MAZZETTI

Lead Author: Jim Crabb, PE, Principal

Updated September 25, 2020

GUIDANCE FOR MANAGEMENT OF COVID-19 IN HEALTHCARE FACILITIES

WWW.MAZZETTI.COM

GUIDANCE FOR MANAGEMENT OF COVID-19 IN HEALTHCARE FACILITIES

GENERAL NOTE:

For the purposes of this guidance, we are using a variation of the Strength of Recommendation Taxonomy (SORT) used by the Infectious Diseases Society of America. That is, in the world of the response to this lightning fast pandemic, a one-size-fits-all solution is not always feasible nor suitable. The solutions must be appropriate to the context (hospital, convention center conversion, or tent) and the resources (time, staff, equipment) available. Thus, we have tried to tier the recommendations in a “must do” (1), or “better to do” (2) kind of taxonomy, roughly equivalent to that of IDSA, and based on the research that has been available to us (which we will freely cite). Then, we “temper” the recommendations based upon feasibility (the proposed Mazzetti Feasibility Taxonomy). This Guidance Document is intended to be a “living” document. We readily aspire to its continuous improvement as more and better data becomes available. Also, please note, this document does not purport to comply with any regulations of any particular AHJ. So many entities are trying to construct temporary facilities, and in many cases, AHJs are allowing them to use the best possible information available to them. We hope that this document can provide such guidance, but, in all cases, it is necessary to consult with relevant AHJs to ensure avoidance of legal issues.

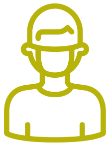
THE IDSA TAXONOMY IS AS FOLLOWS:

Category Grade	IDSA Description
A	Good evidence to support a recommendation for use
B	Moderate evidence to support a recommendation for use
C	Poor evidence to support a recommendation for use
D	Moderate evidence to support a recommendation against use
E	Good evidence to support a recommendation against use

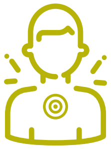
THE MAZZETTI FEASIBILITY TAXONOMY IS AS FOLLOWS:

Category Grade	
1	Must do; strongly recommend regardless of feasibility
2	Good to do; exert reasonable efforts to deploy

TERMS:



PUI - Patients Under Investigation



CIP - Confirmed Infected Patients

CURRENT INFORMATION REGARDING SARS-COV-2 (COVID-19) TRANSMISSION

The science of airborne transmission of respiratory illnesses has evolved since the initial guidance about COVID-19 transmission. The old ideas of a hard line between droplet and aerosol transmission have blurred considerably. Most authoritative sources are now recognizing that many respiratory droplets desiccate and form aerosols.

Dr. Anthony Fauci (NIH) in a webcast on September 10,

“…bottom line is, there’s much more aerosol than we thought.”

That does *not* mean that this virus transmits in the air over long distances. In fact, as of this update, no publicly documented cases of transmission through HVAC systems exist.

According to Dr. Fauci’s presentation, modes of transmission are thought to be:

- Between people in close contact
- Via particles that remain in the air over time & distance
- Infected surfaces
- Stool, blood, semen, ocular secretions; unknown transmission role
- Animals (domesticated included) not a major source of transmission

Transmission requires an infectious dose be delivered to a susceptible person. **Infectious dose has not yet been determined**; it varies with many factors, including the health status of the exposed person.

Dose is a function of aerosol concentration in the inhaled air and time of exposure. **Concentration** can be affected by distance from the source, control of source emission (mask or exhaust capture device), ventilation, and personal protective equipment (mask or respirator). In many situations, **PPE is the single most effective method**.

GUIDANCE FOR TEMPORARY FACILITIES

Refer to the following resources for deployment of temporary facilities to support the COVID-19 response:

- WHO Guide to Treatment Facilities.
- HKS Hotel to Hospital.
- Mass Design Guide to Tent Facilities.

ZONES OF TRANSMISSION

THREE different zones of aerosol transmission--each zone requires different protective measures.

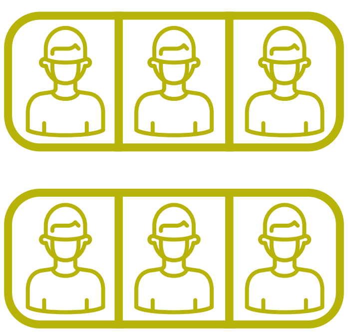
PLUME:
Transmission can occur from both large droplets and aerosols. Movement of these droplets and aerosols is primarily influenced by the momentum from the coughing, sneezing, singing, talking, or even breathing of the infected person. Ventilation is not effective because air currents have little influence. Local exhaust, such as an exhausted headwall or an exhausted enclosure around the patient, can reduce the dispersion of infectious aerosols into the room, but cannot protect the healthcare worker (HCW). In this zone, only PPE can protect the healthcare worker.

ROOM:
Transmission is more likely to be dominated by aerosols, though some droplets may travel directly from an infected person to a susceptible person.

Room ventilation counteracts the generation of infectious aerosols by the patient, leading to a dilute concentration in the air. Compared to the plume, room air at 4 air changes per hour may offer 300:1 dilution.

Proper room airflow design may reduce room concentration even further by directing contaminants toward the return/exhaust, rather than complete mixing in the room. CFD modeling may be helpful in designing airflow patterns.

Despite a relatively lower concentration, room air is still not safe for unprotected exposure; PPE must be worn.



SYSTEM:
In the system, air from rooms with infected patients, already diluted some, is further diluted by air returning from areas without infected persons. This dilution offers further protection. Dilution ratio may be 10:000:1 or greater.

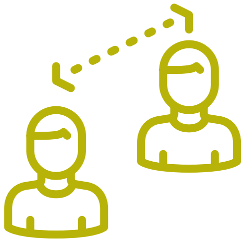
Deposition of viral particles and the natural decay of virus further reduces the concentration in the mixed air at the system level. Filters in the air handling unit further reduce concentration of viral particles. MERV 14 filters are estimated to be 85-90% effective against aerosolized virus particles. HEPA filters are even better, with a 4-log reduction in virus particles.

At the system level, risk of infection is significantly reduced, but remains non-zero. Although transmission at the system-level has not been documented, it is theoretically possible, particularly with lower filtration efficiency and for longer exposure times.

GUIDANCE FOR MANAGEMENT OF COVID-19 IN HEALTHCARE FACILITIES

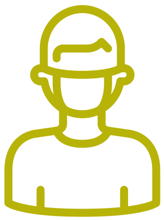
GUIDANCE FOR HOSPITALS

TO THE EXTENT POSSIBLE, have persons under investigation (PUIs) and Confirmed Infected Patients (CIPs) without respiratory distress remain at home. (A,1) If possible, provide remote monitoring for these patients. (A,2)



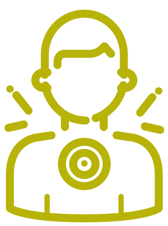
MEDICAL PLANNING CONSIDERATIONS

- Separate entrances and traffic for non-infected patients, CIPs, and PUIs when possible. (A,2)
- Ensure adequate space for donning and doffing of PPE for staff. (A,1).
- Ensure adequate space for transport and disposal of virus-contaminated waste streams. If possible segregate waste transport spaces to avoid proximity to uninfected patients and staff.



PERSONS UNDER INVESTIGATION (PUIs):

- PUIs should be kept in single-person rooms to prevent converting non-infected patients. (A,2)
- Where there are insufficient rooms to house PUIs, they may be cohorted in a nursing unit, away from non-infected or infected patients. (A,1)
- Because they may be infectious, PUIs should be kept in rooms with the door closed. (A,1)
- Room should be either neutral (A,1) or negative pressure (B,2). Negative pressure is preferred, as it may reduce the risk of room-to-room transmission.
- Rooms for PUIs should have dedicated toilet rooms (A,1). If possible, toilets should have lids to minimize aerosolization during flushing. (C,2).
- Ensure easy access to handwashing/sterilization at entry. (A,1)



CONFIRMED INFECTED PATIENTS (CIPs):

- Confirmed patients should be kept in single-person rooms with the door closed, while such rooms are available. (A,2)
- Where there are insufficient single-person rooms to house confirmed patients, these patients may be cohorted, with closed doors. (A,1)
- Room should be either neutral (A,1) or negative pressure (B,2). Negative pressure is preferred, as it may reduce the risk of room-to-room transmission.
- Rooms for confirmed patients should have dedicated toilet rooms (A,1). If possible, toilets should have lids to minimize aerosolization during flushing. (C,2).
- Ensure easy access to handwashing/sterilization at entry. (A,1)

WHEN SURGE CAPACITY IS NEEDED:

- Reserve single-person rooms for PUIs. (A,1)
- Consider placing confirmed patients in a ward style unit, consisting of an open space converted for patient care, such as a PACU or pre/post area with patient stations, or other appropriate support area. (A,1)
- The ward should be separated from other areas by closed doors. (A,1)
- The ward should be maintained at a negative (B,2) airflow relative to adjacent spaces. There is no requirement for specific pressure to be maintained, but air should flow into the ward from adjacent areas. (B,2)
- Air from the ward may contain higher concentration of viral particles than individual patient rooms, so consider exhaust or recirculation through HEPA filters. (A,2)
- Where plumbing must be added to support the surge beds, consider the use of vacuum waste system for plumbing. These systems avoid floor penetrations and reduce aerosolization during flushing. (A,1)

INTENSIVE CARE UNITS (ICUS):

- COVID-19 patients should not be housed in ICU rooms that are positive-pressure. (A,1)
- Where feasible, convert ICU rooms to negative airflow. (B,2) Verify that air flows into the room from adjacent areas.
- Because patients in ICU often undergo aerosol-generating procedures, negative pressure of 0.01 in.w.c. is preferred, while directional airflow is the more important messure. (B,2) Because of the sliding doors often used for ICU rooms, maintaining a specific pressure differential may not be feasible, without the addition of seals and sweeps.

AEROSOL-GENERATING PROCEDURES (AGPS):

- Reserve Airborne Infection Isolation Rooms (AIIRs) for aerosol-generating procedures. (A,1)
- Per CDC guidelines, AGPs should be conducted in an AIIR or, if additional capacity is needed, a room converted to negative pressure. (A,1)
- A portable HEPA filter unit can create a temporary AIIR by increasing air change rate and negative pressure by ducting discharge outside the room. (A,2)
- Consider, after AGP, to sanitize with portable UV room sanitizer in addition to current practices. (A,2)

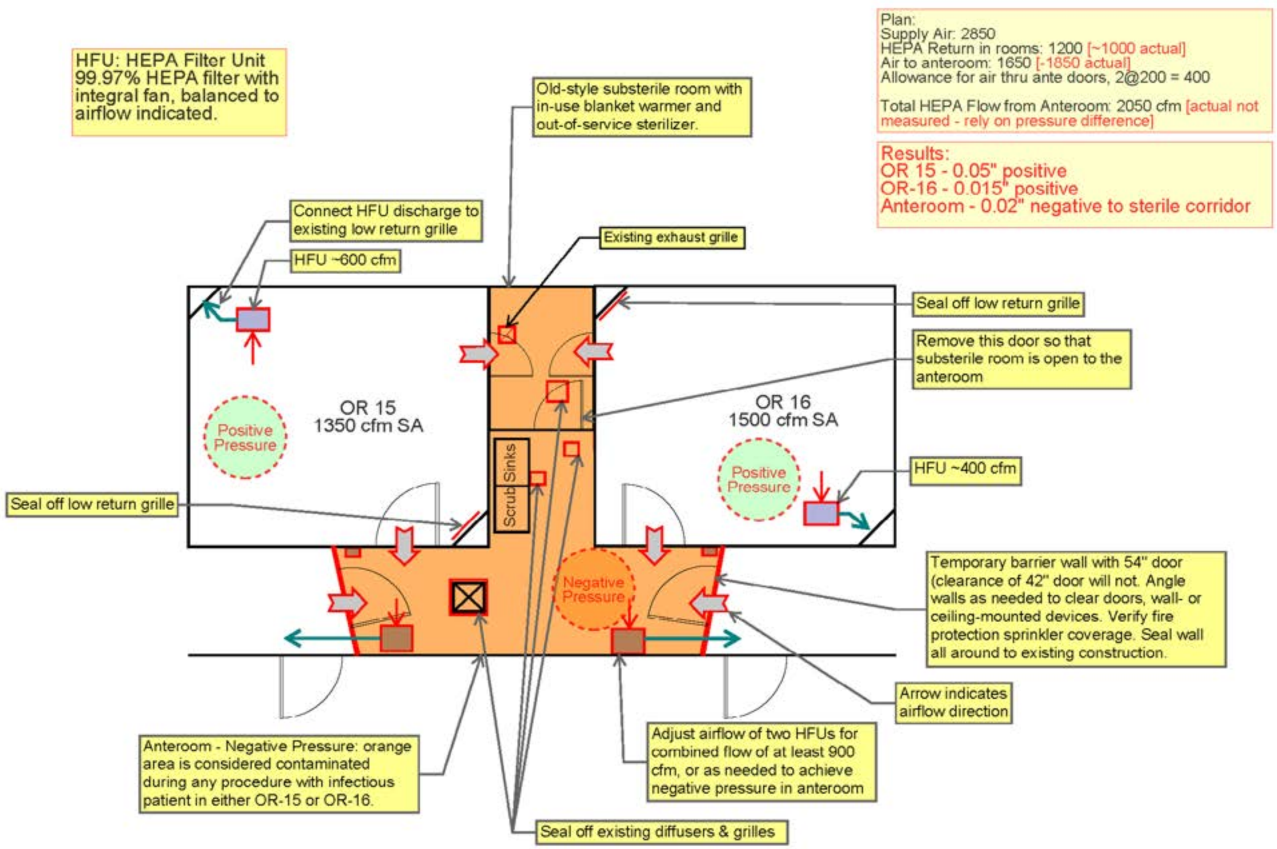
NOTE: This early guidance from the CDC may not actually be practical, as patients with moderate to severe COVID-19 may progress through various stages of clinical management, requiring frequent AGPs. It is not practical to move patients in and out of AIIRs to conduct AGPs. Patients that are in non-AII rooms will receive treatment that sometimes involves aerosol generation while remaining in those rooms. These patients should be placed in rooms that meet as many of the requirements for AII rooms as feasible.

OPERATING ROOMS (ORS):

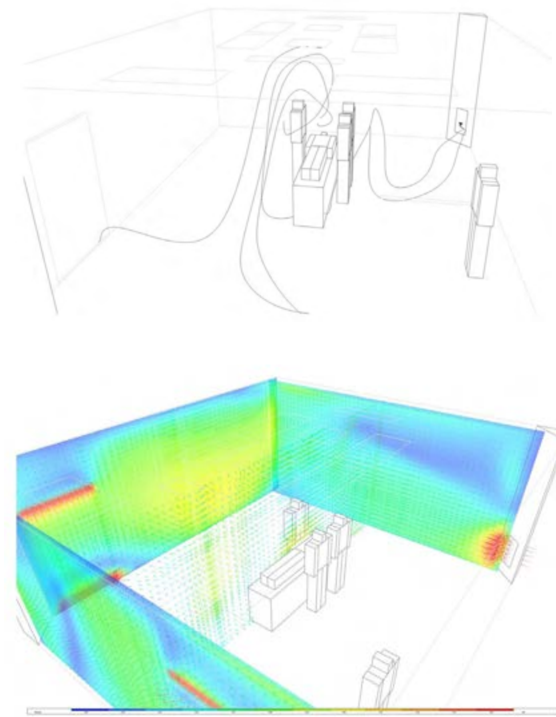
- At least one operating room should be dedicated for infectious patients. (B,2)
- Operating rooms for infectious patients should remain under positive pressure, which is intended to protect the patient from environmental infection. (B,2)
- Where infectious patient operating room HVAC systems recirculate room air through an air handling unit, the facility may elect to either run in 100% outside air mode or a portable HEPA fan-filter unit may be installed and connected to one or more return air grilles inside the operating room. (B,2)
    - » Where a HEPA filter unit is used, remaining return air openings should be sealed so that only filtered air passes into the return ductwork.
- Create an anteroom outside the infectious patient operating room door, using temporary partitions, such as used for infection control barriers during construction projects. (B,2)

- » Use portable HEPA filters, located inside the anteroom and discharging into the corridor, to create a negative pressure zone. The specific pressure is not important, but air should flow into the anteroom from both the operating room and the corridor when a door is opened.
- » Maintain code-required life safety exit from the surgery suite. Avoid creating a dead-end corridor condition.
- » Ensure that at least one door is wide enough to pass a patient bed, to reduce the number of patient transfers and the resulting staff and PPE required.
- » Place additional exit signage as needed.
- » Block off supply and return grilles located within the anteroom.

- In this arrangement, PPE may be donned outside the suite, in the sterile core, but should be doffed after the procedure inside the OR, near the portable HEPA unit.



Temporary Modifications to prepare Operating Rooms for airborne infectious isolation



Mazzetti created a CFD model of the modified operating room to verify that airflow patterns in the sterile field were not interrupted by blocking one return air grille. Particle traces confirmed that the field is not interrupted.

HOW TO IMPLEMENT NEGATIVE PRESSURE:

- Negative pressure does **NOT** make the room safer for the people inside the room. PPE is the primary protection for persons inside a room with an infected patient. (A,1)
- Negative pressure can reduce the risk of airborne particles leaving the room. Evidence is inconclusive whether or not airborne particles leaving a room present a significant risk for transmission of this virus. Effective dilution within a space can also reduce this risk. (B,2)
- Except where required for AIIRs, there is no requirement for a specific pressure differential. The goal is for air to flow from the "cleaner" area into the "less-clean" area. This can be assessed with simple measures, such as smoke tube testing or a portable differential pressure meter. Continuous pressure monitoring is not necessary. (B,2)
- Negative pressure is achieved when the return or exhaust airflow in a room is greater than the supply airflow in the room. Increase exhaust air or decrease supply air to create the negative air balance. (B,2)
- Portable HEPA filter units can be used to create a negative pressure. Place the HEPA unit inside the proposed negative space and duct the fan discharge outside the room – to an exhaust system, a return air system, or into an adjacent space. Take care not to disrupt the air balance of adjacent spaces when connecting to duct systems. (B,2)

AIR SYSTEMS AND FILTRATION

- Current code requires that AIIRs are exhausted directly to the outdoors with exhaust systems that serve no other purpose. (A,1)
- In patient rooms served by recirculating central systems, dilution of airborne particles through mixing with air from other areas, mixing with outside air, and filtration at the AHU with standard MERV-14 filters, reduces the risk of transmission via the HVAC system. (A,1) As the number of infectious patients increases, the dilution ratio diminishes, which potentially increases risk of transmission. Installation of HEPA filters in the air handling unit may be a prudent precaution. (B,2)
- Conversion of central systems to exhaust may be feasible through the use of controls to place AHUs in 100% outside air operation. This mode of operation may not be sustainable through the summer or winter, due to increased cooling and heating loads that the equipment may not be able to manage. The route of exhaust discharge from the air handling unit should be reviewed for proximity to air intakes, operable windows, pathways for people, or even discharge into mechanical rooms. (B,2)
- Patient rooms served by recirculating room units may have ducted outside air and exhaust systems. While the air change rate of outside/exhaust air is low, these room HVAC systems are largely isolated from other spaces. Consider increasing exhaust air flow to create additional dilution and negative pressure. (B,2)
- For the purpose of stopping the virus, HEPA filters rated 99.97% or better can be considered effectively absolute filters. If properly installed in a sealed frame system, HEPA-filtered air is safe to return to occupied space. (B,2)
- The use of ultraviolet germicidal irradiation (UVGI) is effective at irradiating viruses; however, most installations in air handlers are not configured for irradiating viruses in the airstream. Rather, UVGI is mainly used for eliminating microbial growth at the cooling coil. This is because it takes a longer exposure time to irradiate considering the the airstream is running at about 500 feet per minute. Consider in room HEPAs with the UVGI option as an additional means not only to capture but to irradiate.
- Other filtration means such as PCO provide enhanced ability to irradiate and reduce the spread of the virus; however similar to UVGI, if airborne, exposure time is needed.

RELATIVE HUMIDITY

- Some studies suggest that maintaining relative humidity above 40% may help slow the spread of the virus. (C,2)

MEDICAL GAS SYSTEMS

- Most bulk oxygen systems store liquid ox at a very low temperature and use large vaporizers made up of pipes and metal fins that depend on outside air temperature and natural air movement to warm the liquid till it turns into gas. All of the oxygen entering the building's medical oxygen system must be in gaseous form before it leaves the bulk storage equipment. With the increased use, ice starts to form on the vaporizer fins. If excessive ice forms, the vaporizers start losing their ability to do their job. The ice becomes an insulator and has to be removed or they run the risk of freezing their main pressure regulators. Placing fans to blow fresh air across the vaporizer fins will provide significant help with this. It is not recommended to use a gas or electric heating source due to the oxygen rich nature of the surrounding air which increases the risk of combustion.
- Because oxygen consumption will likely be increased, it would be prudent to check tank volumes more frequently.
- Where insufficient oxygen supply exists, deploy bottled oxygen, or use oxygen concentrators.

WATER SYSTEMS

- If possible, ensure toilets have closable covers to prevent aerosolization upon flush. (A, 2)

TECHNOLOGY SYSTEMS

- Ensure proper operation of all necessary equipment, especially ventilators, sterilizers, and medical gas pumps.
- Consider use of a wireless patient monitoring systems such as VivaInk or VitalConnect. These systems help in several ways:
  - The system can allow a patient to be sent home and closely monitored, thus freeing up bed capacity in hospitals for more acute patients.
  - Inside the hospital, the use of a system like this allows the staff to monitor the patients remotely. This could save staff time, in a time when staff time is becoming sorely stretched
  - Remote monitoring also minimizes the frequency at which the nurses and patients interact physically, thus reducing risk of transmission. This risk minimization protects both staff and patients.
  - Continuous remote monitoring allows for fewer wakings of sleeping patients, thus improving the ability of the patient to fight the infection.
  - Research suggests that COVID-19 leads to higher prevalence of Acute Respiratory Distress Syndrome; that is, patients can go into respiratory distress very quickly. A system like this could help healthcare staff better monitor the respiratory condition of these patients.
  - This kind of continuous cardiac monitoring system is likely to be far superior to traditional code blue systems.
  - These systems will notify healthcare staff of patient falls. This kind of monitoring is likely far superior to the traditional nurse call systems with the static pull cord locations.
  - These systems are more easily deployed in a surge kind of occupancy than more traditional nurse call systems.

BIT.LY/COVID19_MAZZETTI

MAZZETTI

CONTACT US

WWW.MAZZETTI.COM