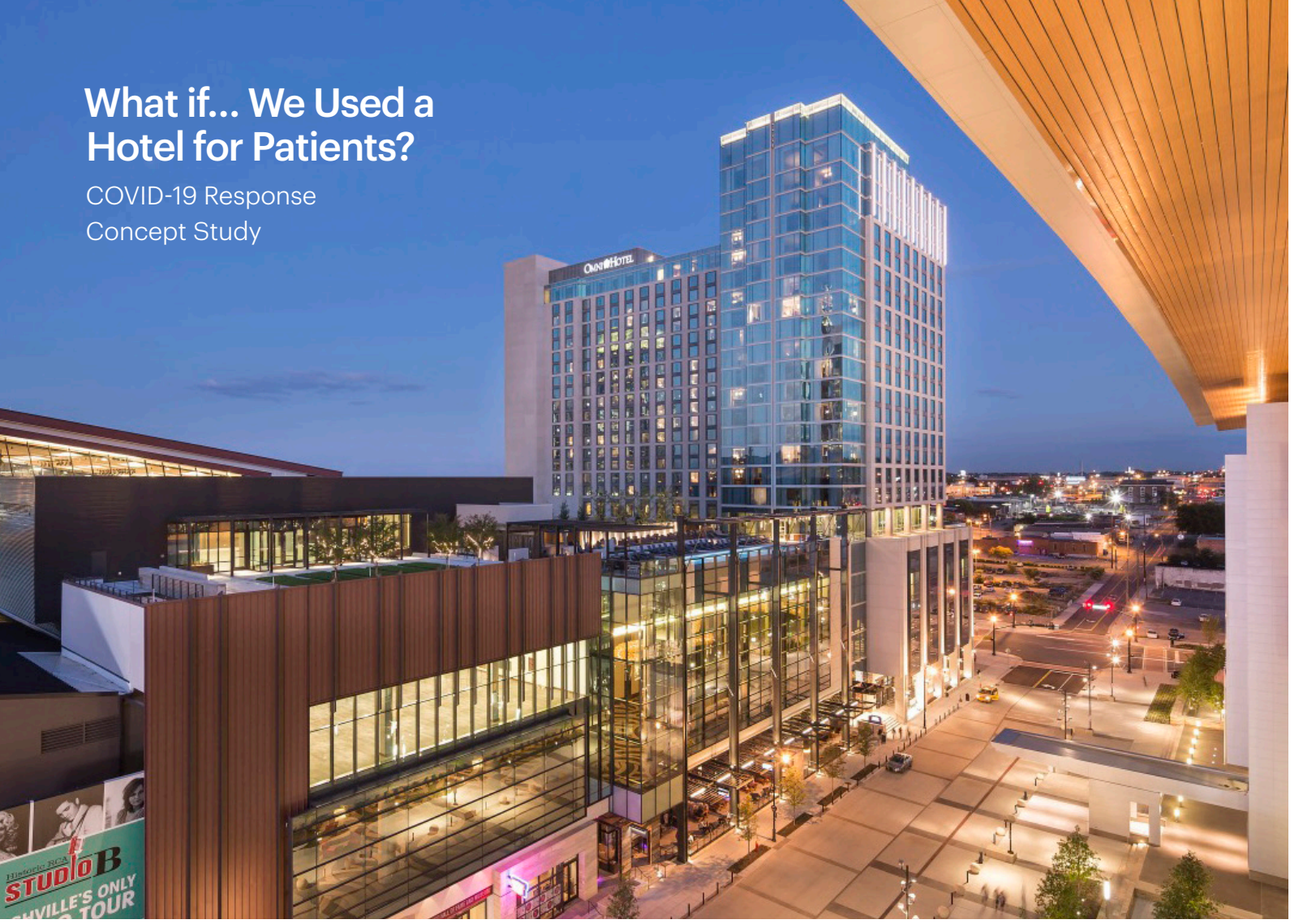
3. **Protect healthcare personnel.** Emphasize hand hygiene, install barriers to limit contact with patients at triage, cohort COVID-19 patients, limit the numbers of staff providing their care, prioritize respirators and AIIRs for aerosol-generating procedures, implement PPE optimization strategies to extend supplies.

We have to manage the outbreak and the surge simultaneously for which we need to start leveraging community resources: convention centres, hotels, dorms etc. As we start planning for surge we need to make sure we understand the operational implications clearly. Prioritizing what ancillary health assets and community assets should be flexed when- is critical.



What if... We Used a Hotel for Patients?

COVID-19 Response
Concept Study



The predicted hospital bed shortage

We should start by stating the obvious: the current COVID-19 crisis is unprecedented in modern times. If predictions are even partially accurate, our best preparations will still fall short of the need for hospital patient beds to handle the potential influx of people needing care.

According to The American Hospital Association, there are approximately 920,000 staffed beds in the U.S. Some studies have estimated that five to nine million infected people in the U.S. may need to be hospitalized, a third of whom might require intensive care.

While all people who get infected will not need isolation and close physiologic monitoring, there may at least be the need for medical care at some point during the illness which likely requires more hospital rooms than are currently available nation-wide and in individual cities. The gaps between current capacity and potential demand stretch our healthcare system beyond anything imaginable.

What if we could utilize hotels for COVID-19 patient care and sequestration?

Knowing that our current USA hospital bed capacity will likely fall short of the need, we need to identify alternatives that can help offload the bed demand from our hospitals. What if, we could utilize hotels for COVID-19 patient care and sequestration?

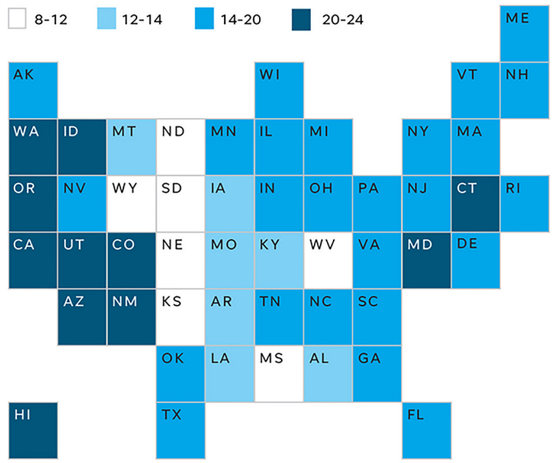
As we dive into this exploration, we should start with some assumptions that will help define the rationale and potential processes required for this secondary use of a hotel.

It would be very difficult, if not impossible without time-consuming major renovations, to convert and renovate a hotel into a fully operational hospital that meets all licensing and compliance requirements. Such conversion would not be practical or quickly done, and it would be very costly.

A hotel can be converted to patient care space that is not quite a "hospital."

While many hotel types were considered, a full-service convention hotel provides the best opportunity to quickly create and support functional patient care spaces that will be needed if the virus spreads to predicted levels. Speed of conversion will be key.

Full-service convention hotels are predominantly located in the population centres where the needs for COVID-19 treatment and sequestration may be higher and likely near major hospitals.



Patients may outpace available hospital beds during a spike in COVID-19. Coloured blocks show the estimated number of seriously ill patients per available hospital bed (for all ages).

Source: JANET LOEHRKE/USA TODAY
https://www.usatoday.com/in-depth/news/investigations/2020/03/13/us-hospitals-overwhelmed-coronavirus-cases-result-in-too-few-beds/5002942002/

Hotel to patient care: potential room-use conversions

Hotel Space	Hospital Space
Guest room	Patient room, nursing support/station, unit storage, unit clean supply storage, staff sleeping
Lobby/check-in	Triage/assessment/intake/registration
Conference room/large meeting areas	Central medication supply, central point of care testing, central medical supply, central materials supply, administration support (open office), nursing support (huddles/shift change)
Kitchen/room service	Kitchen/room service
Restaurant	Staff dining
Dock (logistics supply in, waste out)	Dock (logistics supply in, waste out)
Ballroom	Patient wards for better observation of those with worsening conditions and needing more real-time specialized care

COVID-19: appropriate for care in a hotel setting

Patients with high risk factors based on age and pre-existing conditions would be best suited for the hospital. The hotel solution is intended to preserve hospital resources for the sickest patients.

Assessing patients that present symptoms will be essential to determining the best candidates for care and sequestration in facilities like a hotel converted to patient care.

If hospitals would prefer that suspected COVID-19 carriers are not present at the hospital facility, an on-site triage at the hotel can be considered.

The patients most appropriate for a COVID-19 hotel stay are:

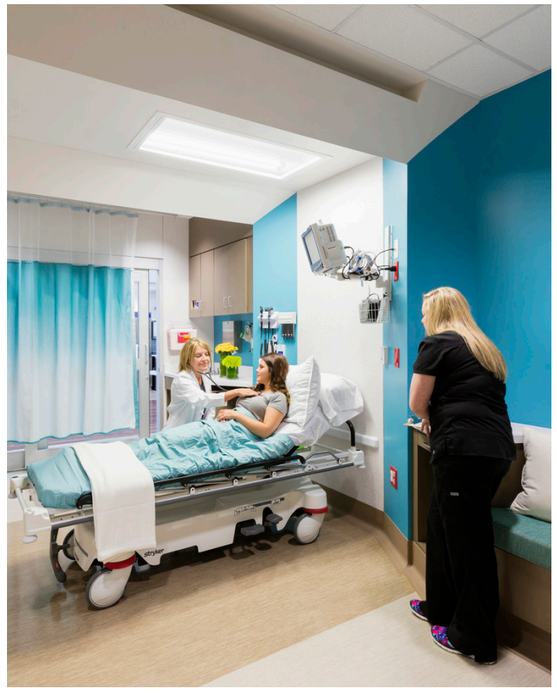
1. Suspected of being a COVID-19 carrier
2. Confirmed COVID-19 positive, but not presenting severe symptoms
3. Recovering from COVID-19 but still require care or sequestration

The patients would be ambulatory — they would not need ventilation or machine assisted breathing and they would not require oxygen or only need minimal oxygen assistance.

In the case of pediatrics, this study recommends that children with severe cases be treated within hospitals due to the likely need of specialized care and patient support.

Patient types suitable for hotel as a patient care site:

- In the age range of 18 to 50
- Require ambulatory care only
- May have high risk family members at home
- Require monitoring due to risk of progression to severe condition



- Have mild symptoms and do not have adequate support or space at home pre-hospitalization
- Have mild symptoms and do not have adequate support or space at home post-hospitalization
- Have improved symptoms or are recovering yet still require sequestration and have a positive test for COVID-19, especially if beds are needed

Assessment/testing/triage

Many hospitals are looking at alternative locations for assessment and testing of potential COVID-19 patients away from their hospitals and emergency departments. For the purpose of this scenario, we are assuming that some form of assessment, testing and/or triage is happening on the site of the hotel.

With potential arrivals presenting with symptoms they will need to be assessed and tested to establish an appropriate determination of sequestration, being sent home or being sent to the hospital. The flow and circulation of those potential cases must well-planned to try and limit cross contamination.

Scenario 1: Guest Room Conversion

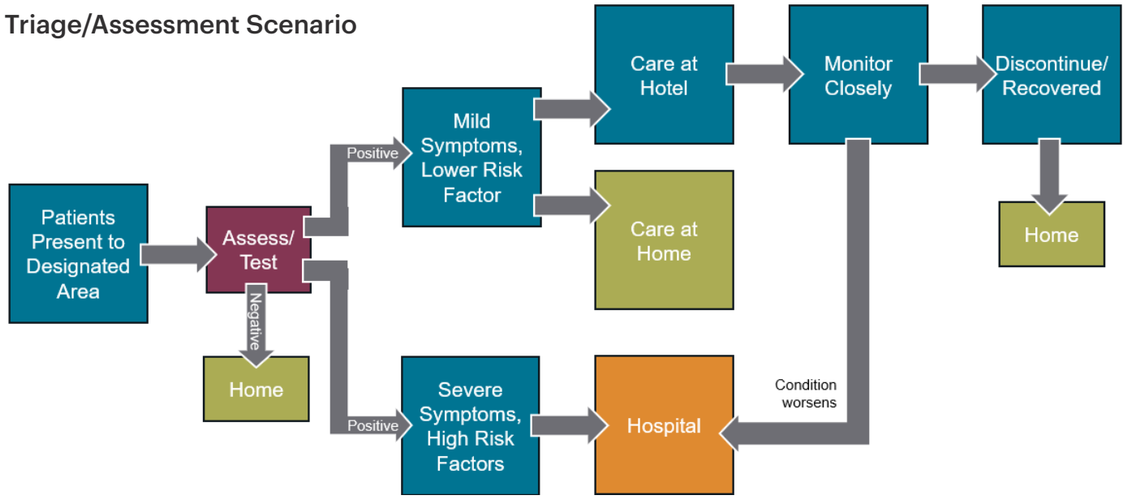
The guest room conversion for low acuity patients can be rather simple with a few considerations.

- Remove, if possible, non-essential furniture. This will allow for more caregiver space and other small equipment such as an IV pole, pulse oximeter and a bedside commode, if necessary.
- Utilize features already in the guest rooms such as the television, a telephone that connects to a central station, Wi-Fi connectivity, and a toilet/shower room with a sink.
- While the bed is not optimal for patient care, it will accommodate the needs for the scenario of this type. It is recommended that all mattresses be fully contained within a waterproof protective wrap. Linens should be replaced as often as possible.
- If additional observation is necessary, consider off the shelf camera systems that are easy to install.

Infection control within the guest room must be addressed and is paramount to contain the further spread of the virus.

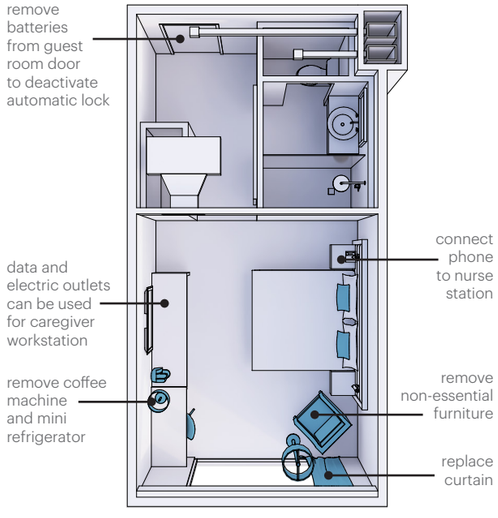
To create a barrier between the carpet and patient care, cover the carpet with "carpet protection tape" that is readily available and can be easily changed between patients. While this is not ideal for infection control it can help to reduce the incidence of contamination and spread due to fluid ejections and spills. And, it is achievable.

Triage/Assessment Scenario

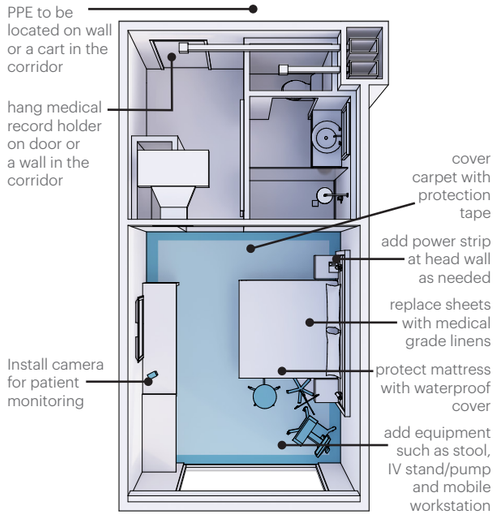


What if... We Used a Hotel for Patients?

Guest Room – Original



Patient Room – Low Acuity



Post-COVID-19 use, all carpet should be removed and replaced before the hotel returns to standard operations.

Stations for hand cleansing and access to personal protective equipment should be create near the entrance to each room if possible

Air Quality Considerations
Most hotel rooms are served by individual room units, typically fan coil units or packaged terminal air conditioners (PTAC), which recirculate air within the room. Fresh air is typically provided by a separate dedicated outside air system and dehumidified air is directly ducted into the room or the fan coil. However, some older facilities may depend on drawing outside air directly through the PTAC.

The average air exchange rate in hospital patient rooms is typically around six air changes per hour (ACH) of locally recirculated air, but probably less than two ACH of outside/exhaust air. Two ACH of outdoor air is similar to a hospital patient room. The advantage of the PTAC or recirculating room unit is that it is localized and does not return to a central air handler to get distributed to other parts of the building. But outside air helps with dilution of infectious particles that may be in the room air, and most of these units do not draw outside air directly.

Achieving negative air pressure is often desired for hospital rooms in which infectious patients are treated. Most hotel HVAC systems are not able to create a negative pressure in the guest/patient rooms, but secondary temporary systems can be used to a supplement exhaust and create negative pressurization. However, recent guidance from the CDC suggests that negative pressure is not imperative for low acuity COVID-19 patients who are not undergoing procedures that could cause aerosolization of droplets.

If using hotel guest rooms for patient care during this surge emergency, the most efficient implementation scenario may be to leave the air conditioning systems as originally intended and operational. A cleaning regimen can be employed for the accessible components of the system but cleaning the fan coil between every room change may be impractical.

Ballroom/Ward Configuration

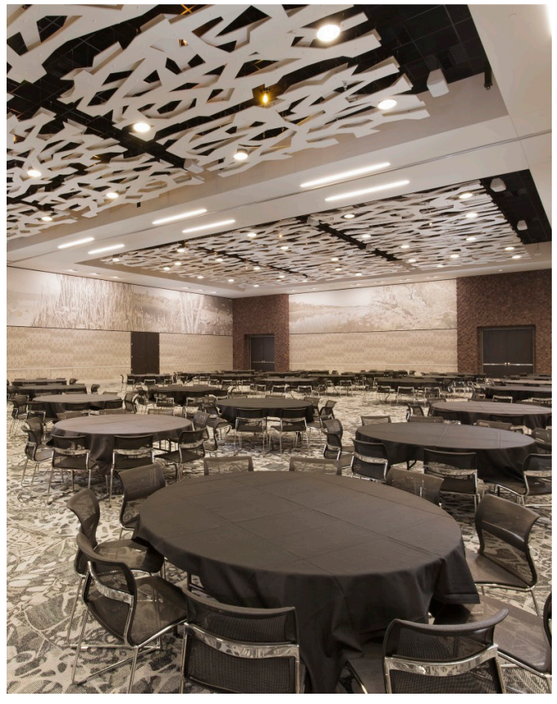
In the case where guest rooms will not be utilized for patient care (Scenario 1) or there is a need for a for higher patient observation area (Scenario 2), we recommend using the ballroom(s). Advantages include:

- Large flexible spaces with the ability to accommodate high weight loads on the floor and if necessary, hanging from the ceiling.
- Spaces can easily accommodate a ward configuration where beds are cohorted in small groups. For general planning purposes, it is likely you can comfortably accommodate one bed per 200 SF to accommodate appropriate spacing along with decentralized nursing care support spaces.
- This type of configuration is also conducive for more efficient staffing ratios.
- Other support spaces such as a point of care lab, central medication storage, supply storage, waste staging and a control centre could be accommodated in connected/adjacent meeting rooms.
- Air exchange rates in ballrooms tend to be higher than guest rooms which will serve a ward configuration well.

Access to toilets, showers and sinks could be challenging because these spaces are typically supported by large gang toilet configurations. Depending on the location and adjacency, planners may need to consider mobile toilets within the ballroom/ward for closer proximity to and containment of patients.

Toilet use is a potential source for significant contamination. Toilets should be enclosed and must be cleaned frequently. Bedside toilets and bedpan use will add to the workload for already-overloaded staff, also increasing potential for contamination with fecal matter and urine.

Bathing and hygiene would likely have to be accommodated at the bedside, although there could be paths for ambulatory patients to utilize



guest room showers if the pathway to and from these rooms does not cross contaminate other traffic.

Another option within the ballroom is to set up prefabricated patient care tents or units that can be self-contained and sometimes provide options for showers, toilets and sinks – if these can be connected properly to domestic water and power.

Air exchanges in ballrooms tend to be at higher rates than guest rooms, with higher percentages of outside air, which will serve a ward configuration well. Temporary ducting from central systems to the patient wards/units may be necessary, depending on configuration.

Command Centre Considerations

Operations in these scenarios must be highly organized. A central location for command will be essential to maintaining operations and organizational efficiency of facility in this scenario. A large meeting room near triage and large care areas would be ideal. Or, consider a location that may have connectivity to the main phone control board in addition to office support equipment such as computers, copiers and printers.

It is likely that there will be a shortage of qualified staff to support this emergency scenario. Alternative teams will be necessary because the standard caregiver-to-patient ratios will not be achievable. An additional benefit of a hotel conversion is that some guest rooms can be reserved for staff who can remain on site after their shifts, thereby reducing the likelihood of community spread. Food service on site can be provided and can support staff needs.

Using an electronic medical record system, at least initially, may be difficult due to lack of hardware, remote connectivity to systems and staff training requirements. The planners should consider use of a paper medical record system, often stored at the door/entry to each guest room or at the foot of the bed. Conversion to electronic data can come at later time.

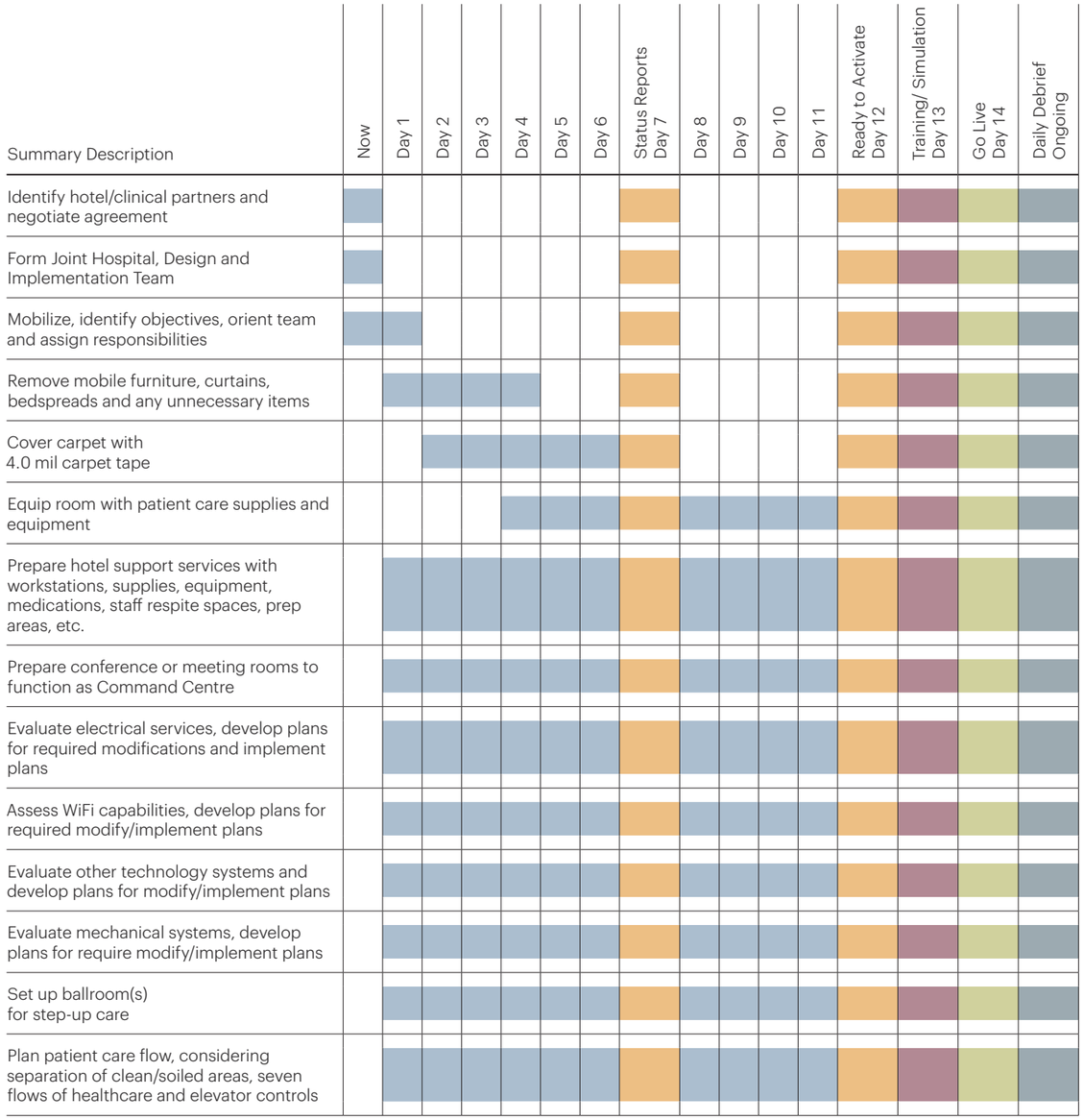
Closing Thoughts

This exploration is meant to ask the question, “what if?” and investigate some ideas that could be considered when facing a conversion scenario. It must be acknowledged that this study is far from comprehensive. It does not identify or resolve all the issues that may arise in a hotel conversion scenario. Nor does it consider other hotel types such as limited service hotels, non-convention models or other building types. Most importantly, there will likely be staffing deficiencies and potential medical equipment shortages.

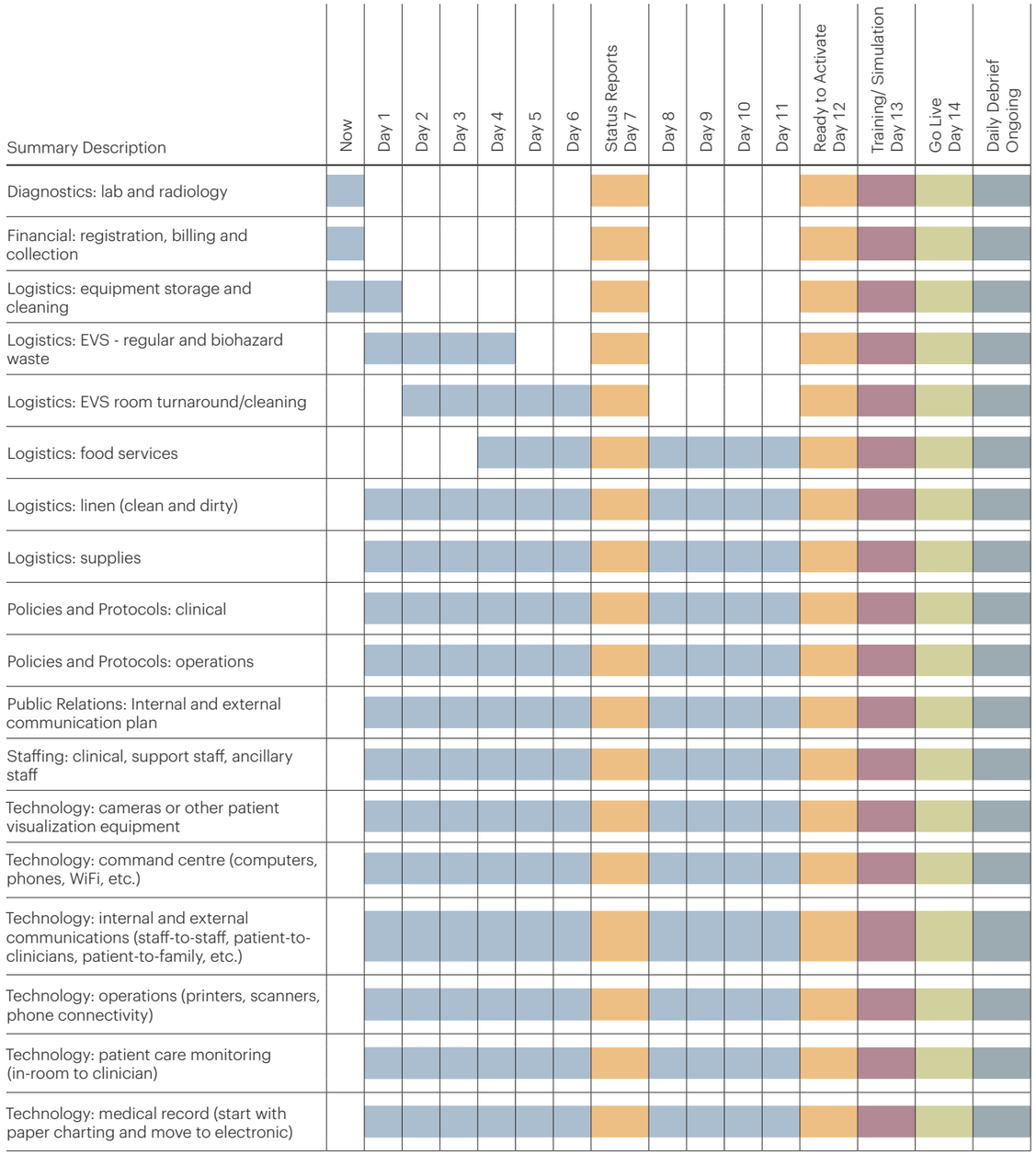
Systems may need modification that were not addressed as part of the study. While most convention hotels share the same programmatic spaces, they often differ in configurations and will require individual assessments. This analysis sets the groundwork for deeper dives into these topics, each of which will require additional study and consideration.

This is an approach that is based on the ability to convert a non-hospital building for the use of patient care very quickly — a full-service convention hotel offers this opportunity. With the right resources and team, a conversion time-line of 10 to 14 days is reasonable. The following are exhibits that visually begin to tell the story.

Conversion Time-line (10 to 14 days)

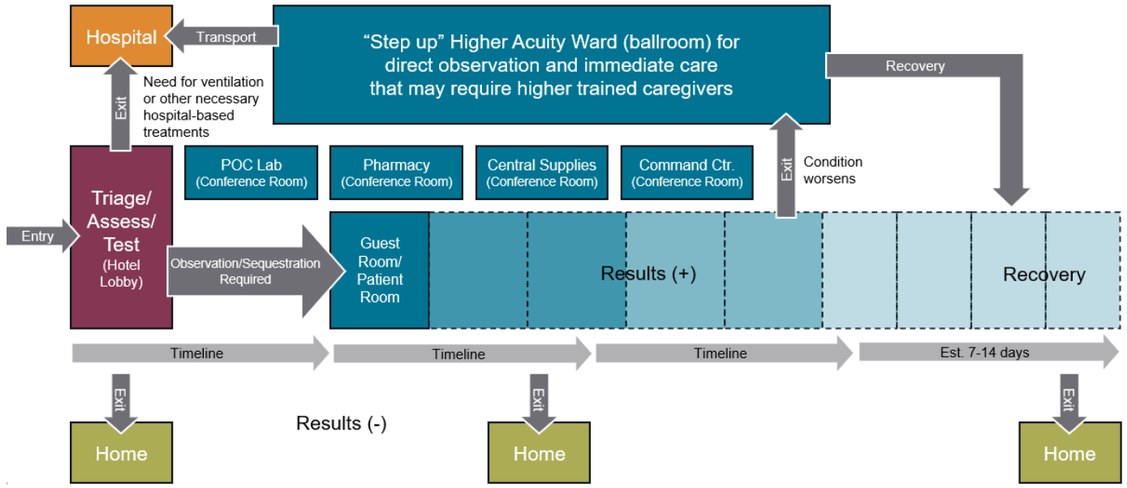


Operational Considerations



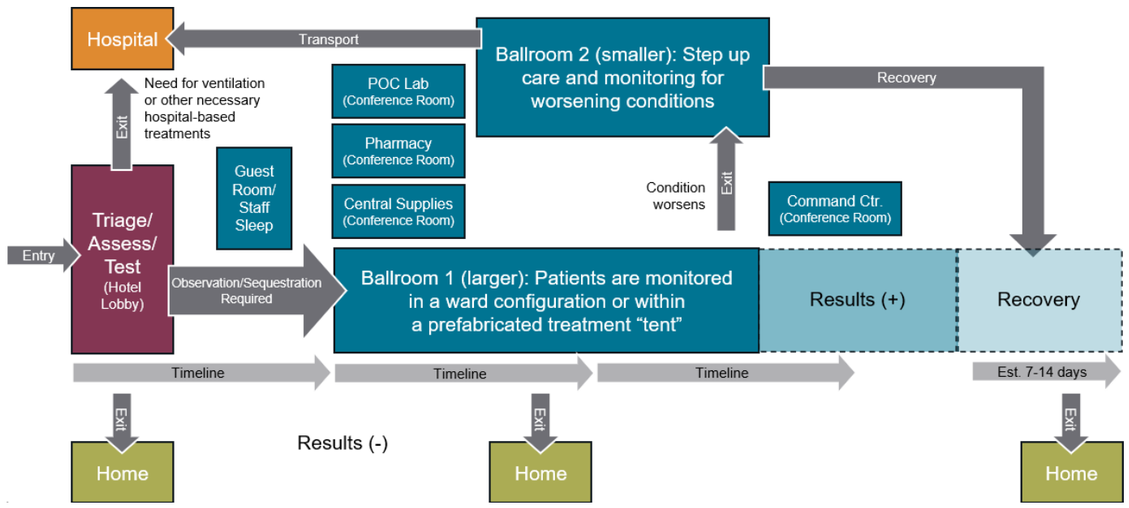
Ballroom/Ward Configuration

Scenario 1: Use of Lobby, Guest Rooms and Ballrooms

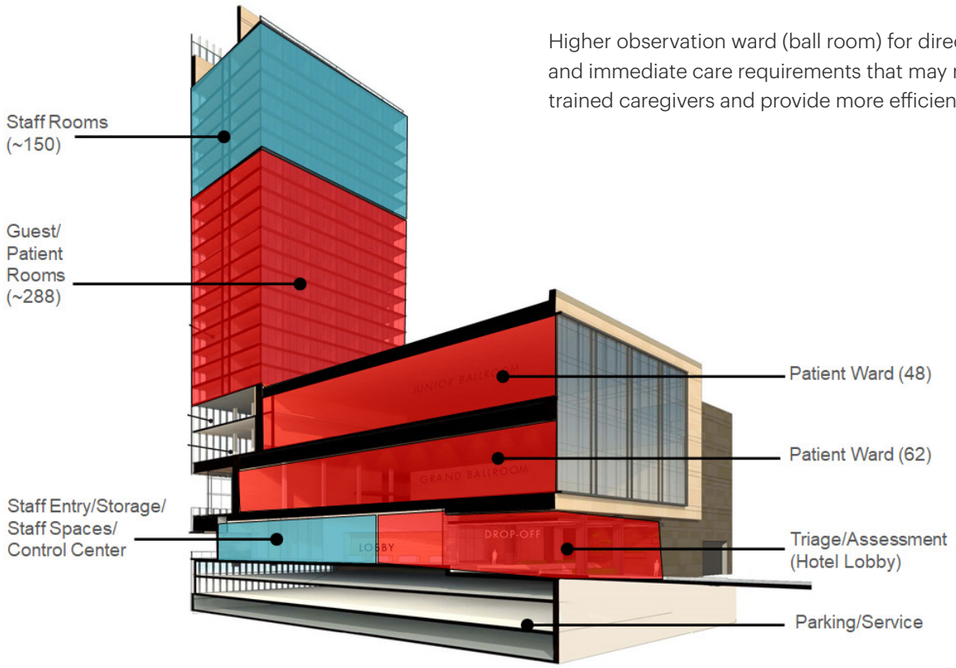


Ballroom/Ward Configuration

Scenario 2: Use of Lobby and Ballrooms



What if... We Used a Hotel for Patients?



Higher observation ward (ball room) for direct observation and immediate care requirements that may require higher trained caregivers and provide more efficient staffing.

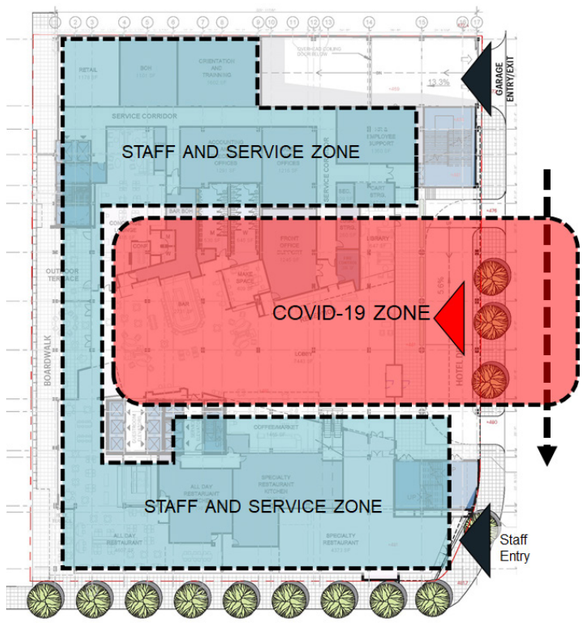
Key Insights

Pre-Admission Flow

- People will be permitted access to the hotel if they have been confirmed positive with COVID-19.
- People under investigation (PUI) will be tested at an off-site location or from their car. They will wait in their car until the results are available.
- Negative patients will return to their home environment.
- Positive patients will be triaged with a physiologic assessment and social assessment to determine ability to recover at home.

Patient Flows

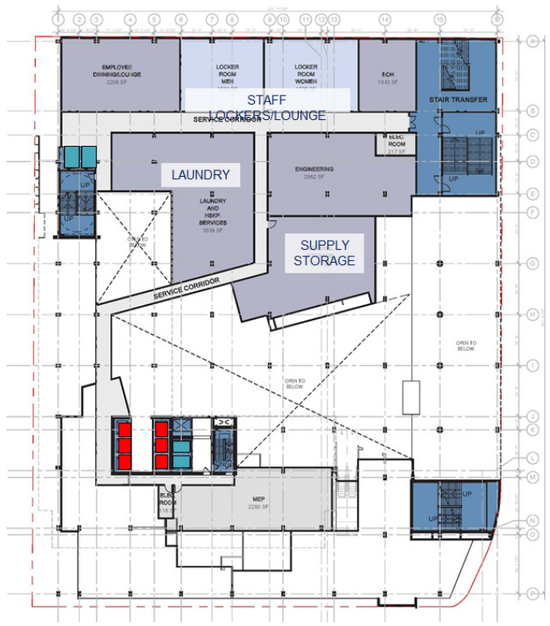
- Entry into the hotel will begin with an intake process at the 'hotel reception desk.'
- Patients will then walk to triage for assessment
- If require admission they will take the designated elevators to the guest room floor or to one of the ballroom floors



Key Insights

Entry Level Zoning

- Consider zoning the entry level floor for a variety of options for COVID-19 arrivals
- Potential for drive-through testing integration
- Assessment capable spaces and flow
- Triage capable spaces and flow
- Direct admit COVID-19 arrivals
- Separation from for staff and non COVID-19 support entry and circulation

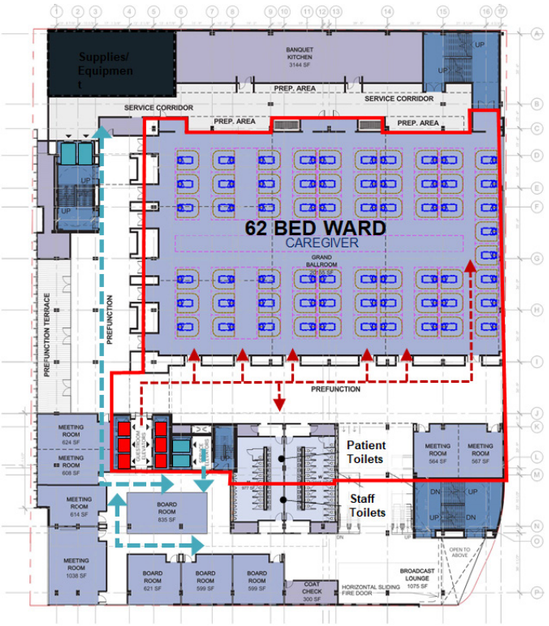


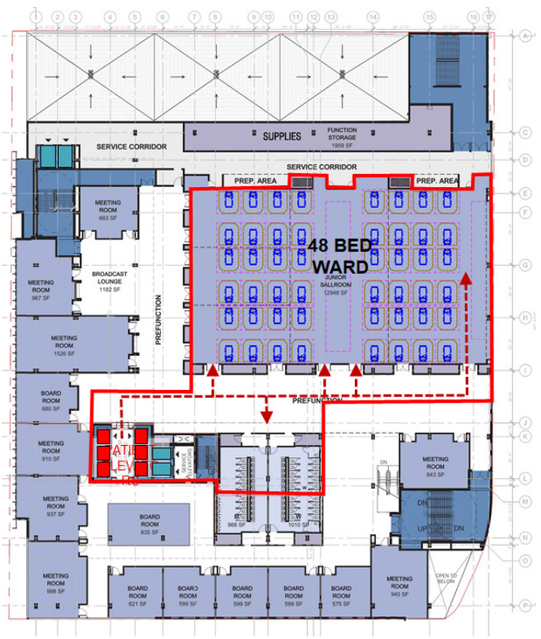
Key Insights

Staff/Support Services

- Support services floor
- Laundry from all hotel areas will be processed here
- Clean and soiled linen will be transported from this floor to the guest room and ballroom floor via the staff/service elevators
- Staff will keep their belongings in the hotel locker rooms

What if... We Used a Hotel for Patients?

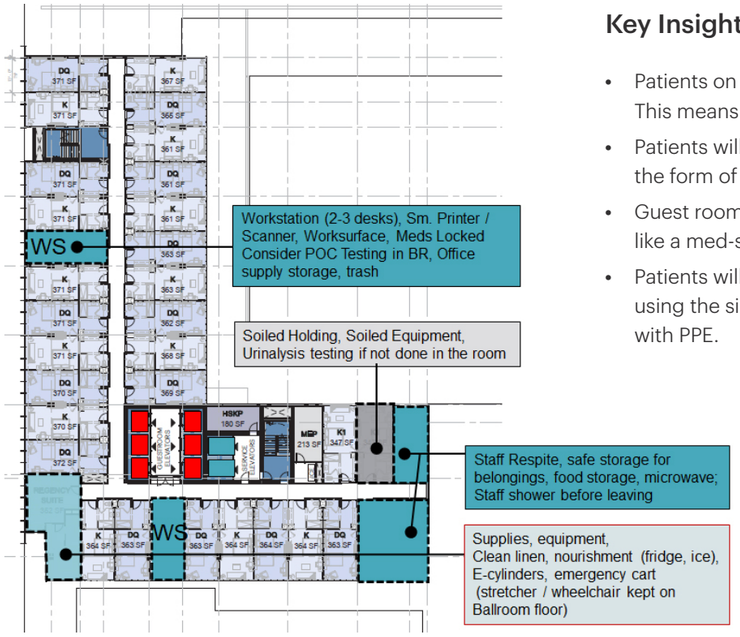




Key Insights

Patient Care and Support Services/Ward

- Positive patients will be accompanied by a designated representative to the open care area (ballroom).
- Patients are expected to be febrile, have shortness of breath and general malaise and be ambulatory.
- Positive patients in this area may require oxygenation. Medical gas will be provided in a 12-bed area close to the elevators in case of need of immediate transport to the hospital.
- Close physiologic monitoring is required for patients with co-morbidities or moderate shortness of breath. Ideally, older patients or patients with co-morbidities will be cared for in the hospital. Patients with shortness of breath and requiring oxygenation will be moved to a different location of the hotel.
- These bays will be open, without curtains. Screens will be used when absolute privacy is required.
- This open environment will maximize visibility. Staffing models will be based on hospital policy.
- Electrical cords will be taped to the carpet and used to charge patient care equipment, provide examination light, patient mobile devices and other items.
- Centralized supplies, equipment and nourishment will be kept in a location either on or off the floor based on available space.
- Workstations, equipment, supplies and other support needs can be kept in the centralized caregiver work zone or in the periphery of the ballroom.
- Bathrooms will be shared. In this design, the bathroom will be divided for male and female use. Showers will be provided on an as-needed basis.



Key Insights

- Patients on this floor will require "droplet" isolation. This means staff use gown, gloves and N95 mask.
- Patients will not require respiratory assistance in the form of aerosol or oxygen.
- Guest rooms are slightly positive to the corridor like a med-surg floor.
- Patients will be triaged and walk to the guest floor using the six guest elevators. Staff will be donned with PPE.
- Portable x-ray kept downstairs. Staff use sanitizer in and out of the room. Each room has hand-sanitizer inside the room. PPE with sanitizer on cart outside the room or hanging on the door. Share carts/container between rooms for patient dedicated PPE. Staff wash hands in workstation room.
- Guest room – bed, bedside table, guest chair, patient specific supplies, linens, work surface
- Staff shower before leaving for home.

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Fundamentals of epidemic containment and critical event preparedness

Prevent:
- General hygiene and sanitation practices
- Specific prevention measures – immunizations, etc.

Detect:
- Monitoring/surveillance for risk of emerging disease

Respond:
- Cohort patients – Containment / Propagation mitigation – Quarantine / isolation
- Mortality / morbidity reduction – Treatment

When aligned our result is a comprehensive view of helping organizations define specific strategies to reduce transmissions to protecting the healthcare team and provide spaces where they can effectively provide high quality care.

These fundamentals are highly relevant to the built environment and are the framework for the guiding principles of design. While there are multiple specific solutions depending on the specific project requirements, limitations and client preferences the guiding principals of design remain constant. In other word any design solutions should support 1-5 above in some way.

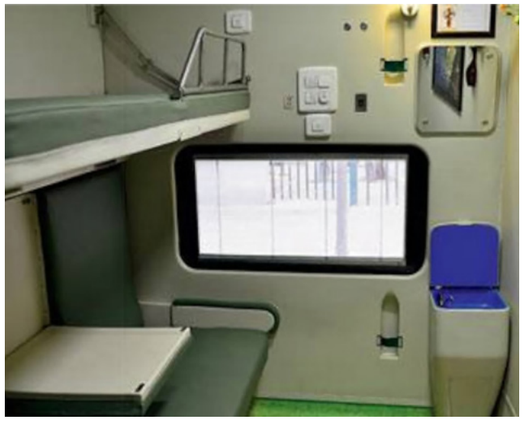
The guiding design principles

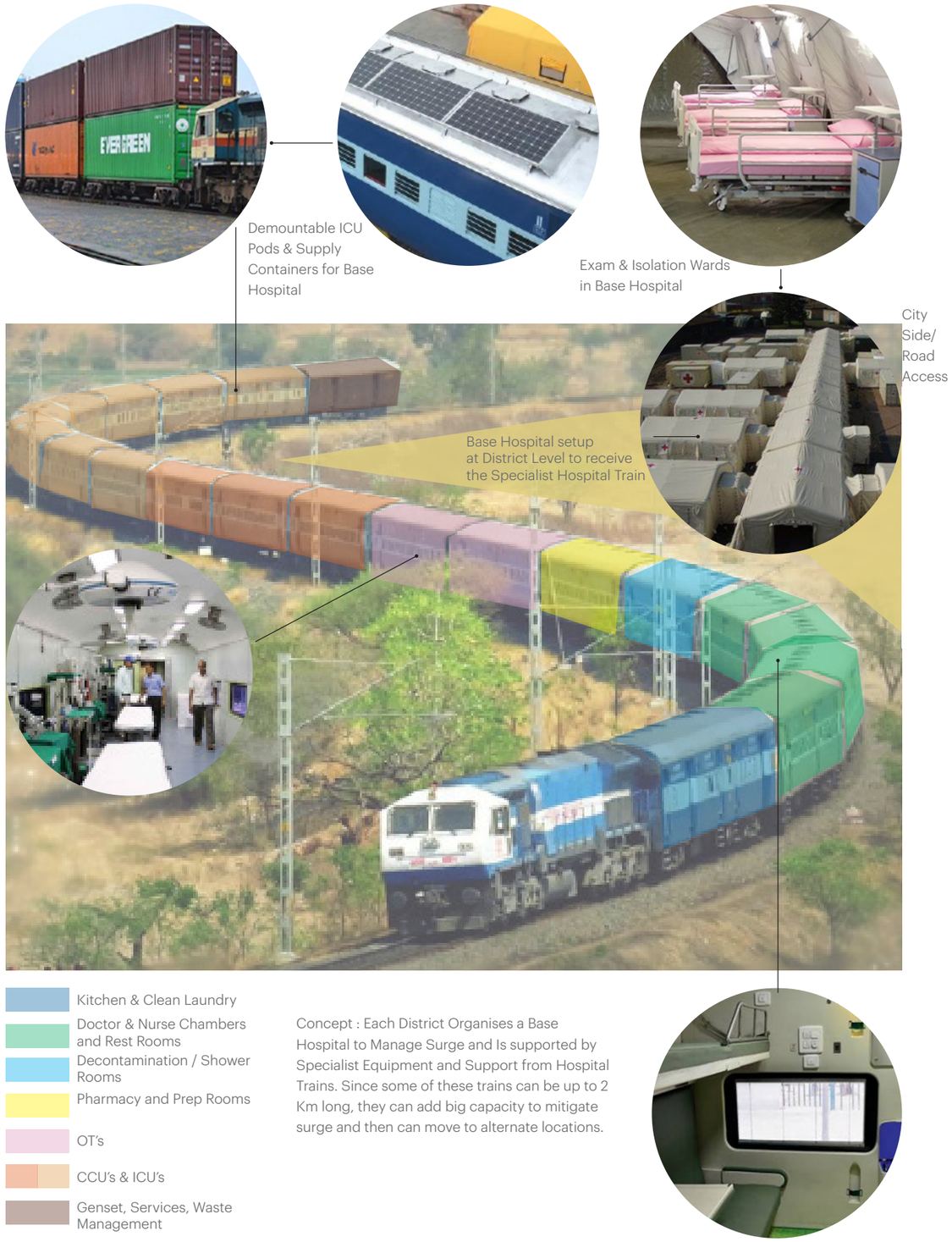
Support Universal precautions – although it initially sounds trivial the availability and convenience of hand washing, masks, gloves, disposal of sharps and contaminated material has a major impact on disease spread during either normal operations or epidemic outbreaks. Design responses include convenient and accessible placement including in contingency spaces.

Allow to Cohort patients – With large epidemics hospitals and especially emergency departments will typically be unable to provide a private isolation room for every individual. Therefore, cohorting patients with the same infectious disease is an excellent general strategy. The concept is that the worst that can happen is they will be exposed to an infectious agent they already have. (this is an application of 4 above). In order to effectively create the cohort, there needs to be a decision point where someone is placed into one cohort or the other – effectively this is triage. The argument can be made for highly infectious diseases that this separation should be done before patients enter the hospital. Those with suspected highly infectious disease would use a separate entry so as not to contaminate the general entry. There are numerous potential design and operational approaches to achieve this.

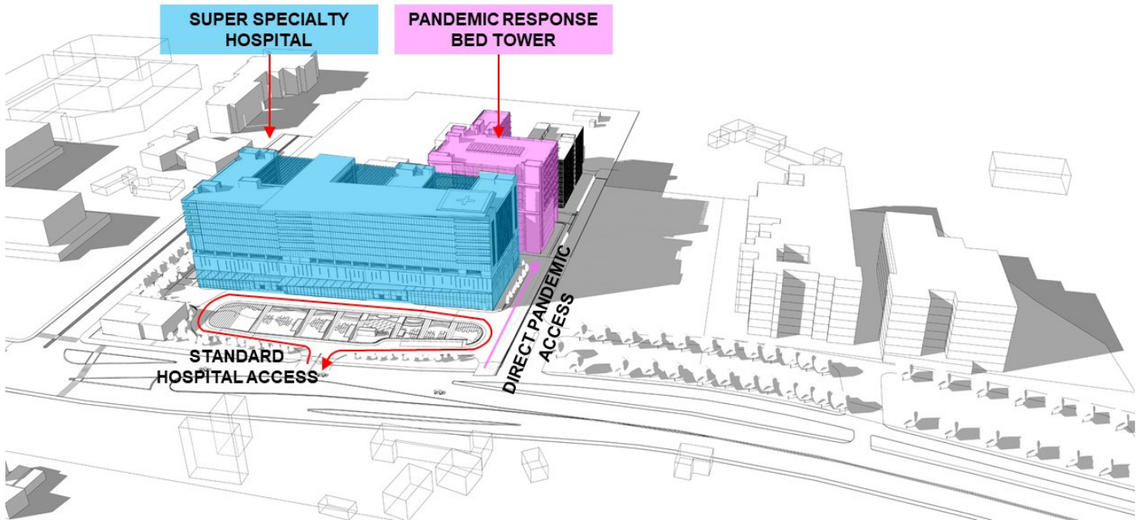
Create Compartmentalized areas – There is little good in creating the cohort of patients if the other non infected patients can be exposed to them. Compartmentalization that essentially quarantines the infected group in an area of the ED is useful. This requires a design strategy that allows for such "closed" compartments.

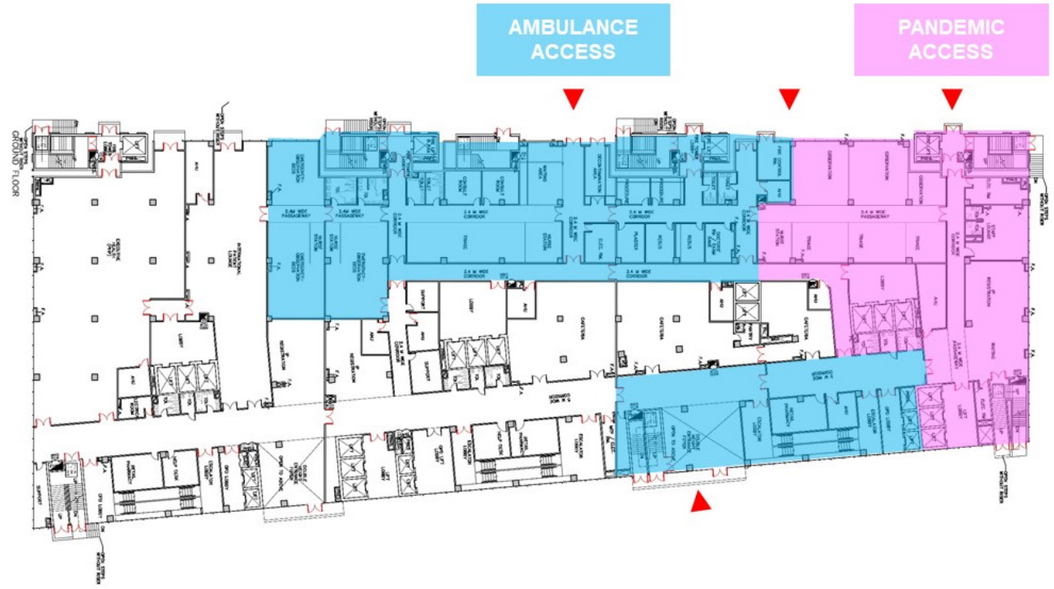
Separate air handling -– as many highly infectious disease outbreaks involve airborne spread the ventilation systems for the compartmentalized areas should not mix with other ventilation. Adequate filtration and negative pressure should be considered to protect the rest of the hospital.





Concept : Each District Organises a Base Hospital to Manage Surge and Is supported by Specialist Equipment and Support from Hospital Trains. Since some of these trains can be up to 2 Km long, they can add big capacity to mitigate surge and then can move to alternate locations.





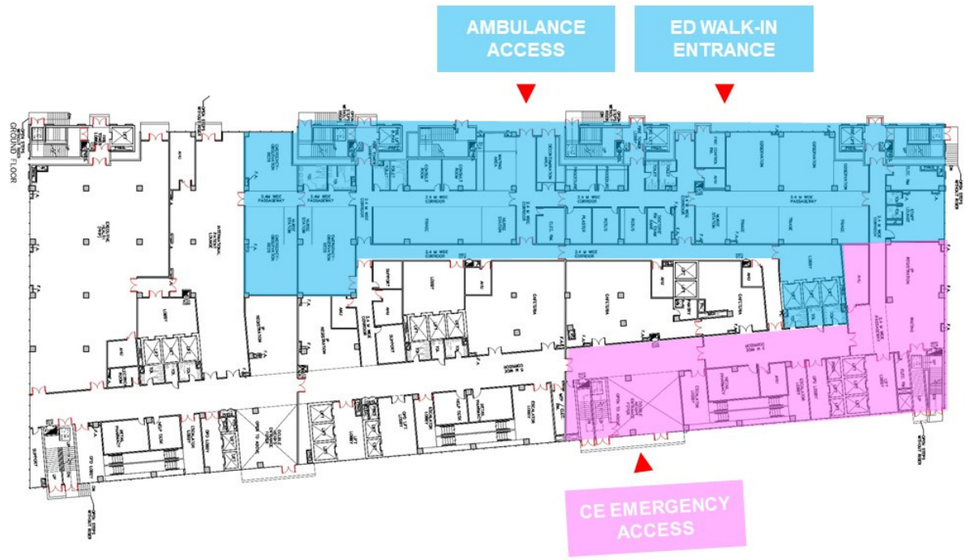
MAX Smart Super Specialty Hospital

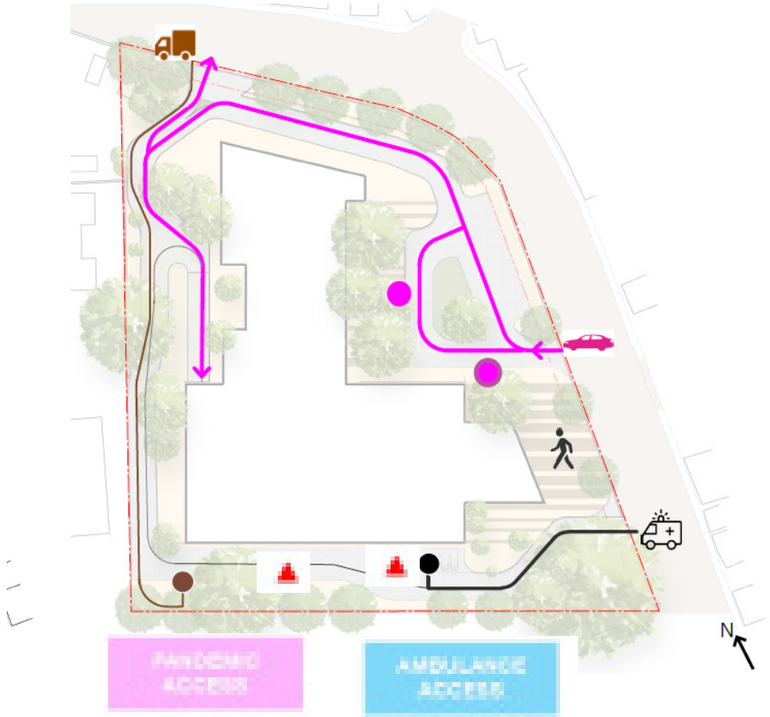
New Delhi, India

Key Design Elements:
Integration of new 900 bed facility at campus level with existing facility
Department Compartmentalization
Horizontal Consolidation of Modalities
Flexible Patient overflow
Segregated entrances and flows

HKS is currently engaged in the expansion of Max Hospital, New Delhi, India to be a beacon for medical care and research as the first choice of destination for tertiary and quaternary care in Asia.

The design involves building a new facility and integrating the same with existing facility. The integration is planned in a manner to segregate entry/exits into different parts and managing circulation at campus level. The hospital has the capability of segregating an entire wing with dedicated emergency triage, imaging, surgery unit and isolation ICU's and wards in case of an emergency.





Site plan showing dedicated access for ambulance entry

Tata Memorial Hospital

Mumbai, India

HKS provided concept design and peer review services for the new building, with Biophilia as a central design concept.

For disaster preparedness, the Emergency department is designed such that a separate access is provided, uninterrupted by the regular Hospital traffic. The Emergency department can expand in times of crisis towards the southern side. Also the observation bays within the Emergency department can be converted for Pandemic use.

Lifts that can be used for services or materials during regular times can be dedicated lifts for infected patient transfer during a pandemic outbreak. Individual isolation rooms are provided within the inpatient floors instead of wards to control the infection in a significant way.

The mechanical strategy during normal operation the return air damper is open, the exhaust damper is closed, and the air handling unit is only bringing in the minimum amount of outside air required for the space. However, when the area is under isolation a command can be sent from the controls system to close the return air damper, open the exhaust air damper and also open the economizer damper in the air handling unit. When the damper positions are confirmed by the controls the exhaust fan starts, the area becomes active pressure and is isolated from spreading contamination to adjacent patient care areas.

Observation bays can be converted to pandemic bays in times of an outbreak, and one lift from the adjoining lift bank can be cordoned off from the lobby and used for transporting isolation patients vertically

Ground floor plan showing observation bays and lifts

Macau Island Hospital

Macau, China

Key Design Elements:
Departmental compartmentalization
Expandable/convertible exterior space
Mass casualty decontamination design solutions
Dedicated patient transfer elevators
Emergency observation unit conversion to pandemic isolation floors
Mechanical system infrastructure

HKS was engaged by the Macau Health Bureau in the winter of 2014 to consult on the design of a new 1200 bed Macau Government Hospital Complex in Macau, SAR. The new facility was designed with several key elements that support the hospital's objectives for meeting emergency and disaster preparedness initiatives.

The Emergency department was designed to operate under normal circumstances with 6 key zones including a Fever Clinic, multiple floors with 23-hour emergency observation, Level 1 Trauma/resuscitation rooms, Level 2 and 3 emergency room beds, Level 4 and 5 Fast Track/Triage area and dedicated CT and Radiology Imaging services.

The final design was developed to allow for compartmentalization into multiple zones which provide isolation and expandability during a mass casualty or pandemic outbreak. The department was designed in such a way to allow for a portion of the emergency department to be isolated for a mass casualty or contagious outbreak, while at the same time allowing for the main emergency department to remain operational. Both the interior of the emergency department as well as the exterior were designed to allow for expansion and compartmentalization.

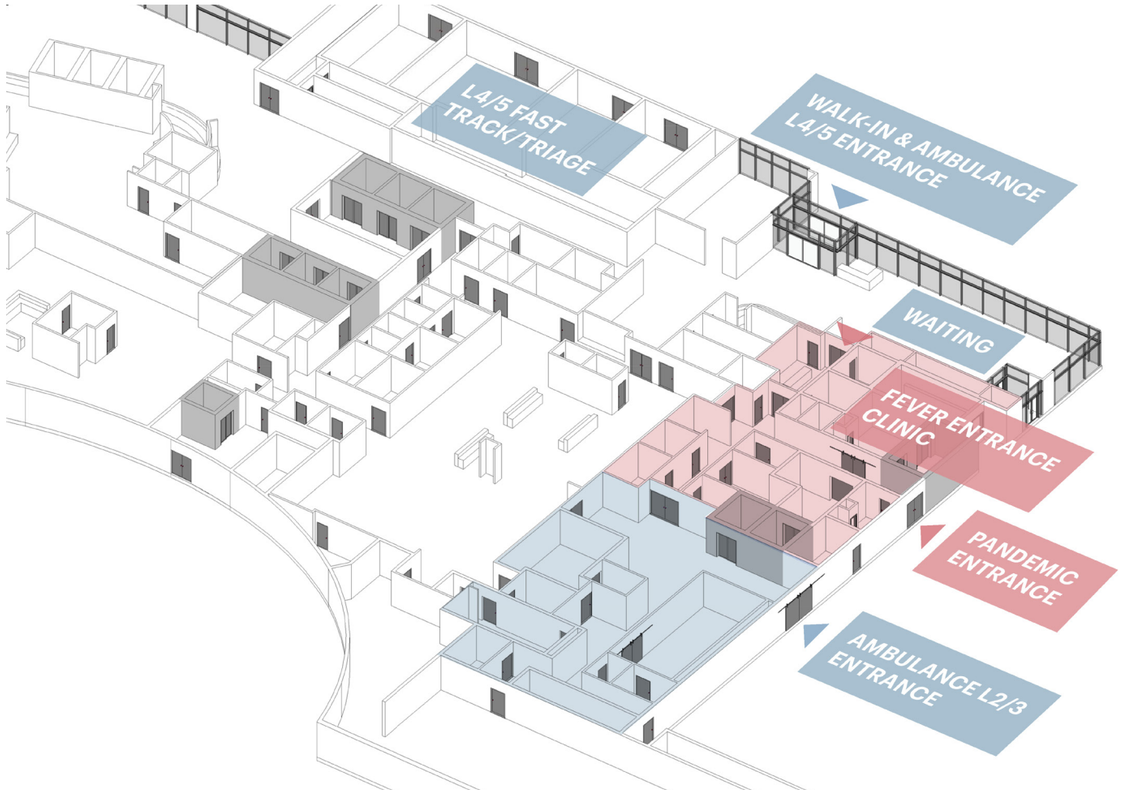
Several design features are integral to allow for the expansion of exterior Emergency drop-off area into a temporary triage area and separate decontamination area that allows for the treatment of potentially contagious or contaminated patients.

- Structural davit connections or permanent ceiling mounted tracks can be provided to accommodate temporary fabric partitions or curtains.
- Strategically located hose bibs with shower heads for decontamination of patients
- Trench drains with dedicated plumbing diverted for decontamination

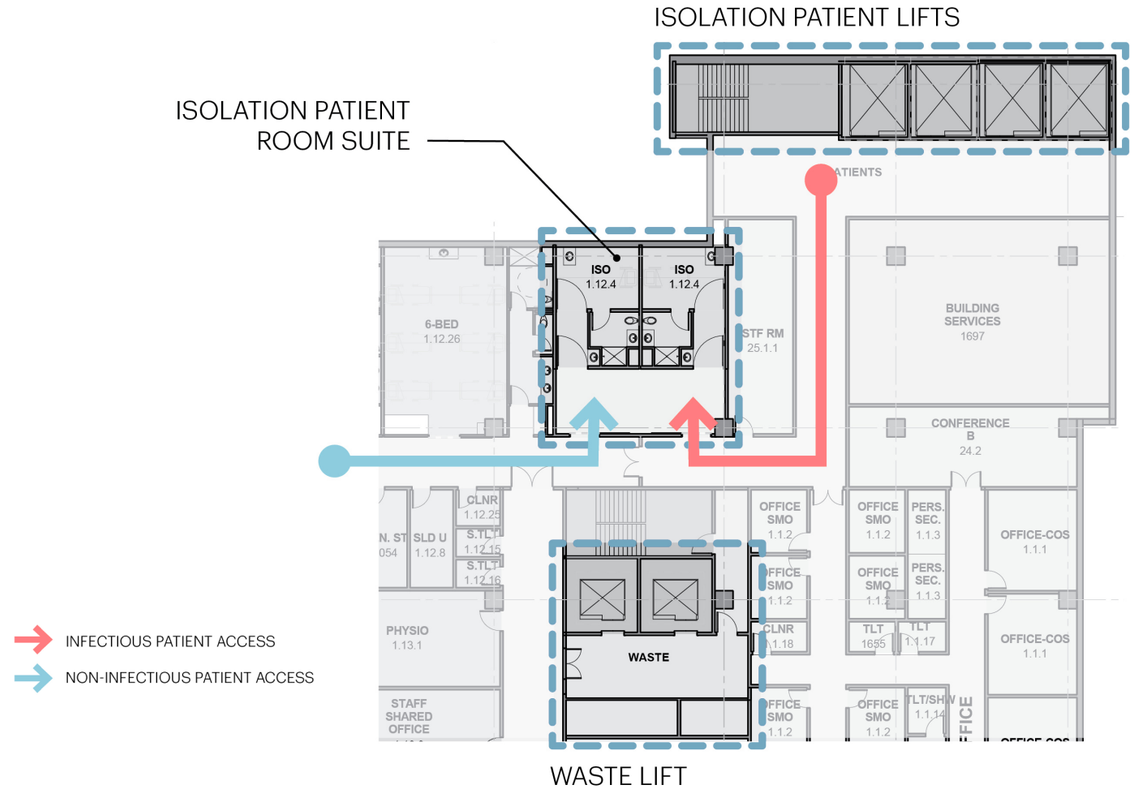
In order to provide sufficient accommodations for isolation of large patient populations during quarantine events, it was necessary to provide dedicated vertical circulation access to multiple levels of the facility. This access was coordinated to allow for the segregation of these isolated floors while also maintaining vertical circulation capabilities for the remainder of the hospital tower to allow for normal operations to continue during quarantine and pandemic events.

The AGV Supply and Soiled Service Elevators will be temporarily quarantined for isolation of infectious patient movement from the emergency department to the isolated emergency observation floors on levels 8 and 9.

While the physical design and planning of the facility were instrumental in creating pandemic zones within the facility, it was imperative that a mechanical strategy be implemented to compliment the design and provide true isolated zones within an operating hospital. This required mechanical systems which were designed to allow for the compartmentalization and isolation of several zones during seasonal flu season or potentially pandemic events.



Emergency Department Isolation Plan Diagram



Isolation Room Access Routes

While providing flexibility to convert patient care areas to negative pressure zones during mass quarantine or pandemic events is crucial, the solution must also be designed to conserve energy during normal use. Areas programmed for quarantine isolation zoning are typically areas that are not fully exhausted during normal operation. Operating these areas with full exhaust during normal operation would increase the energy required to condition the necessary extra outside air. Using strategically placed dampers and direct digital controls energy can be conserved and the isolated areas can still be converted to negative pressure with minimal effort or disruption.

During normal operation the return air damper is open, the exhaust damper is closed and the air handling unit is only bringing in the minimum amount of outside air required for the space. However, when the area is under isolation a command can be sent from the controls system to close the return air damper, open the exhaust air damper and also open the economizer damper in the air handling unit. When the damper positions are confirmed by the controls the exhaust fan starts, the area becomes active pressure and is isolated from spreading contamination to adjacent patient care areas.

Queen Mary Hospital

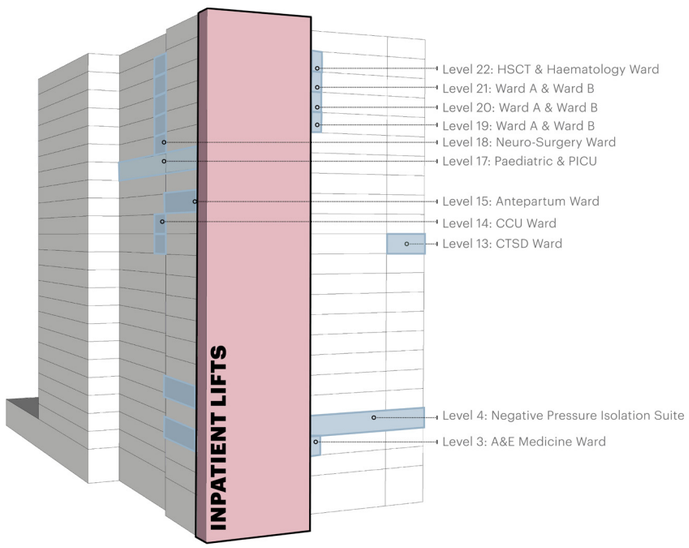
Hong Kong

Key Design Elements:
Departmental compartmentalization
Dedicated patient transfer elevators
Emergency observation unit conversion to pandemic isolation floors
Mechanical system infrastructure (seasonal/pandemic exhaust design)

HKS teamed up with a local architectural firm in the winter of 2016 to compete in a Government Hospital Complex in Hong Kong, SAR with the concept of a pandemic-ready facility.

Over the course of the last decade, outbreaks of H1N1, SARS, and COVID-19 have raised concern about how to control and isolate patients with potentially highly contagious diseases. In the case of a pandemic event a comprehensive preparedness strategy for the facility is supported by a range of features incorporated in the design. These features are tailored to work individually or in concert with each other, to provide the ability to respond to a potential pandemic event in a measured and appropriate manner.

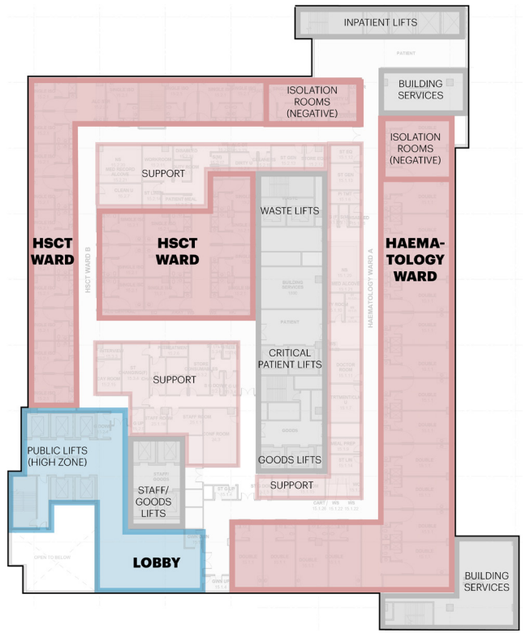
Our Experience



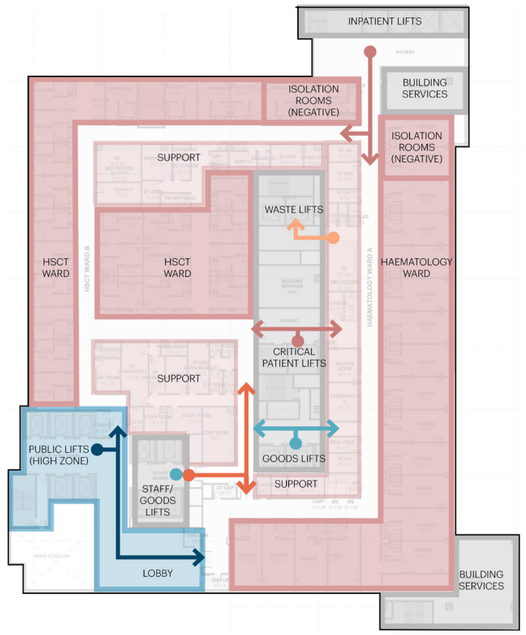
Isolation Suite Locations

Isolation Patient Room Suites

These suites are areas where isolation patient rooms have been consolidated along a dedicated corridor with two entrances: one from the ward they are associated with, and a secondary entrance from outside the ward. This will allow utilization of these rooms both as part of the department or as a free-standing infectious patient suite.



Isolation Ward Floor Plan

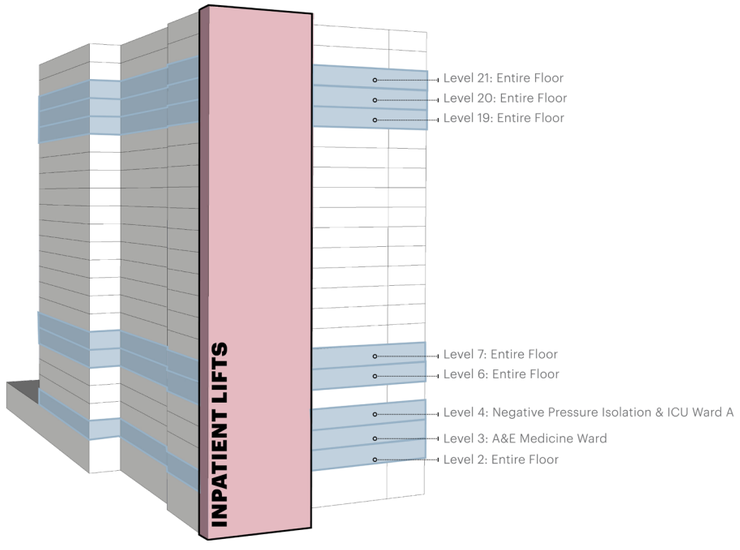


Isolation Ward Circulation Diagram

- PUBLIC CIRCULATION
- STAFF CIRCULATION
- INPATIENT CIRCULATION
- SOILED CIRCULATION
- CLEAN CIRCULATION

Vertical Partitioning

The design team proposed to leverage the verticality of the building to compartmentalize areas during pandemic events. The key to successful vertical partitioning is the ability to reach the respective floors. In this facility, separate access points for infectious and non-infectious patients are provided on the A&E floor, while designating the two patient lift banks to infectious and non-infectious patients respectively can help maintain the separation throughout the building.



Vertical Partitioning

Emergency Department Remodel

Singapore

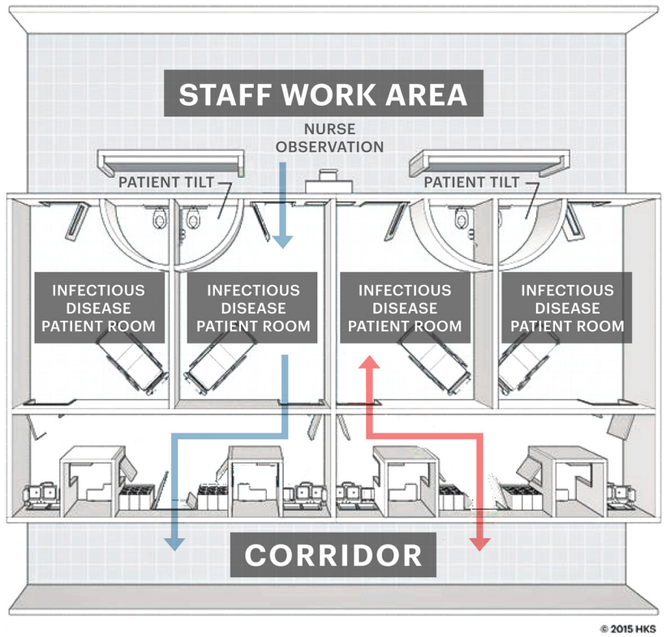
Key Design Elements:
Dedicated pandemic entrance and zones
Departmental compartmentalization
Flexible patient overflow
Mechanical system infrastructure (pandemic exhaust design)

HKS is currently engaged in the remodelling of Changi General Hospital with MOH Holdings as medical planner in Singapore.

The remodelling of Emergency Department is still ongoing with the participation of the Emergency Preparedness team at an early stage. The pandemic work-flow is introduced and incorporated into medical planning with several key planning points to ensure the hospital has the ability to respond to a pandemic event effectively within a short time-frame.

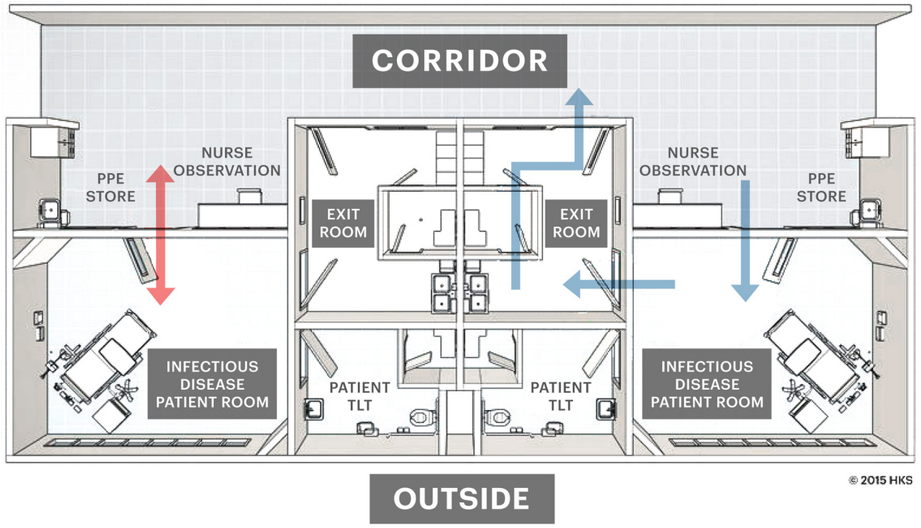
Emergency Department Setting

STAFF FLOW
PATIENT FLOW



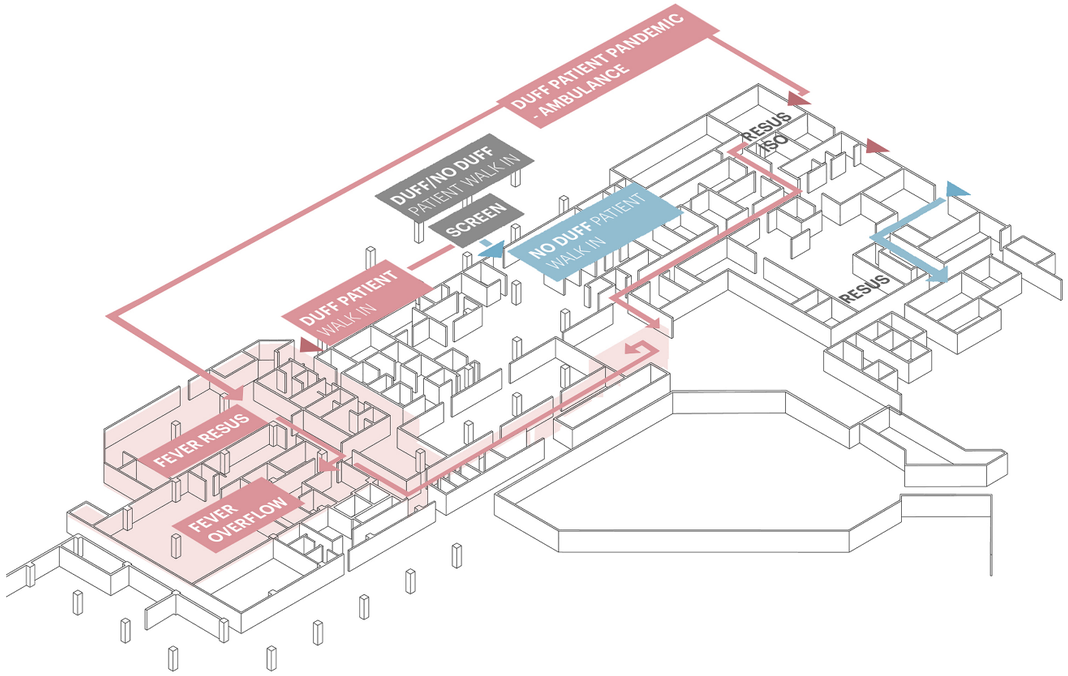
Inpatient Setting

STAFF FLOW
PATIENT FLOW

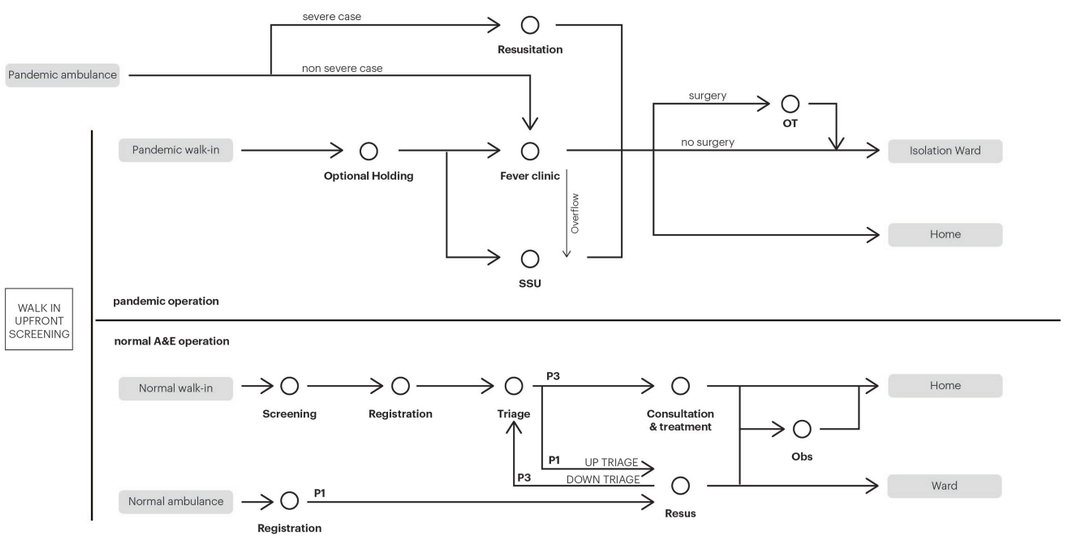


Enhanced Infection Control (unidirectional flow)

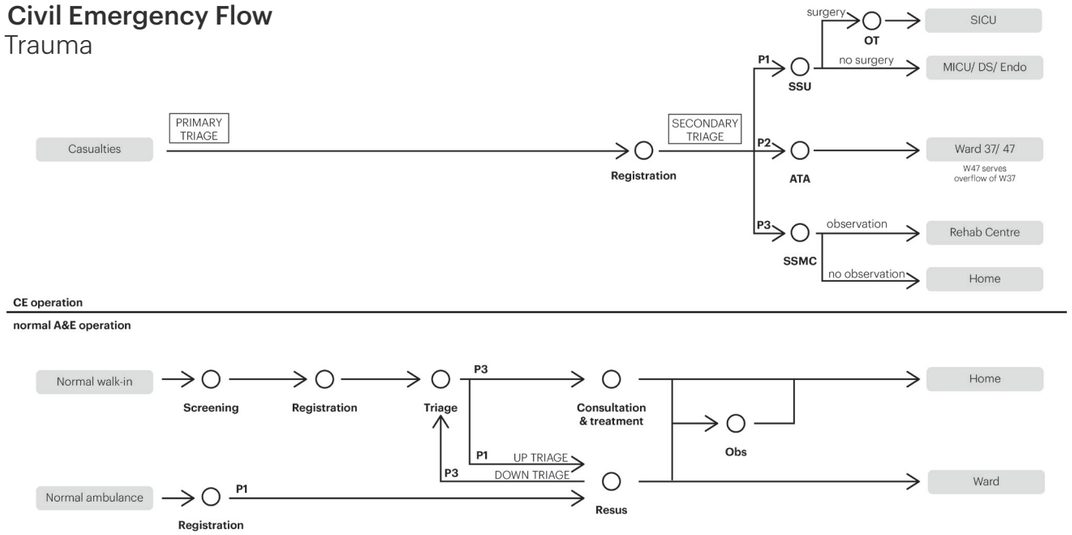
Our Experience



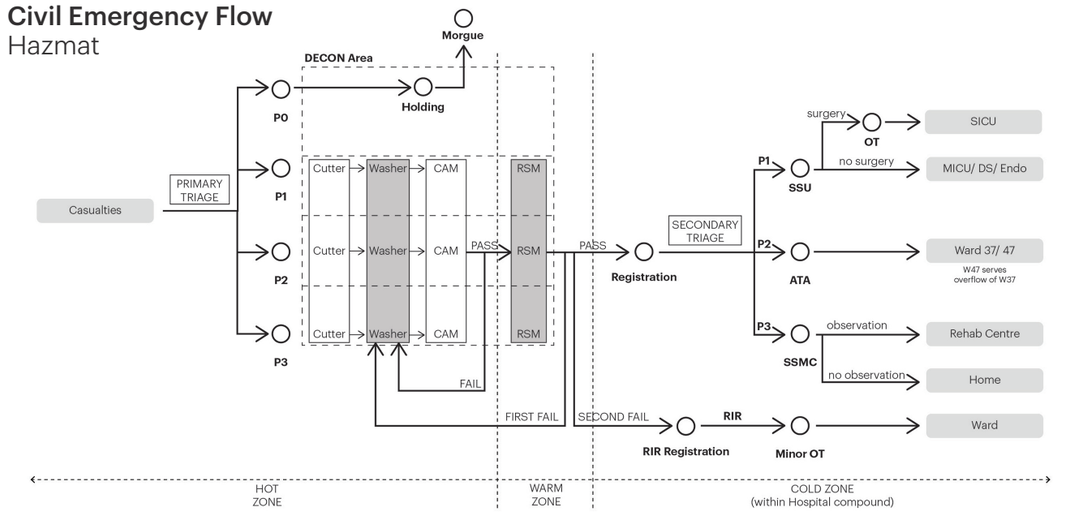
Pandemic Flow



Civil Emergency Flow
Trauma



Civil Emergency Flow
Hazmat



Feasibility Study for a Medical College

Cuttack, India

The Medical Campus is an integrated facility with Research, Academic and Clinical functions along with accommodation for the students, staff and doctors. This campus is envisioned to be redeveloped as the first Medical College in India which integrates pandemic and disaster preparedness right from the conceptualisation stage.

This is done in two major ways, apart from several other strategies:

1. Emergency Department planning:
The new emergency department is designed to ensure that to ensure higher footfalls can be accommodated during an outbreak. Thus adequate space is left in planning such that the department can expand. Dedicated access for Emergency Department from Ring Road ensures a convenient approach for emergency vehicles that do not need to wait for the regular traffic.

An emergency drop-off area can be converted into a temporary triage area and separate decontamination area is also created. The current emergency department can also be retrofitted till the new department is built using measures that align with the pandemic flows. This will also require proposing a mechanical system which has to be designed to allow for the compartmentalization and isolation of several zones.

2. Creation of a dedicated Isolation Tower
A new building prototype which is flexible and pandemic ready is introduced. During regular circumstances, the building can function as an academic building, wherein mock Operating theatres and ICUs can also be set up for students to understand real situations through simulations. Classrooms and other teaching spaces that can get converted into Inpatient bed rooms with isolation facilities during a pandemic will ensure the building can be used at all times. This will ensure that regular patients do not have to be moved and the conversion can be done seamlessly during an outbreak as academic use will not continue during such times. during an outbreak as academic use will not continue during such times.