HEALTHCARE / WHITE PAPER

Redefining Emergency Department and Hospital Surge Preparedness

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Refining Emergency Department and Hospital Surge Preparedness

Health experts anticipate that already-taxed healthcare systems may face a surge of both flu and COVID-19 patients simultaneously this fall / winter and recommend that facilities continue to make contingency plans.

The initial COVID-19 response found many systems implementing temporary facilities remotely from their main campus. Post-peak analysis has shown that the biggest detriment to the success of offsite locations is lack of supplies, equipment and staff[1].

Additionally, due to the varied bodily systems impacted by the virus, critically ill COVID-19 patients require up to three times the number of providers than other critically ill patients[1], putting further strain on the availability of providers to work offsite. This suggests that increasing capacity at hospital campuses should be prioritized to maximize the efficient use of equipment, supplies and provider talents.

One method of increasing that capacity prior to the arrival of flu season is to further refine and develop the hospital's surge capacity and disaster response plan.

Whether the event is a mass casualty or a viral pandemic, there are many universally applicable strategies for surge planning, which can be divided into a three-pronged approach:

SITE ANALYSIS
Determine access to and movement through the site and buildings; locate zones for external surge space.

SITE INFRASTRUCTURE
Verify necessary systems are able to support exterior surge functions.

BUILDING DESIGN
Design strategies for building flexibility, staff efficiency and safety for all occupants.

SITE ANALYSIS

Best practices research shows that during a surge event, patients and visitors should be segregated based on the reason for their visit as soon as possible.

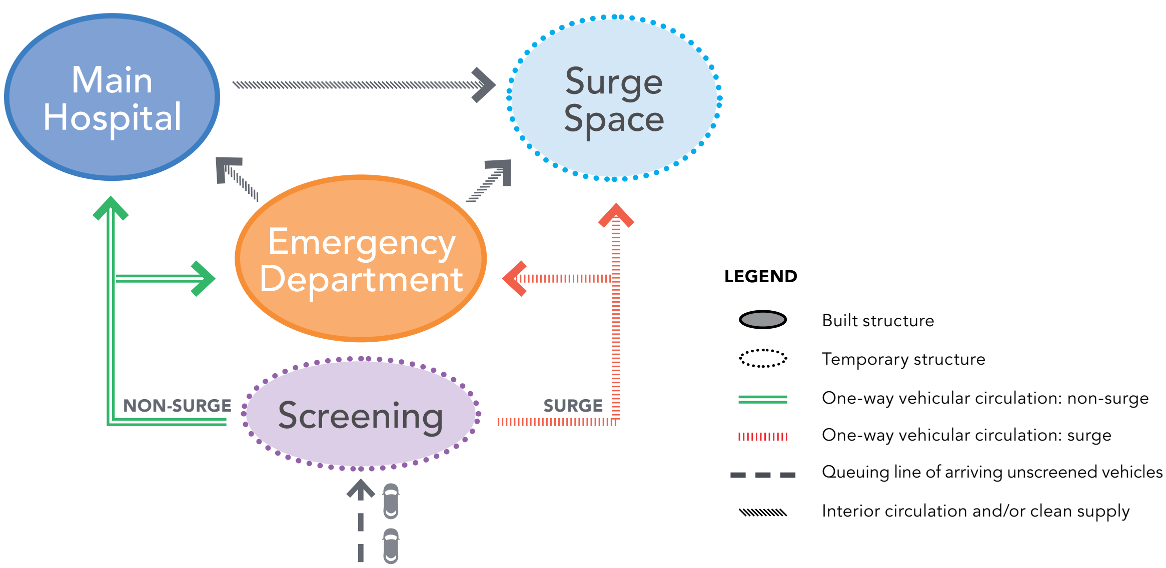
Experience during the current pandemic has shown tele-intake screening to be an effective tool in sorting and directing patients before arriving on campus to minimize surge. Therefore, detailed advanced planning for quick rollout of tele-intake should be included in surge planning so systems can be prepared, even during sudden events. Once a patient arrives on-site, it is critical to further separate based on need by going through a screening process prior to being granted access to the campus.

Vehicular Access:
Triage Patients Starting at the Campus Entrance

VEHICULAR ACCESS STRATEGIES

- **Campus entrances should be limited or manipulated** to provide clear wayfinding for the visitor.
- **Consider locations that allow for vehicular queuing** for intake questions or temperature scanning without blocking roads.
- **New, temporary entrances** may be required.
- **Redirect any cars** that do not require access before they enter the campus.
- **Parking and patient flows should be one-directional and segregated** by acuity and need with clearly marked signage to limit cross-contamination.

SITE PLAN DIAGRAM – VEHICULAR ACCESS



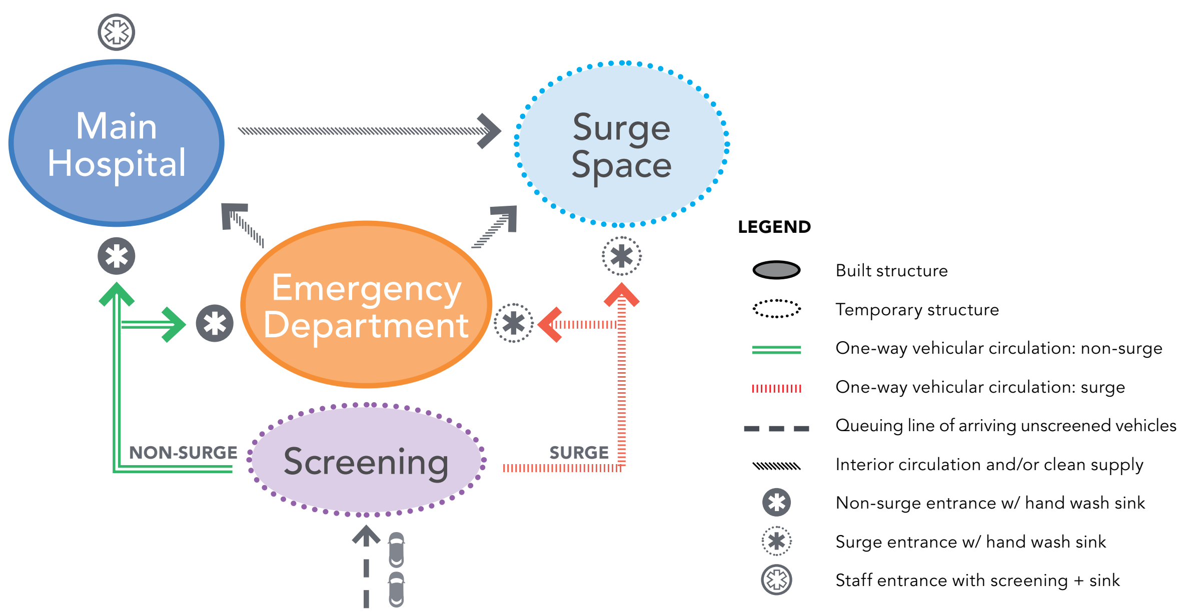
Using screening checkpoints to segregate traffic into surge and non-surge groupings as soon as visitors arrive on-site and then moving them through in a one-way direction towards a separate exit minimizes cross-traffic and cross-contamination. Internal traffic patterns should be separate from ambulance traffic to prevent blockages.

Building Access:
Control Entrances to Segregate Populations

BUILDING ACCESS STRATEGIES

- **Building entries should be flexible to segregate patient, staff and visitor flows,** or to be closed as required.
- **Minimize cross-traffic** between affected and non-affected populations.
- **Minimize travel distance** to destinations.
- **Allow space for additional screening** at the door with supportive infrastructure of power, water and IT.
- **Enhance entrance points with color-coded and clearly discernable signage** to increase compliance with the required flows.

SITE PLAN DIAGRAM – BUILDING ACCESS



Using screening checkpoints to segregate traffic into surge and non-surge groupings as soon as visitors arrive, and then moving them through in a one-way direction towards a separate exit, minimizes cross-traffic and cross-contamination. Internal traffic patterns should be separate from ambulance traffic to prevent blockages.

Exterior Staging:
Configuring the Site to House Temporary Structures

Exterior surge space adds resiliency to the plan by creating opportunities for highly adaptable interaction zones for minimal infrastructure cost.

Performing triage functions in outdoor temporary structures reduces the risk of internal hospital contamination and removes stress from ED reception/triage. Temporary structures can also be used be for testing, registration, decontamination or treatment overflow, depending on the needs of the event. The size and type of structure will depend on many factors, beginning with what size structure can be accommodated on the site identified by the site analysis, and the maximum level of patient acuity to be treated, based on the surge plan assessment.

SITE CONFIGURATION STRATEGIES

- **In choosing a site,** consider levelness, vehicular/public access defined by the site analysis, ambulance access, and distance from main facility for staff efficiency and support functions such as nutrition and supply delivery.
- **Prioritize proximity** so the site can serve as an extension of the ED. If such a site is not feasible, evaluate other access points into the hospital that minimize cross traffic with unaffected patients and staff when selecting an alternate location.
- **Plan exterior staging space for surge decontamination** adjacent to the ED with a reliable source of water supply and containment. Patients should be able to enter an emergency treatment area directly from decontamination. The location should not interfere with ambulance drop-off.

BUILDING CODE REQUIREMENTS

Circumstances around COVID-19 have prompted regulatory associations such as the National Fire Protection Association (NPFA) and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) to recognize some requirements may be impossible to meet in a temporary structure. Therefore, they have issued guidance to help local and state code officials evaluate a balance between life safety and patient care needs on a case-by-case basis [2,3,9].

The Facilities Guidelines Institute (FGI) has indicated that this is a category they will enhance in future guidelines [4]. Therefore, when refining the surge response plan, systems should involve local and state reviewing agencies in the formulation of strategies to receive buy-in and set expectations prior to implementation.

SITE INFRASTRUCTURE

The two most important utilities to access from an exterior site during a surge event are reliable sources of power and potable water for patient care equipment, lighting, hand washing, sterilization and waste removal.

During the initial COVID-19 response, many systems were challenged to quickly establish exterior staging and temporary on-site structure areas due to lack of infrastructure[1,7]. Examples include:

- **Lack of access to readily available generators of sufficient capacity.**
- **Lack of an exterior water source fitted with a backflow preventer to prevent contamination of the primary source.**

Therefore, it is critical to refine a surge plan to allow for rapid connection to these utilities. Because modern electrical service and water supplies are reliably stable — barring any disasters that affect local utility service — the timeliest method is to install dedicated connections at the identified exterior surge site.

These permanent connections can be installed on most existing sites with reasonable upfront cost, in a short time frame and with minimal disruption to the internal hospital functions, making them a very quick and effective method for bolstering a surge plan.

Infrastructure Requirements for Temporary Structures

ELECTRICAL CONSIDERATIONS

- **Determine the normal and emergency electrical loads** required by the surge response plan, based on planned temporary structure size and maximum patient acuity.
  - **Structure size** determines support functions such as the amount of lighting, mobile climate control units and mobile toilet units needed.
  - **Acuity** informs the quantity of normal and emergency outlets needed. Consult electrical and plumbing Engineers as needed to assist with load calculations.
- **Emergency power** for most critical loads can be provided by either building capacity into the main hospital generator system or arranging for a temporary generator for emergency stand-by power.
- **Electrical panels and disconnects** typically have a serviceable life of 30 years, making them relatively cost effective and a low-maintenance investment.

PLUMBING CONSIDERATIONS

- **Water lines** connecting to temporary facilities must be fitted with a backflow preventer to avoid contamination of the main source. Line size will be determined by the number of patients and mobile toilet facilities anticipated by the response plan.
- **Mobile toilet units** should be handicap accessible and inclusive of lighting, ventilation and fixtures. Most units utilize chemical waste receptors, so sewer connection is not required. Separate staff and patient toilets should be provided as common toilet areas can contribute to viral transmission. Plans should follow ASHRAE guidelines for hand washing in temporary structures [2].

MEDICAL GAS CONSIDERATIONS

- **The need for medical gases in a temporary structure** will vary depending on the maximum acuity determined by the response plan with options ranging from limited oxygen use to the need for medical air and vacuum.
- **The feasibility of providing dedicated connections** will be determined by the existing capacity within the main med gas system. Hospitals may consider standby equipment or tanks to add capacity.
- **Vacuum systems** should be isolated from the main source to prevent contamination.

Infrastructure Requirements for Temporary Structures

IT CONSIDERATIONS

Rapidly implemented telemedicine practices have proved to be a crucial component of managing surge and extending provider capacity. IT and communications can be supported by running conduit to the designated temporary structure location to provide cabled connections and Wi-Fi extension. Test signal strength at site and coordinate with the IT department.

HVAC CONSIDERATIONS

HVAC should be provided to all temporary structures for temperature and humidity control, and for maintaining pressure differentials when required.

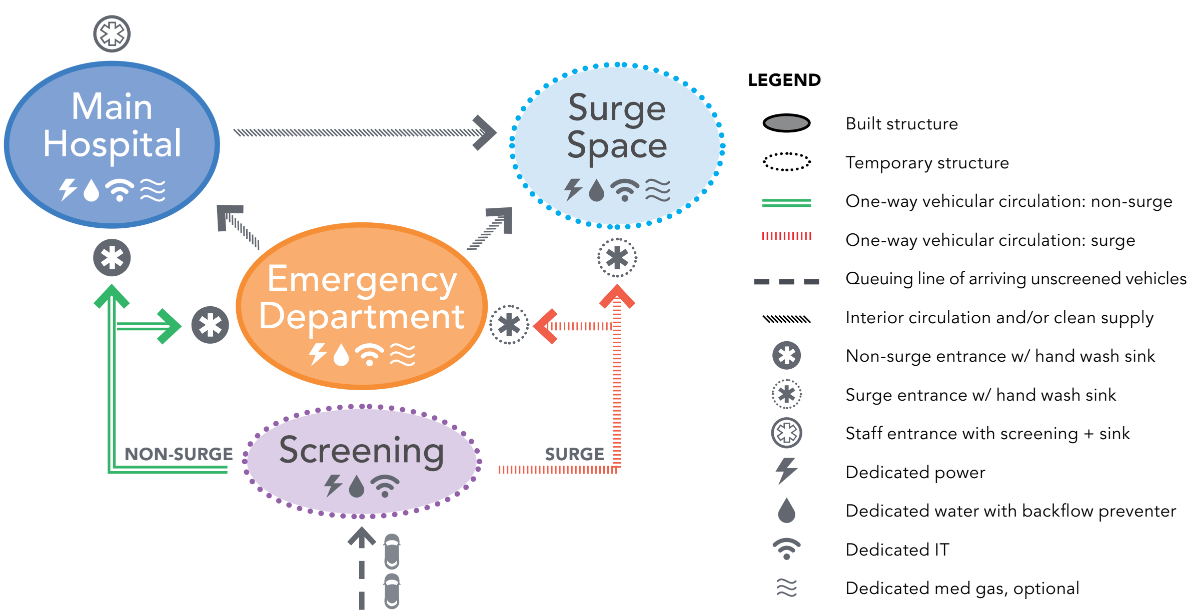
ASHRAE recommends that temporary facilities maintain space conditions between 70-75 degrees Fahrenheit and 40%-60% relative humidity for emergency surge patient spaces.

Strategies include fans, heaters, natural ventilation, rental air handlers or prefabricated structures with HVAC included.

During airborne infection events, structures should maintain negative pressure.

It is not recommended that permanent air handler units be installed for use in possible surge events as they may not function properly without routine maintenance and operation, making their installation an unwise investment.

SITE PLAN DIAGRAM – INFRASTRUCTURE LOCATIONS



Adding dedicated connections for critical infrastructure at designated exterior surge locations and entrance screening zones allows for rapid deployment of temporary structures and surge protocols.

Location-Specific Considerations for Temporary Structures

After identifying exterior surge locations based on the site analysis, install infrastructure based on proximity of the site to the main building.

DESIGNATED SITE CLOSE TO HOSPITAL

Electrical

Install a connection point with a power disconnect on the exterior of the building closest to the site. Depending on available electrical capacity existing within the hospital, this may require the addition of a separate panel. Expect to work with an electrical engineer to evaluate the available capacity of the system and prepare drawings as necessary for code approval.

Plumbing

Install the water line with backflow preventer at the exterior of the building closest to the site. Expect to work with a plumbing engineer to prepare drawings and calculations as necessary for code approval.

Medical Gas

Install a connection point at the exterior of the building closest to the site. Expect to work with a plumbing engineer to prepare drawings and calculations as necessary for code approval. Vacuum systems must be isolated.

IT

Install data access points and Wi-Fi extenders at the exterior of the building closest to the site. Coordinate with IT and low-voltage provider.

DESIGNATED SITE AWAY FROM HOSPITAL

Electrical

Install a remote connection point with a power disconnect and panel feeding directly from the nearest utility-owned transformer. Expect to coordinate with the utility provider, who may require engineering drawings to provide details such as location of panels and load requirement calculations.

Plumbing

Install a remote connection point with backflow preventer feeding directly from the utility-owned water main. Expect to coordinate with the utility provider, who may require plumbing and civil engineering drawings to provide details such as location of connectors and capacity requirement calculations.

Medical Gas

Providing remote connection may not be feasible unless the site is near the main medical gas farm. Expect to work with a plumbing engineer to prepare drawings and calculations as necessary for code approval. Vacuum systems must be isolated.

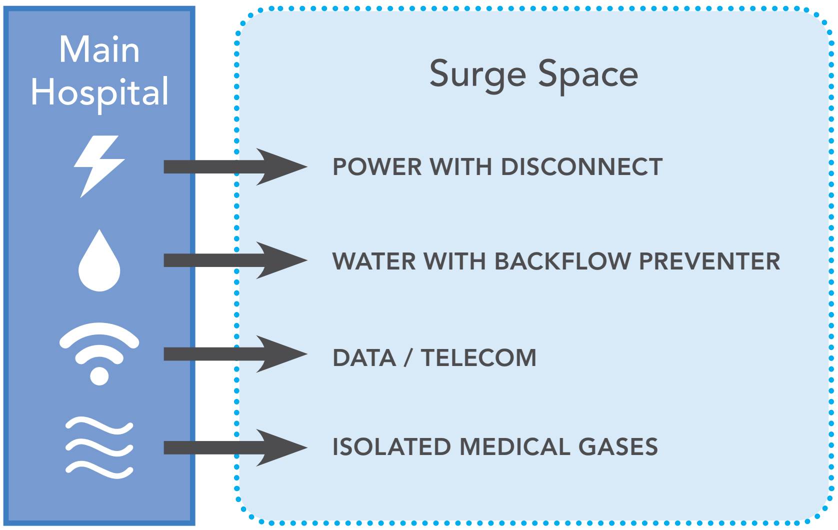
IT

Install a conduit for data runs to the remote site. Coordinate with IT to determine the source origination point.

Location-Specific Considerations
for Temporary Structures

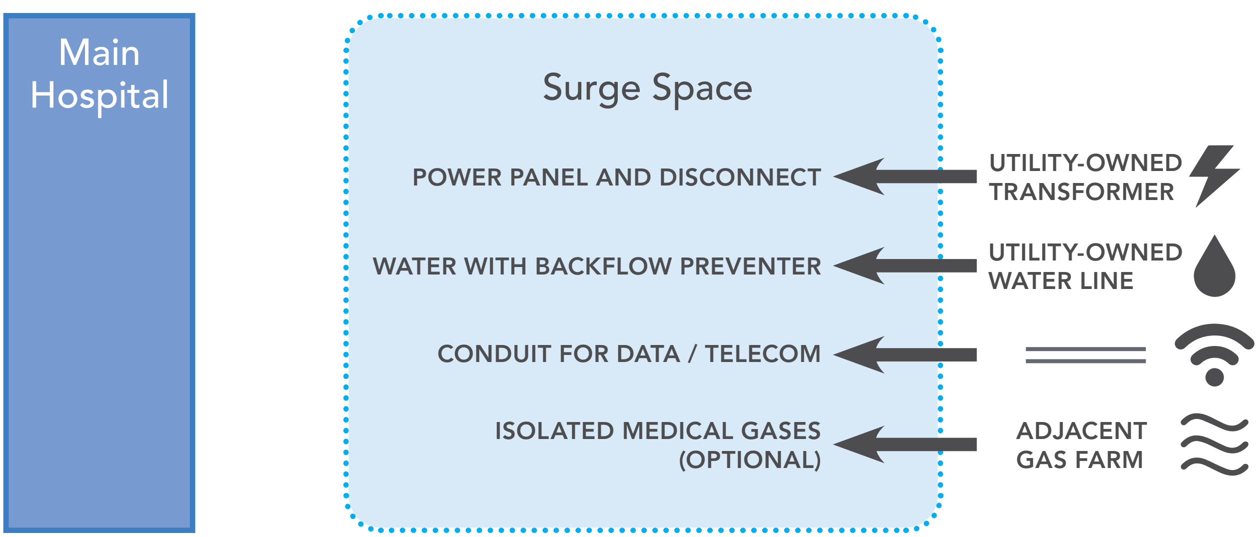
DESIGNATED SITE CLOSE TO THE HOSPITAL

If the designated site is adjacent to the main hospital building, connections can be installed as an extension of building services.



DESIGNATED SITE AWAY FROM THE HOSPITAL

If the designated site is on campus, but removed from the main hospital building, connections can be pulled directly from utility-owned service points. Connections for medical gases can be made directly from the farm if in close proximity, and conduit can be used to extend IT service.



BUILDING DESIGN

Considerations for Emergency Department Renovations or New Construction

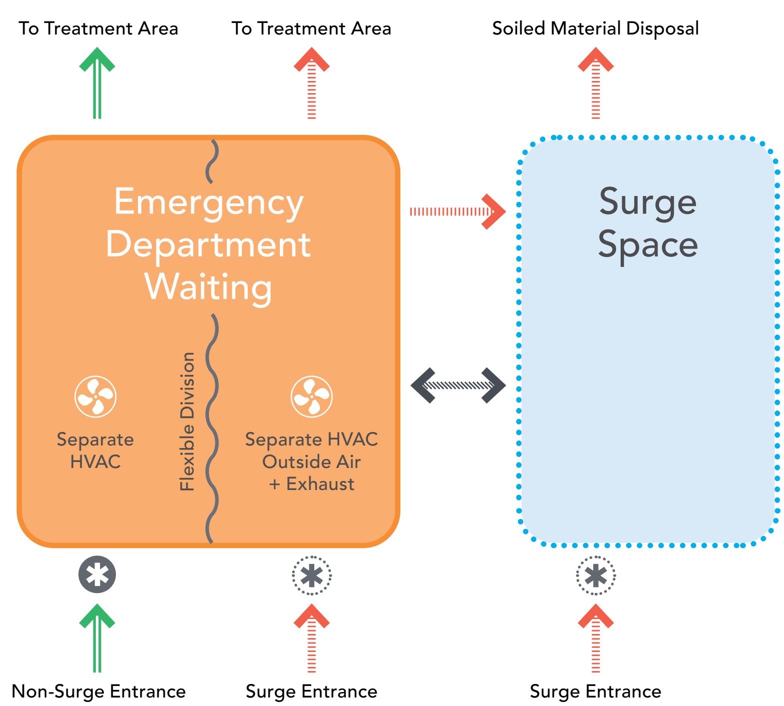
There are several recommended strategies for the interior of ED and hospital spaces to support surge planning. Based on their current facility configurations, hospitals should evaluate these suggested best practices to determine which can be feasibly planned and implemented ahead of the coming flu season and which should be included in future renovation/new construction planning.

Facility and Patient Care Planning

DESIGN STRATEGIES

- **Design entrances and waiting rooms with flexibility** to be divisible by acuity during surge events.
  - Rooms should be flexible to account for separate entrances from the exterior and from the waiting area to the respective treatment areas, always maintaining separation by acuity.
  - Separate HVAC systems should be planned for each zone of the waiting area, with exhaust and increased outside air available on the surge side.

SPACE DIAGRAM: EMERGENCY DEPARTMENT WAITING ROOM



Waiting rooms with that are divisible by acuity with flexible HVAC systems and entrances allow for adaptability during surge events.

Facility and Patient Care Planning

DESIGN STRATEGIES

- **Locate security and/or greet desk** to provide direct observation of patient and family entry to facility to provide additional screening and distribution of Personal Protective Equipment (PPE,) as required.
- **Locate Triage** as close as possible to entry points with expansion capabilities and room to space patients 6 feet apart, minimum.
- **Provide dedicated circulation paths** for visitors, patients, medical staff and materials.
- **Design toilet rooms with out-swinging doors** to minimize direct contact with handles after hand-washing. If not feasible, install paper towel dispensers with trash receptacles within reach of the door handles. Foot operators for non-latching doors are also available.
- **Provide additional hand wash stations** throughout public spaces with touchless soap and paper towel dispensers. Touchless faucets are not recommended as studies have shown less compliance with proper hand washing duration and water temperature when using touchless versus standard faucets.

Example of hand-wash sink at entrance to unit

Hand-washing stations at entrances create flexibility for adding screening functions. Highly visible stations also increase compliance with handwashing requirements and present opportunities for public education on proper techniques.

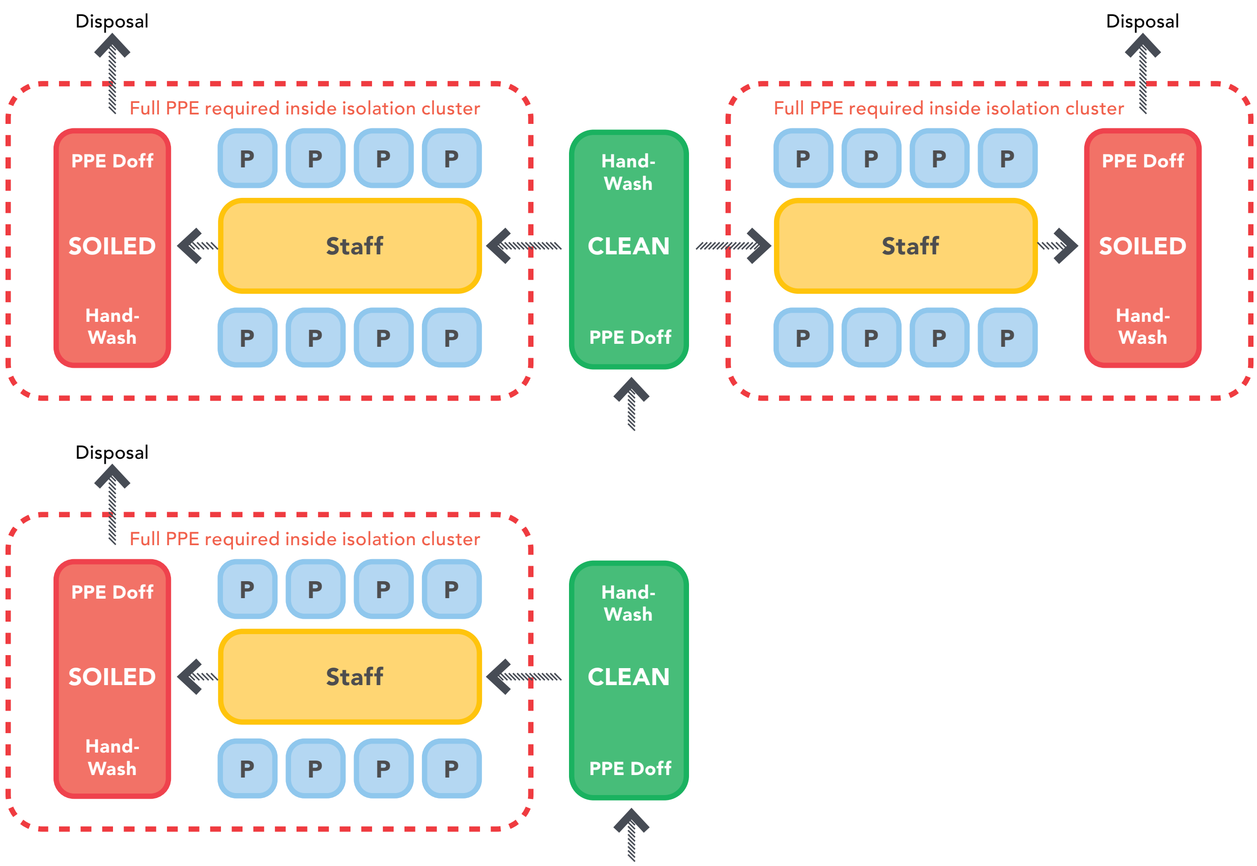
Facility and Patient Care Planning

DESIGN STRATEGIES

- **Design treatment clusters** with the ability to separate by acuity/illness and maintain flexible, separate HVAC/airflow control.
- **Plan one-way circulation** into and out of treatment clusters with a hand-wash station and PPE donning area at a dedicated entrance. Plan a hand-wash station and contaminated PPE disposal area at a designated exit.
- **Design dedicated isolation units** with segregated air-handling units.

FLEXIBLE TREATMENT CLUSTERS / ISOLATION UNIT DIAGRAMS

Identify clusters of rooms that can be sectioned off during a surge event, and provide infrastructure at separate entrances and exits for one-way circulation of soiled materials. Clusters can be grouped in series to allow for flexible staging by acuity.



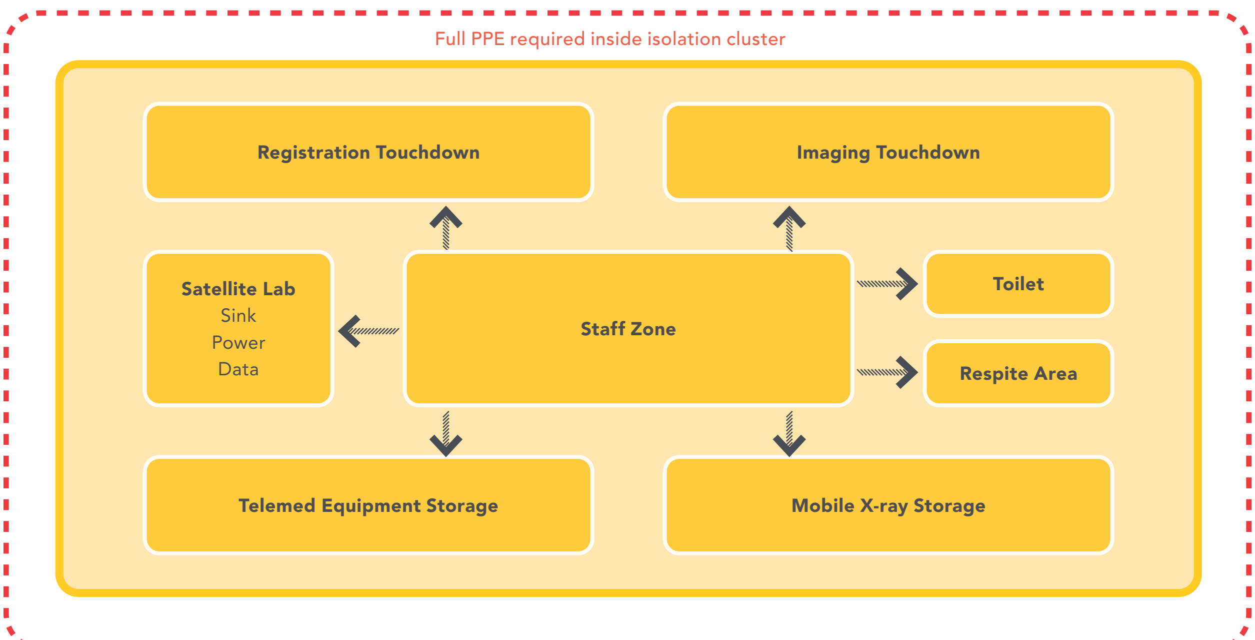
Facility and Patient Care Planning

DESIGN STRATEGIES

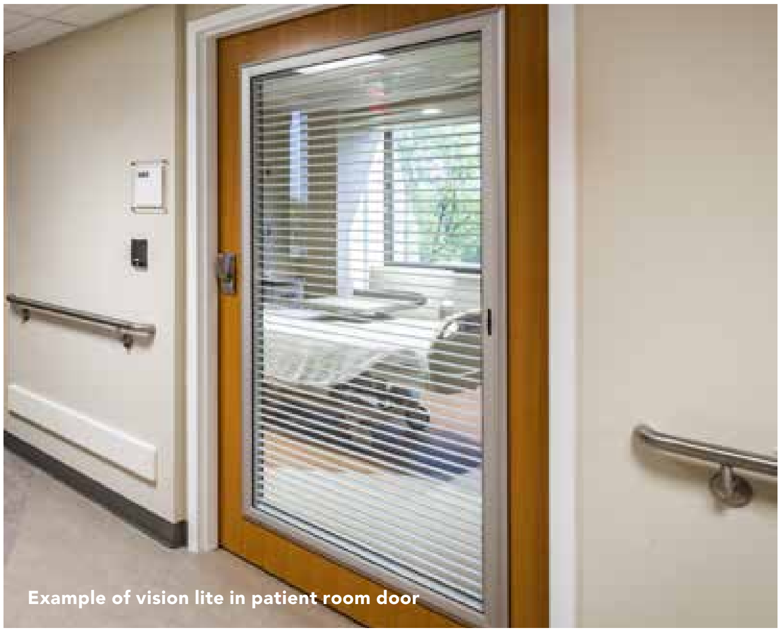
- **Provide infrastructure** for satellite labs, registration, mobile X-ray and other patient support functions within the flex pods/isolation unit to minimize staff cross-traffic and conserve PPE.
- **Provide a dedicated staff toilet** within the isolation unit or cluster to prevent unnecessary PPE changes and staff cross traffic between units.
- **Provide a staff respite space** within the isolation unit or cluster to allow staff opportunities for mental reprieve without crossing the containment barrier or traveling far from patients. Consider adjustable lighting, adjustable white noise and a soothing paint scheme.
- **Provide additional storage** for PPE, gas cylinders and equipment.

ENLARGEMENT PLAN OF STAFF ZONE

The provision of support spaces within the isolation area is critical to minimizing passage in and out of the zone. This allows for more efficient use of PPE and reduces cross-contamination.



Facility and Patient Care Planning


Example of vision lite in patient room door

DESIGN STRATEGIES

- **Minimize required staff/patient contact** by providing glass patient room doors or windows along the corridor wall to provide observation of patient and equipment without entering the room and by adding a vision lite to existing solid doors.
- **Provide controls** for IV pumps and equipment accessible from the corridors.
- **Place patient rooms with visibility** from the clinical work station, including isolation rooms.
- **Consider physical separation** at nurse station, security, greet desk and reception desks, larger than a sneeze guard.


Example of glass separation panel at nurse station

Finishes and Signage

DESIGN STRATEGIES

- **All materials installed should be easily cleanable** with minimized crevices and ledges.
- **Place televisions and touchscreen devices** behind a clear washable panel or inside the wall (if provided).
- **Design spaces to be touchless** where possible, including lights, screens and plumbing fixtures. However, touchless faucets are not recommended as studies have shown less compliance with proper hand washing duration and water temperature when using touchless versus standard faucets.
- **Consider the use of biocidal materials,** such as copper, in the most frequently touched places. Though more expensive than materials like stainless steel or composite solid surface, copper has been shown to disrupt and kill viruses such as COVID-19 in as few as four hours, compared to 72-96 hours for other hard surfaces [5]. Products range from sinks and faucets to bed rail covers and handrails.
- **Consider the use of UV lighting systems** to sterilize spaces. Mobile systems have been developed from a variety of manufacturers that can sterilize a space within a 15 to 30-minute time frame. While the process is comparatively fast and effective, there have been reports of faster degradation of finish materials. Studies have shown that using a UV reflective paint can increase the effectiveness of light distribution.
- **Develop a standard signage package** for use during a surge event identifying zones such as Clean, Soiled, Isolation, Restricted, Staff Work, Equipment Storage, and PPE Storage. Using universal signage throughout the facility and training staff in advance reduces stress and confusion and increases infection prevention compliance as spaces flex from normal conditions in response to the event. Signage should be color coded and printed on material that is durable and scrubable and attached without exposed adhesives.

HVAC

DESIGN STRATEGIES

- **Provide in-line filtration** with a minimum Merv 7 pre-filter + HEPA filter, ensuring proper filter fit and installation. Return air should be HEPA filtered.

- **Maintain humidity levels** between 40%-80% relative humidity, with a target range of 40%-60%.

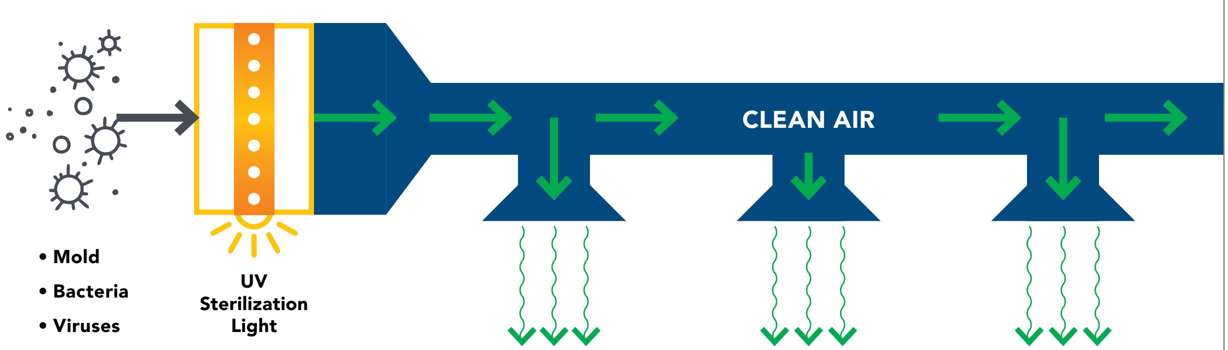
- **Design pressure flexibility in rooms with attached toilets** by sizing toilet exhaust fans with increased capacity. When combined with HEPA filtration through fixed or mobile units and units with increasable outside air to offset pressure differentials, rooms can be converted to negative pressure at comparatively low upfront investment. Evaluate pressure influence on entire floor during design.

- **Consider UV in-line duct sterilization.** Evidence shows reliable sterilization performace, but anecdotal feedback from users indicates some maintenance challenges.

- **Ventilated headboards** have been developed that are easy to erect at the patient head, in lieu of changing room pressure, and have been shown to remove 99% of infectious-sized particles [5].

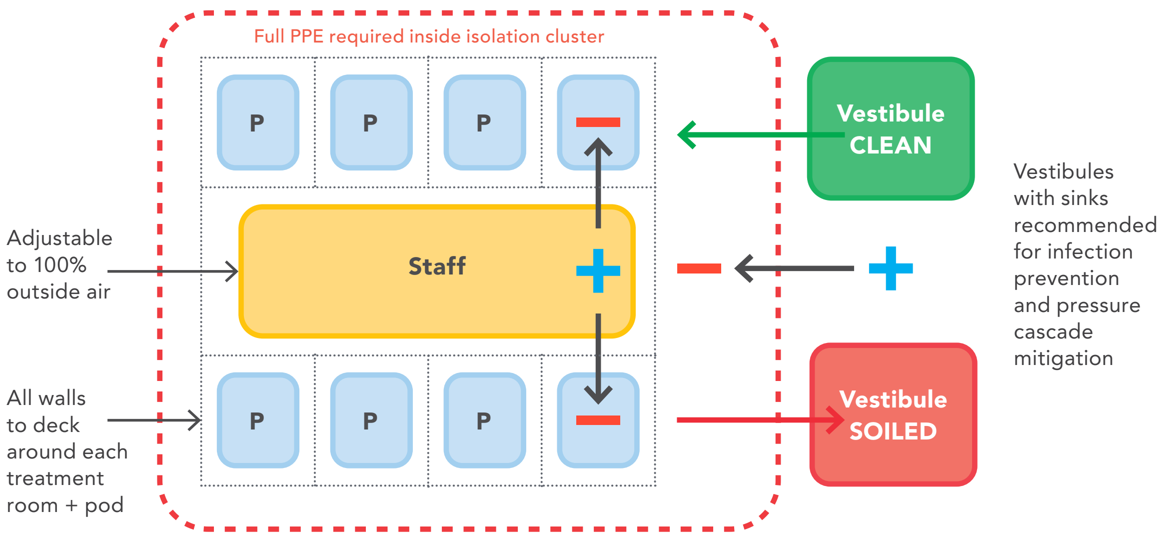
IN-LINE UV LIGHT STERILIZATION

In-line UV light kills airborne mold, bacteria, and viruses that enter the duct system, sterilizing the air as it moves forward for distribution.



HVAC

FLOOR PLAN DIAGRAM OF PRESSURE-ADAPTABLE ROOMS AND ROOM CLUSTERS



Pressure adaptable room configurations provide opportunities for rapid on-demand flexibility during surge events.

Design pressure-adaptable rooms, clusters of room or wings/pods with the following:

- **System supplying the area** must be designed to go to 100% outside air.
- **Walls to deck** at the perimeter of each room. Also walls to deck around the cluster if planning for a segregated grouping of rooms.
- **To minimize pressure cascade,** vestibules are recommended at the entrance to each room and/or cluster, if planning for a segregated grouping of rooms.
- **Individual exhaust vertically discharged from each room,** or exhaust from each room ganged to a high velocity exhaust with vertical discharge if an entire cluster is to operate at the same negative setting simultaneously.

Conclusion + Next Steps

Hospital systems can better position themselves for maximum effective preparedness ahead of the coming flu season, as well as future surge-generating events, by taking steps to refine plans through the application of lessons learned from the initial COVID-19 response with respect to site planning, site infrastructure and building planning.

Having a well-vetted surge capacity and disaster response plan is critical to system operational success and community health during any large-scale emergency.

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