Expedient Patient Isolation Rooms

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Oftentimes, local and national protective guidance issued during a pandemic might call upon the use of airborne infection isolation rooms (AIIRs) for patients and/or specific patient procedures. Within U.S. hospitals, AIIRs are patient rooms with specific engineered features, intended to isolate and more-quickly remove potentially infectious patient aerosols. During a pandemic, the demand for AIIRs may exceed their availability. When this occurs, healthcare facilities may choose to use portable fan systems with high-efficiency particulate air (HEPA) filtration to establish surge AIIR capacity. Although there has been substantial research indicating potential shortcomings when HEPA fan/filter units are deployed incorrectly, there has historically been minimal guidance on how to deploy these units correctly. The National Institute for Occupational Safety and Health (NIOSH) has developed guidance for using portable high-efficiency particulate air (HEPA) filtration systems to create expedient patient isolation rooms. The Expedient Patient Isolation Room guidance is researched based, and is an effective solution for surge isolation capacity during airborne infectious outbreaks when traditional airborne isolation rooms are not available.

In ventilation system design, a "zone" is a space served by a ventilation system. The expedient patient isolation room approach involves establishing a high-ventilation-rate inner isolation zone that sits within a larger ventilated zone. Contaminated air is contained within the inner zone where it is quickly captured and cleaned while the outer zone remains free of contaminant and is a safer environment for healthcare facility staff, other patients and visitors. The inner zone is the space immediately surrounding an infectious patient's bed. The HEPA filtration system is placed between the inner and outer zones. Contaminated air is pulled from the inner zone and into the HEPA filtration system, where it is cleaned and then discharged into the outer zone, thus maintaining a negative pressure relationship of the inner zone relative to the outer zone. Using a HEPA filtration system with an air-cleaning capacity to provide at least 12 air changes per hour (ACH) to the overall patient room, this approach results in an even higher air-cleaning rate within the inner isolation zone which thus increases the rate at which airborne contaminants within the inner zone are removed. The inner isolation zone is created using a floor-to-ceiling retractable curtain that replaces the traditional patient curtain surrounding the patient bed.

Make-up air into the inner zone flows through a designated curtain gap that also serves as the entrance point into the inner zone. The outer zone is the space between the inner zone and the patient room boundary. Depending upon the size of the patient room, one or two inner zones may be located within the same patient room and share the same outer zone.

Air is removed from the inner zone(s) through the use of a freestanding HEPA filtration system that utilizes a nonducted air inlet. The HEPA system can be positioned to serve up to two patient inner-zones simultaneously, with no exchange of contaminated air between the two inner zones. See Figure 1 for an example expedient patient isolation room for 2-bed patient room.

Placement of the HEPA filtration system will influenced by the room configuration. Though not always feasible, the optimum goal to be achieved by HEPA placement is to not only contain the contaminant within the inner zone but to generate directed airflows within the inner isolation zone that capture and pull the contaminant directly into the HEPA filtration unit. When successfully achieved, the directed airflows allow for a prompt removal of contaminated air within the worker-occupied areas of the inner zone. Combining this protective effect with the higher ventilation filtration rate of the inner isolation zone (in comparison with the total room) yields a more rapid removal of airborne contaminant. Regardless of whether these directed airflows are successfully achieved, the inner isolation zone's negative pressure containment aspects will dramatically inhibit contaminant migration throughout the patient room, thus reducing the opportunity for surface contact and fomite exposures. The outer zone then becomes a safe haven for donning and doffing of PPE and potentially reduces the need for worker respiratory protection in the outer zone area.

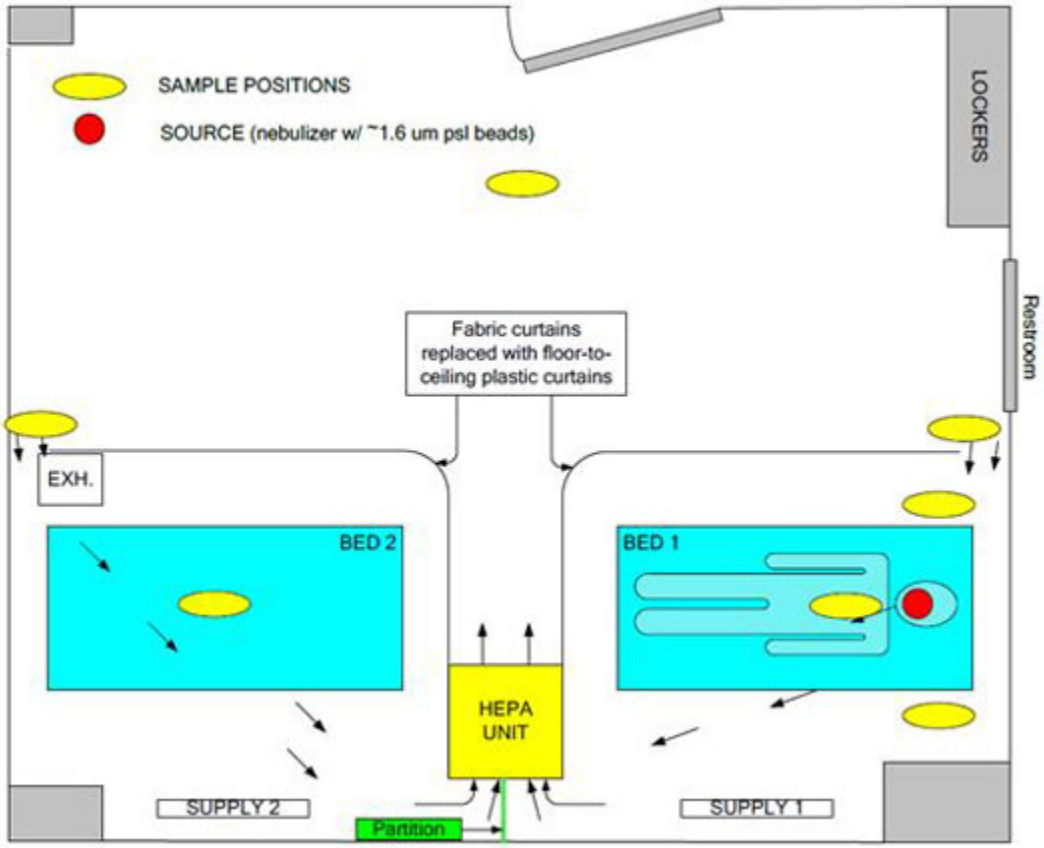

Figure 1. Diagram of an example expedient patient isolation room for 2-bed patient room.

Results from NIOSH research revealed that the evaluated expedient patient isolation room configurations were universally successful in their ability to contain surrogate infectious aerosol within the inner isolation zones. Performance evaluation sampling showed geometric mean reduction ratios (GMRRs) of 98–99 percent or greater outside the inner zone. While airborne concentration reductions were more variable within the inner isolation zone, depending upon the configuration's ability to establish directed air currents, all of the tested inner isolation zones benefited from the faster air cleaning rate (30–60 ACH) that resulted when the HEPA filtration system was sized to provide at least 12 ACH to the overall patient room.

Instructions for Establishing Expedient Patient Isolation Room for Surge Airborne isolation Capacity Within a Traditional Healthcare Environment

Background

The following instructions are for the creation of expedient airborne infection isolation within a traditional healthcare patient room. The expedient isolation techniques described are intended to be an emergency alternative to establish surge capacity in airborne infection isolation. It is intended for use during an infectious disease emergency when insufficient engineered airborne infection isolation rooms are available to meet patient demand. Selection of patient areas suitable for conversion into expedient patient isolation room configurations should be made in consultation with the healthcare facility's safety officer, infection control, and building facilities department participation. Selected patient isolation zones should be evaluated to ensure fire sprinkler coverage is not significantly impaired by the isolation curtains. The inner patient isolation zones should not include recirculating HVAC wall units or HVAC return air grills unless they can be sealed tightly shut. Depending upon the patient room, the zone-within-zone configuration may be set up to serve one or two patients. The following instructions are for the two-patient scenario. The single-patient scenario may be established following the same directions, but with the HEPA filtration system's inlet rotated ninety degrees such that it serves just the one inner isolation zone.

Instructions

Each inner isolation zone requires a physical containment perimeter that encircles each patient bed and its surrounding work area and incorporates a designated opening for air make-up and personnel entry. Inner isolation zone boundaries are based upon the existing patient areas, as defined by their cloth privacy curtains, as well as compatibility with HEPA filter placement within the overall room geometry. For some facility configurations this will result in inner zone boundaries where the make-up air entrance (curtain gap) and exhaust points are located at diagonally opposite corners of the inner zone (See Figure 1). At other locations, the airflow may enter near one corner of the inner isolation zone and flow directly across the head of the bed to an exhaust point at the adjacent corner (Figure 2). During NIOSH testing, while both entrance – exhaust orientations provided excellent contaminant containment within the inner isolation zone, the "across pillow" orientation

that resulted in directed air flow across the head of the patient bed provided a more rapid contaminant concentration control within the inner isolation zone itself.

To construct the inner zone boundary, replace the existing cloth curtain with a floor-to-ceiling plastic curtain that will utilize the same curtain track. The plastic curtains can be constructed with medium weight (3.5 to 4-mil) plastic sheeting such as you might find in local hardware stores. Your facility safety officer or jurisdictional code officials may require you to use a flame retardant plastic. The top of the plastic curtain should be double-folded (allow extra curtain length to accommodate the double fold), and taped into place along the curtain's width using fiber-reinforced tape to create a tape-reinforced border. Use a paper hole punch to punch holes along the length of the taped border (use the removed cloth curtain for a guide on hole-spacing) to allow hanging of the curtain using the existing curtain hooks and track, thus retaining the curtain's ability to be opened and closed. The curtain should extend down to the floor, leaving an approximate ½-inch gap at the top due to the curtain hooks. This gap should be subsequently covered by a loose hanging 12-in long baffle that is constructed of plastic sheeting and secured to the outer edge of the curtain track (but not secured to the curtain itself), thus inhibiting airflow through the gap while not interfering with curtain operation. Incorporation of the 12" baffle results in greater dependence on the curtain entrance gap itself as the predominant source of makeup air into the inner isolation zone.

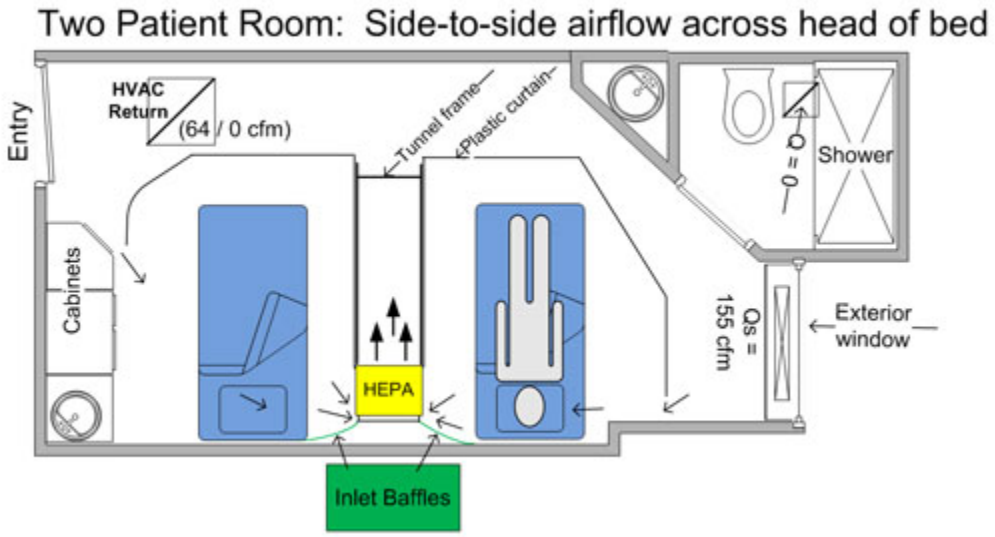

Figure 2. Example schematic of a two-patient expedient patient isolation room configuration. In this configuration, the occupied inner isolation zone shows the make-up air gap and HEPA filter exhaust inlet positioned to induce directed airflow across the head of patient's bed. A pvc-framed tunnel was erected near the HEPA outlet to facilitate HEPA exhaust discharge without disrupting plastic curtains.

Roughly 50% of the curtain length (starting with the curtain gap) needs to maintain its retractable features. The remaining 50% (closest to the HEPA filter inlet) should be sealed into place with tape and plastic, closing all gaps and thus making this portion of the curtain non-retractable. For the retractable portion of the curtain, build a 3-to-4-inch pocket fold (add additional height to account for this when cutting plastic curtain material) into the bottom of the curtain and insert a medium-weight utility chain into the length of this fold to act as a curtain ballast. This ballast feature holds the bottom of the curtain snug to the floor and prevents it from being pulled inward when the inner zone is under negative pressure, yet it allows the curtain section to be retracted for compatibility with real-world scenarios involving patient/equipment movement.

A freestanding portable HEPA filter with non-ducted inlet is positioned equidistant between the two patient beds. The HEPA unit should be positioned in a location so as not to interfere with anticipated patient care activities. The suction side of the HEPA filter serves the inner containment zones for both patients, placing them under negative pressure relative to room pressure. The HEPA filters the contaminated air captured from the inner zone and returns the clean air to the outer zone (remainder of the patient room) that surrounds the inner containment zones. Adjusting the patient bed heights to position the mattress height consistent with the bottom of the HEPA inlet height may help to establish the desired directed airflow patterns within the inner isolation zone. For the two-patient configuration, the inlet into the HEPA filter from each inner isolation zone should incorporate a divider that allows each side of the filter inlet to be distinctly separate. This divider prevents cross-sharing of contaminated air between the two zones. The HEPA filter inlet design will affect how this separation is achieved. In Figure 1, a plastic sheeting vertical partition is built between the center of the HEPA inlet and the adjacent wall in order to independently separate the two inner isolation zones. In Figure 2, inlet baffles were installed to separate the two zones and to deflect the contaminated air into HEPA unit's intake slots. Since airflow near the floor is less critical than that up near the occupied zone, a plastic-sheeting "bed skirt" should be installed between the bottom of the mattress and the floor to restrict incoming makeup air from flowing beneath the bed towards the HEPA unit. For each inner isolation zone, the non-operable section of curtain from each inner isolation zone should be taped to the sides of the HEPA filtration unit and all remaining curtain gaps sealed with tape and plastic sheeting.

Adjust the HEPA filtration system's variable speed control to achieve a minimum ventilation filtration rate of 12 air changes per hour (ACH) based upon the overall patient room volume (if the fan/HEPA has the capacity, higher ventilation filtration flow rates are even better). The 12 ACH value is equivalent to the ventilation rate specified by U.S. standards for newly constructed airborne infection isolation rooms. If HVAC return air grilles are located within the inner isolation zone, these should be tightly sealed to prevent airborne contaminants from recirculating back to the central HVAC unit.

Supply louvers within the inner isolation zone may be sealed if their conditioning capacity is not necessary or they may be left open and deflected towards the HEPA inlet if their contribution towards overall patient room conditioning is still desired. In the rare

occurrence that an HVAC supply rate discharged inside the inner isolation zone is so large that it adversely affects makeup airflow into the inner isolation zone's curtain gap, then the HVAC supply should be relocated to the outer zone or the flow rate should be throttled down and/or the HEPA filtration unit's ventilation filtration rate increased until smoke tests verify a consistent inward airflow across the full length and width of the isolation zone's make- up air curtain gap.

As long as the HEPA filter is in operation, makeup air will flow into the inner isolation zone to replace the air removed by the HEPA filtration system for cleaning. To facilitate a controlled airflow into the inner isolation zones that best establishes the desired directed airflow conditions, establish an initial curtain entrance gap of approximately 10-to-12-inches to be maintained at all times when the inner isolation zone is occupied. This gap provides an intentional path of least resistance to pull clean air into the inner isolation zone and towards the space occupied by bedside health care personnel. Verification of the inward airflow should be demonstrated using a handheld smoke generator or smoke tube. This verification should be repeated and the results documented on a daily basis, whenever the inner isolation zone is occupied. If time allows, the curtain entrance gap width and height may be optimized through the use of a qualitative "Curtain Gap Determination Protocol" that uses a smoke tube or handheld smoke generator to verify directional airflow into and within the inner isolation zone. For this protocol, first release smoke outside the full height of the gap to verify consistent (from floor-to-ceiling) airflow into the inner isolation zone. Second, repeat the smoke release at the gap entrance while observing the smoke streamlines after it enters the inner zone. Adjust the curtain gap width and height until smoke streamlines reveal an inward airflow path across the upstream healthcare personnel position, across the patient's head position, and into the HEPA filtration unit's inlet.

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