Prevention by Design

Construction and Renovation of Health Care Facilities for Patient Safety and Infection Prevention

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KEYWORDS

• Construction • Health care facilities • Risk assessment
• Waterborne and airborne pathogen • Health care design • Ventilation • Water quality
• Operating room design

KEY POINTS

- Outbreaks of disease are associated with construction and renovation when planning and risk mitigation are ignored or not effective.
- The infection control risk assessment (ICRA) and mitigation recommendations are essential components of infection prevention and patient safety programs.
- Infection preventionists/health care epidemiologists should be aware of and have access to the guidelines for design and construction of health care facilities developed by the Facility Guidelines Institute as well as other applicable requirements enforced by the authority having jurisdiction that applies to their local affiliates.
- Infection preventionists/health care epidemiologists can inform and proactively assist multidisciplinary teams involved in construction and renovation but this needs to be part of the project as early as possible in its inception to ensure the protection of patients, personnel, and visitors.
- Policies and procedures that address ICRA, safe work practices, training, monitoring, contingencies, and authority should be established and made operational.

In Jules Verne's[1] 1879 novel, "The Begum's Millions" ("Les Cinq Cents Millions de la Bégum" in French), one of the main characters, Dr Sarrasin, inherits a large fortune and sets out to create a utopian model city. He desires that this new city address unsanitary conditions evident in his native country, France. Of note, his designs include a preference that health care is delivered in the home. Recognizing that an acute care hospital would still be needed, he specified that this be limited to 20 to 30 beds per

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Infect Dis Clin N Am 30 (2016) 713–728
http://dx.doi.org/10.1016/j.idc.2016.04.005 id.theclinics.com
0891-5520/16/$ – see front matter

ward but that each room be a single-patient room with attached bathroom. In addition, the structure was to be disposable (meaning made of pinewood) with no carpet or wallpaper and incinerated at the end of the year of use. This article shows that Verne was prescient in that many of these design elements, except for the disposable nature of the built environment, have been incorporated into contemporary guidelines.

INTRODUCTION

The built environment encompasses a broad range of physical design elements, including spaces for care of patients, support services, electronics, and major technical equipment; building systems that provide air and water; and surfaces and finishes. This spectrum of spaces and surfaces collectively is referred as the environment of care (EOC). In general, these are less frequently a source of microorganisms causing health care–associated infection (HAI) compared with other sources, such as the patient's endogenous microflora, especially when an invasive device is present, or a surgical procedure.[2] Carriage of microbes on hands of health care personnel (HCP) also is a more likely mechanism of exposure to potential pathogens. Even so, the proportional contribution of the EOC as a reservoir of pathogens is estimated at 20%.[3] Over the past several years there have been several studies showing that the EOC is a significant source of multidrug-resistant organisms (MDROs), *Clostridium difficile*, and norovirus.[4] In addition, investigation of the role of the EOC has found that admission to a patient room previously occupied by a patient with an MDRO or *C difficile* is a risk factor for their acquisition by the next occupant.[5]

Specific pathogens can suggest an environmental source; for example, from demolition of drywall or gaps in maintenance of key mechanical systems, which include *Aspergillus* spp, *Fusarium* spp, *Rhizopus* spp, *Bacillus cereus*, *Legionella* spp, a wide range of gram-negative bacteria, and nontuberculous mycobacteria.[2] When HAIs are caused by opportunistic pathogens it is important to apply key principles such as chain of transmission and the following criteria to determine whether reservoirs are present in the environment and to help guide implementation of mitigation strategies, if applicable.

CRITERIA FOR EVALUATING THE STRENGTH OF EVIDENCE FOR ENVIRONMENTAL SOURCES OF INFECTION

1. The organism can survive after inoculation onto the fomite.[2]
2. The organism can be cultured from in-use fomites.
3. The organism can proliferate in or on the fomite.
4. Some measure of acquisition of infection cannot be explained by other recognized modes of transmission.
5. Retrospective case-control studies show an association between exposure to the fomite and infection.
6. Prospective case-control studies may be possible when more than 1 similar type of fomite is in use.
7. Prospective studies allocating exposure to the fomite to a subset of patients show an association between exposure and infection.
8. Decontamination of the fomite results in the elimination of infection transmission.

Annual spend on construction or renovation of health care facilities is approximately $40 billion.[6] Because cost of construction per square meter ranges from $4300 to $12,920, there has been some modulation in the build of larger inpatient rooms.[7] A large proportion of current construction projects therefore involve a shift toward construction of outpatient facilities. A recent survey of providers found that the types of outpatient projects include ambulatory surgery centers (48%), freestanding imaging (23%), health system–branded clinics in retail space (23%), health system–branded general medicine and family care in the community (53%), immediate care facilities (49%), medical office buildings (60%), and telehealth (23%).[7] This finding reflects the general direction toward home-based and ambulatory-based care delivery with an emphasis on population health and value-based purchasing.

Disturbance of the EOC, especially from construction, renovation, or remediation, can result in exposure of patients and personnel to microorganisms present in air, water, or on surfaces. Other maintenance activities, such as repair and remediation work (eg, installing wiring for new information systems, removing old sinks, and repairing elevator shafts) can also disrupt and release contaminants. Aging equipment, deferred maintenance, and natural disasters provide additional mechanisms for the entry of environmental pathogens into high-risk patient-care areas.

To mitigate contamination of patient-care areas several infection preventionists developed the use of infection control risk assessment (ICRA).[8] ICRA is a process that begins during planning and design of construction and renovation to ensure that elements of infection prevention are incorporated into the project. It includes strategies such as physical barriers to contain and confine dust, soil, and contaminants (eg, fungal spores) that may be released into the air during demolition, once construction begins. Use of an ICRA has been incorporated into design standards as well as Healthcare Infection Control Practices Advisory Committee guidelines that address construction and renovation.

OVERVIEW OF DISEASE TRANSMISSION RISKS FROM THE BUILT ENVIRONMENT

Air as a Reservoir of Health Care–associated Infections

Although the percentage of HAIs directly related to construction is unknown, the morbidity, mortality, and costs of mitigation of these preventable infections are considerable. The mechanism of exposure of patients to airborne pathogens during construction is often from disturbance of building materials or surfaces that have been contaminated; for example, intrusion of water onto drywall substrate where fungal spores are present. Demolition of these substrates releases bursts of spores into the air and, if not contained and removed, can result in exposure of occupants.

Vonberg and Gastmeier[9] reviewed outbreaks of infection caused by *Aspergillus* spp and found that almost half were associated with construction or renovation in hospitals. In addition, they identified that the infective dose of invasive pulmonary aspergillosis in immunocompromised patients can be as low as 1 colony forming unit/m^3. This finding highlights the critical need for isolation and containment of construction activities from other occupied spaces.

Patient populations at increased risk of fungal infection and that are exposed to contaminated airborne spores include those undergoing hematopoietic stem cell or solid organ transplant, undergoing chemotherapy for conditions such as leukemia, in receipt of high-dose steroid therapy, the critically ill, neonates, those undergoing cardiac surgery, and those with chronic lung disease.

Kanamori and colleagues[10] recently reevaluated disease outbreaks from airborne fungal spores associated with construction. They found it encouraging that since 2010 there have been fewer reports of outbreaks. Although not necessarily a direct causal relationship, this points to the efficacy of ICRA in mitigating transmission and protecting patients, personnel, and visitors in facilities that have ongoing construction or renovation. Their search of the literature found 28 construction-associated outbreaks between 1976 and 2014, *Aspergillus* spp being the most common pathogen, and a predominance of pulmonary infection with attributable mortality approaching 60%.

Water as a Reservoir of Health Care–associated Infections

The spectrum of microorganisms present in water is broad and includes gram-negative bacteria (eg, legionellae and *Pseudomonas* spp), nontuberculous mycobacteria, protozoa, and fungi.[2] Potable water provided by municipal water authorities must meet federal standards for drinking water and these are enforced by the US Environmental Protection Agency.[11] Water supplied to the health care facility is then distributed through an extensive network of plumbing to fixtures such as handwashing stations, ice machines, medical equipment (eg, automated endoscope reprocessors), and utility systems. This distribution network readily supports development of biofilm, and the microbial contaminants embedded in this matrix of extracellular polymeric substances, mainly composed of exopolysaccharides, proteins, and nucleic acids, protects microorganisms from disinfectants that are otherwise effective against planktonic forms.[12] Stagnant water in this network, often from renovation of areas in the facility that has resulted in redundant lengths of pipework that are left in place and capped, also enhances development of biofilm. In addition, disruption of water utility systems during construction or renovation can disrupt biofilm and release contaminants into the water delivery network, posing a possible risk to patients, including those far away from the work area.

A recent, extensive review of waterborne disease outbreaks found that the more susceptible patient populations, such as the critically ill, neonates, transplant recipients, surgical patients, and those with hematological disease, are often the sentinel signal of a new cluster.[13] Of late the types of devices and architectural features that were a source of infections are growing in complexity. This article discusses these outbreak investigations and emphasizes the need to be vigilant for their detection and mitigation.

> …*Waterborne healthcare-associated outbreaks and infections continue to occur and were mostly associated with well-recognized water reservoirs as previously described. Moreover, recent studies document electronic faucets (P. aeruginosa, Legionella, M. mucogenicum), decorative water wall fountains (Legionella), and heater-cooler devices used for cardiac surgery (M. chimaera) as water reservoirs*…[13]

There are some landmark investigations of waterborne disease outbreaks worth highlighting because these investigations have informed guidelines for construction and renovation in the United States.

HANDWASHING STATION DESIGN

Hand hygiene is the foundation of infection prevention and control. The 2 primary methods HCP use to clean their hands are alcohol-based hand rub (ABHR) or soap and water and a handwashing station. Hota and colleagues[14] reported an outbreak of *Pseudomonas aeruginosa* infections that, ironically, centered on handwashing stations in intensive care units (ICUs) and transplant units. The outbreak unit featured single-occupancy patient rooms with convenient access to a handwashing station near the entrance in each for use by HCP. Biofilm within the drains of these were identified as the source and the sink design included a shallow basin with the faucet spout directly over the drain. This arrangement resulted in splashes of water contaminated with *P aeruginosa* out of the drain contaminating surfaces near the sink, including a medication preparation area and the patient bed. Interventions to mitigate contamination from sinks included a physical barrier between the sink and adjacent countertops, offset of the faucet spout so it did not discharge directly into the drain, and lower water pressure. The lessons from this outbreak have been incorporated into guidelines published by the Facility Guidelines Institute (FGI).[15] Key design features in current FGI guidelines include:

- Basins that reduce the risk of splashing and are made of porcelain, stainless steel, or other solid surface material
- Basin size of no less than 929.08 cm^2 (144 square inches) with 22.86 cm^2 (9 square inches) width or length
- Sealed to prevent water intrusion into supporting cabinet, wall, and countertop
- Discharge of water from faucet spout is at least 25.4 cm (10 inches) above the bottom of the basin and avoids dropping directly into the drain
- Water pressure in station fixture is regulated
- Allows controls for sink fixture to be wrist blade, single lever, or sensor activated

WATER FEATURE: NOT ALLOWED

Decorative water features have been a popular element of design. However, there have been 2 recent outbreaks of legionnaires' disease associated with these. The first involved 2 patients with extended hospital stay preparing for stem cell transplant for treatment of leukemia.[16] Investigation identified a decorative water fountain as the source; of note, testing of water identified a diverse range of other microorganisms in addition to *Legionella pneumophila* serogroup 1. This fountain had been turned off for several months and the investigators commented that stagnation in the water circulation conduits likely promoted development of biofilm.

Haupt and colleagues[17] investigated a cluster of legionnaires' disease associated with a decorative water wall that was installed in a public corridor near the main entrance lobby of a community hospital. Eight cases were detected and the only common risk factor was visiting the hospital where this feature was in use; most patients simply walked through the lobby past the water wall. *L pneumophila* serogroup 1 was detected from the water in this fountain despite adherence with the manufacturer's instructions for cleaning and maintenance. This incident and other evidence has led the FGI to state that, "unsealed, open water features are not permitted."[15]

Inpatient Rooms, Surfaces, and Finishes

The microbiome of the inpatient room has undergone renewed appreciation following a considerable body of evidence that finds significant risk of acquisition of pathogens such as MDROs or *C difficile* related to infection or colonization in the room's prior occupant, for as long as 3 weeks.[5] However, this contamination can be removed with attention and focus on thorough cleaning and disinfection of surfaces in rooms that are touched with high frequency, combined with real-time feedback.[18,19]

The evidence that MDROs can persist in the environment for a prolonged time, as described earlier, in combination with the observed efficiency of cross-transmission of these in multibed rooms, has led to a preference for single-patient rooms. This design also enhances safety related to a variety of other potential harms, supports patient privacy, and lessens disruption from ambient noise.[20] By contrast, the lack of spatial separation between patients in multibed rooms or wards has been associated with increased risk of respiratory viral infections and bacterial infection when patient with similar devices are in the same room.[21,22] Other investigators identified a temporal association between fewer bloodstream infections, detection of MDROs, and prevalence of antibiotic resistance with redesign of patient-care units from open wards to single-patient rooms.[23]

Studies of cross-transmission of microorganisms in health care facilities have identified that surfaces nearer to patients are more likely to be contaminated. Further, patients with acute infection, especially when symptoms result in contamination of the immediate environment with body fluids containing the pathogen (eg, diarrhea), result in higher microbial burden on environmental surfaces.[5] This finding is particularly true of norovirus, for which studies find that person-to-person transmission depends on close or direct contact as well as short-range aerosol exposures. Also, experience with control of outbreaks of norovirus highlight the need to clean and disinfect frequently touched surfaces (eg, patient and staff bathrooms, utility rooms, tables, chairs, commodes, computer keyboards and mice, and items in close proximity to symptomatic patients).[24]

STRATEGIES AND DESIGN ELEMENTS TO SUPPORT INFECTION PREVENTION

The FGI guidelines serve as a foundational resource for the design of health care facilities.[15] They are used as a basis for regulation and a national standard in 42 states as well as being cited by the Joint Commission, the Department of Housing and Urban Development, and the Indian Health Service as normative, national standards. The guidelines are consensus-based and developed by the Health Guidelines Revision Committee and are updated every 4 years. The 2014 guidelines include 2 separate standards, one for hospitals and outpatients and the other for residential health, care, and support facilities. Importantly, they provide minimum design standards; not necessarily parameters that involve daily operations of facilities. Many of the elements discussed later are addressed in these guidelines and readers are referred to this resource for more details.

ICRA is the core framework of design and construction/renovation. It is a component of the overall safety risk assessment called for in the FGI 2014 guidelines. ICRA calls for design recommendations and infection control risk mitigation recommendations (ICRMR) that are applied to the construction project being planned. Key aspects that ICRA needs to address include:

- Design elements that support infection prevention and control
- Proactive planning for mitigating sources of infection both within and external to the construction project that will be affected
- Identify potential risk for transmission of airborne and waterborne pathogens during construction, renovation, and commissioning
- Develop ICRMRs to mitigate identified risks (see Appendix A for a stepwise approach to developing ICRMRs)

There is evidence that an effective ICRA process can prevent HAIs.[25] **Fig. 1** provides examples of effective containment methods.

Select Elements of Design

Heating, ventilation, and air conditioning

Heating, ventilation, and air conditioning (HVAC) is a building system that is designed to provide comfort, support aseptic procedures, remove contaminants from air, and deliver an acceptable indoor air quality. FGI 2014 includes the American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) 170 Standard for design of HVAC for health care facilities. This standard provides a wide range of

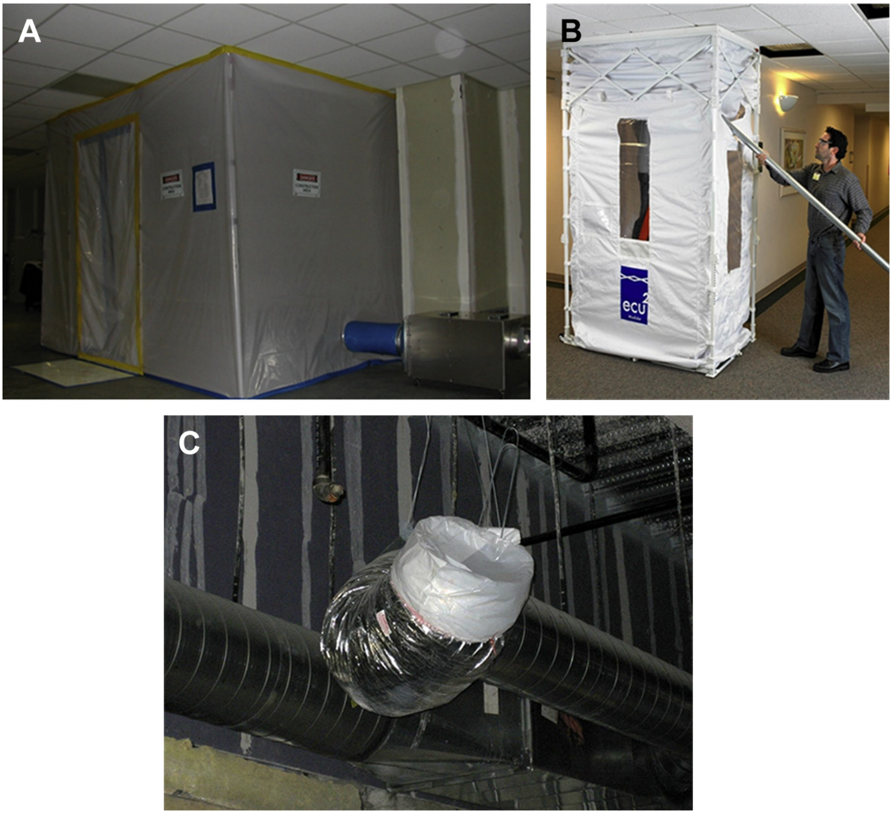

Fig. 1. Examples of containment methods for construction and renovation. (*A*) One hour, fire-rated, temporary containment wall. (*B*) Portable environmental containment unit. (*C*) Protection of new duct work with cover over open end.

parameters for HVAC systems that supply patient-care, procedural (eg, surgery suite), and support areas. Parameters included in ASHRAE 170 include air changes per hour, design temperature and relative humidity ranges, and pressure relationships to adjacent areas.[26]

Universal or acuity-adaptable and single-occupancy patient-care rooms

The FGI commissioned a systematic review of available evidence on the value of single-patient rooms[20] that found suggestive, albeit low-quality, evidence that this prevents infection and improves overall patient safety and experience of care. The addition of adaptability of these based on the patient's need also is worth considering. Additional elements for adult ICUs have been described elsewhere and support this need for flexibility to accommodate changes in care practices and advances in technology.[27]

Airborne-infection isolation room

Planning for airborne-infection isolation rooms (AIIRs) should be based on the local epidemiology and risk assessment for the prototype airborne disease, tuberculosis. Other diseases in which AIIRs are used include chickenpox and measles, and experience with these can also help inform on location and number of AIIRs for a facility planning team as part of ICRA. There are also procedures that increase the risk of transmission if performed on someone with active pulmonary tuberculosis (eg, bronchoscopy), and these need to be considered when identifying the optimal number of AIIRs. More recently, emerging and remerging diseases, such as Ebola and Middle East respiratory syndrome coronavirus, have highlighted the need to plan and respond as appropriate, from frontline facilities that receive patients to regional and national emergency preparedness and response. Details of regional facilities designed for definitive treatment of patients with infections such as Ebola are described elsewhere.[28]

Protective environment room

A protective environment (PE) room is designed to provide a filtered supply of high-efficiency particulate air (HEPA) to rooms used to care for patients who are severely immunocompromised (eg, solid organ transplant patients or allogeneic neutropenic patients). These rooms need to be designed to ensure that rooms are well sealed by maintaining ceilings that are smooth and free of fissures, open joints, and crevices; sealing walls above and below the ceiling; and, once occupied, to monitor for leakage. Additional details are available elsewhere.[2] Recommendations for quality processes to ensure protection of immunocompromised patients during construction have been published.[29]

Handwashing stations and hand hygiene

Design features were identified earlier in the review of water as a reservoir. Reliable, readily available access to devices and products to use for hand hygiene is the foundation of infection prevention and control. The FGI guidelines include both handwashing stations and proactive planning for placement of dispensers of ABHR that are readily visible to HCP.

Toilets and disposal of human waste

The move to single-patient rooms has resulted in most rooms having an attached bathroom/shower for use by the patient. For critically ill patients, the ability to use the bathroom is less likely; the exception might be a cardiac ICU. Swing-out or fold-down fixtures (Swivette toilets) should be avoided, because they are prone to mechanical problems and leakage, are difficult to use (especially for the acutely ill), and may not be rated for the bariatric patient population. Alternatives for the ICU population to manage human waste include body fluid disposal systems or plumbed, bedpan flushing/disinfection devices. If planned, it is important for these to be convenient for HCP because there are aesthetic and safety barriers to transport of human waste over long distance. Importantly, fixtures used for disposal of human waste should be limited to that purpose and not used for other activities, such as hand hygiene.

Surfaces, finishes, and furnishings

The renewed attention on the inanimate environment as a source of pathogens has stimulated interest in strategies that can support infection prevention. There are several antimicrobial treatments that have been applied to inanimate surfaces; nonporous and soft surfaces such as textiles and privacy curtains. The types of antimicrobial treatments include photoreactive substances that release antimicrobials when exposed to natural sunlight, heavy metals like copper and silver, organosilane, triclosan, and quaternary ammonium compound. There is suggestive evidence that many of these can reduce the concentration of microorganisms on environmental surfaces.[30] Direct evidence that these treatments reduce the incidence of HAIs in which transmission from the inanimate EOC is involved is lacking. This lack of evidence reflects the complex environment in an acute care facility given the myriad of sources by which personnel can contaminate their hands (eg, shared equipment) so treating several surfaces in a room may still not be more effective than processes and real-time feedback to personnel who clean and disinfect the built environment. Guidance is available for some of the surfaces and finishes being planned for health care facilities. Highlights of these include[31]:

1. Nonupholstered surfaces should be capable of being easily cleaned; minimize surface joints and seams.
2. Upholstered surfaces used in patient-care areas should be impervious (nonporous); untreated (non–high performance) woven fabrics should not be used. Upholstered surfaces should be durable and resist tearing, peeling, cracking, or splitting; damaged surfaces are more difficult to clean effectively. Upholstered furniture in patient-care areas should be covered with fabrics that are fluid-resistant, nonporous, and can withstand cleaning with hospital-grade disinfectants.

Floors, walls, and ceilings

CDC guidelines have identified that, "…Compared to hard-surface flooring, carpeting is harder to keep clean, especially after spills of blood and body substances. It is also harder to push equipment with wheels (eg, wheelchairs, carts, and gurneys) on carpeting…"[2] There are several recommendations on carpeting in these guidelines but a key one is to avoid the use of carpeting in high-traffic zones in patient-care areas or where spills are likely (eg, burn therapy units, operating rooms, laboratories, and ICUs). Walls should be cleanable and able to withstand repeated exposure to chemical surface disinfectants. Ceilings in areas needing special HVAC requirements, such as AIIR, operating room, PE, and so forth, are an important aspect of ensuring that the room envelope is sealed to maintain desired pressurization and contain contaminants. For operating rooms, FGI 2014 guidelines call for a monolithic ceiling as a strategy to facilitate effective envelope seal.

FUTURE DIRECTIONS FOR HEALTH CARE IN THE UNITED STATES

The FGI convened a futures summit to assist with development of upcoming editions of their guidelines. This summit identified the following trends and needs going forward, and awareness of these is important for infection preventionists and health care epidemiologists in applying relevant infection prevention strategies[32]:

Trends

- More health care provided at home
- More access to medical care in the community
- More specialized diagnosis and treatment facilities
- Hospitals provide only for the sickest or those with most complicated needs
- Navigators and health coaches provide assistance to patients, providers, and/or payers
- Increased use of technology for health care monitoring and communication
- Continued government involvement in regulating health care

Informing Future Guidelines Development

- Health care will increasingly be provided in outpatient facilities and residential care settings of numerous types.
- Acute care facilities will see slower growth and be focused on providing care to higher-acuity patients with more complex treatment and care needs.
- As a society, the United States needs to encourage development of high-value, high-engagement models of care; how the design of health care facilities can relate to this goal should be considered.

- A 4-year cycle for document development is not optimal for responding to the rapidly changing health care landscape.
- Documents focused on fundamental design requirements are important but do not address complex health care delivery needs. FGI also needs to facilitate development of best practice and alternative concept guidance for health care design.

RESOURCES FOR DESIGNING IN INFECTION PREVENTION

Scientific studies that inform design of the EOC are challenging. Even so, Zimring and colleagues[33] called for the use of evidence-based design (EBD) to drive design and construction of health care facilities. The steps in the process of EBD include:

1. Framing of goals and models; most recently the emphasis is on patient-centered care
2. Incorporation of health care facility guidelines; for example, FGI
3. Planning and design
4. Operations: daily care delivery issues that may require variation from design parameters; for example, reducing the temperature in the operating room to address comfort of surgeons and perioperative personnel

Other resources are available to improve the effectiveness of the planning and design. These resources include a comprehensive safety risk assessment tool sponsored by the Agency for Healthcare Research and Quality and FGI.[34] Elements of this tool include ICRA, patient handling, medication safety, mitigating risk of patient falls, and security. A manual for incorporating infection prevention into construction projects is also available.[35]

SUMMARY/DISCUSSION

Infection prevention and control is an essential component of the built environment. When absent or when there are disruptions, risk of exposure of patients and disease outbreaks often result. However, there are well-established, evidence-based guidelines to assist infection preventionists and health care epidemiologists with identifying strategies for prevention in collaboration with the multiple disciplines involved in construction and renovation (EIC 2003[2], FGI 2014[15]). The ICRA remains the keystone of designing in prevention at the inception of a project through the completion and commissioning phases. Future trends in care delivery in the United States are going to have a significant impact on construction and renovation of health care facilities; however, involvement and subject matter expertise provided by infection preventionists/health care epidemiologists will remain a core component into the future.

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APPENDIX A: STEPWISE PROCESS FOR INFECTION CONTROL RISK MITIGATION RECOMMENDATIONS FOR CONSTRUCTION AND RENOVATION

Step 1: using the following table, identify the type of construction project activity (types A–D)

Type A	Inspection and noninvasive activities Includes but is not limited to: • Removal of ceiling tiles for visual inspection only; eg, limited to 1 tile per 4.6 m^2 (50 square feet) • Painting (but not sanding) • Wallcovering, electrical trim work, minor plumbing, and activities that do not generate dust or require cutting of walls or access to ceilings other than for visual inspection
Type B	Small-scale, short-duration activities that create minimal dust Includes but is not limited to: • Installation of telephone and computer cabling • Access to chase spaces • Cutting of walls or ceiling where dust migration can be controlled
Type C	Work that generates a moderate to high level of dust or requires demolition or removal of any fixed building components or assemblies Includes but is not limited to: • Sanding of walls for painting or wall covering • Removal of floorcoverings, ceiling tiles, and casework • New wall construction • Minor duct work or electrical work above ceilings • Major cabling activities • Any activity that cannot be completed within a single work shift
Type D	Major demolition and construction projects Includes but is not limited to: • Activities that require consecutive work shifts • Requires heavy demolition or removal of a complete cabling system • New construction

Step 2: using the following table, identify the patient risk groups that will be affected. If more than 1 risk group will be affected, select the higher risk group:

Low Risk	Medium Risk	High Risk	Highest Risk
Office areas	• Cardiology • Echocardiography • Endoscopy • Nuclear medicine • Physical therapy • Radiology/MRI • Respiratory therapy	• Cardiac care unit • Emergency room • Labor and delivery • Laboratories (specimen) • Medical units • Newborn nursery • Outpatient surgery • Pediatrics • Pharmacy • Postanesthesia care unit • Surgical units	• Any area caring for immunocompromised patients • Burn unit • Cardiac catheterization laboratory • Central sterile supply • ICUs • Negative pressure isolation rooms • Oncology • Operating rooms, including cesarean section rooms

Step 3: match the:

- Patient risk group (low, medium, high, highest) with the planned:
- Construction project type (A, B, C, D) on the following matrix, to find the:
- Class of precautions (I, II, III, or IV) or level of infection control activities required.
- Class I to IV or color-coded precautions are delineated later.

Infection control matrix for class of precautions: construction project by patient risk

Patient Risk Group	Construction Project Type			
	TYPE A	TYPE B	TYPE C	TYPE D
Low-risk group	I	II	II	III/IV
Medium-risk group	I	II	III	IV
High-risk group	I	II	III/IV	IV
Highest-risk group	II	III/IV	III/IV	IV

Note: infection control approval is required when the construction activity and risk level indicate that **class III** or **class IV** control procedures are necessary.

Description of required infection control precautions by class

	During Construction Project	Upon Completion of Project
Class I	1. Execute work by methods to minimize raising dust from construction operations 2. Immediately replace a ceiling tile displaced for visual inspection	1. Clean work area upon completion of task
Class II	1. Provide active means to prevent airborne dust from dispersing into atmosphere 2. Water mist work surfaces to control dust while cutting 3. Seal unused doors with duct tape 4. Block off and seal air vents 5. Place dust mat at entrance and exit of work area 6. Remove or isolate HVAC system in areas where work is being performed	1. Wipe work surfaces with cleaner/disinfectant 2. Contain construction waste before transport in tightly covered containers 3. Wet mop and/or vacuum with HEPA filtered vacuum before leaving work area 4. Upon completion, restore HVAC system where work was performed
Class III	1. Remove or isolate HVAC system in area where work is being done to prevent contamination of duct system 2. Complete all critical barriers (ie, sheetrock, plywood, plastic) to seal area from nonwork area or implement control cube method (cart with plastic covering and sealed connection to work site with HEPA vacuum for vacuuming prior to exit) before construction begins	1. Do not remove barriers from work area until completed project is inspected by the owner's safety department and infection prevention and control department and thoroughly cleaned by the owner's environmental services department 2. Remove barrier materials carefully to minimize spreading of dirt and debris associated with construction 3. Vacuum work area with HEPA filtered vacuums

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	During Construction Project	Upon Completion of Project
	3. Maintain negative air pressure within work site utilizing HEPA-equipped air filtration units 4. Contain construction waste before transport in tightly covered containers 5. Cover transport receptacles or carts. Tape covering unless solid lid	4. Wet mop area with cleaner/ disinfectant 5. Upon completion, restore HVAC system where work was performed
Class IV	1. Isolate HVAC system in area where work is being done to prevent contamination of duct system 2. Complete all critical barriers (ie, sheetrock, plywood, plastic) to seal area from nonwork area or implement control cube method (cart with plastic covering and sealed connection to work site with HEPA vacuum for vacuuming prior to exit) before construction begins 3. Maintain negative air pressure within work site using HEPA-equipped air filtration units 4. Seal holes, pipes, conduits, and punctures 5. Construct anteroom and require all personnel to pass through this room so they can be vacuumed using an HEPA vacuum cleaner before leaving work site, or they can wear cloth or paper coveralls that are removed each time they leave work site 6. All personnel entering work site are required to wear shoe covers. Shoe covers must be changed each time the worker exits the work area	1. Do not remove barriers from work area until completed project is inspected by the owner's safety department and infection prevention and control department and thoroughly cleaned by the owner's environmental services department 2. Remove barrier material carefully to minimize spreading of dirt and debris associated with construction 3. Contain construction waste before transport in tightly covered containers 4. Cover transport receptacles or carts. Tape covering unless lid is solid 5. Vacuum work area with HEPA filtered vacuums 6. Wet mop area with cleaner/ disinfectant 7. Upon completion, restore HVAC system where work was performed

Step 4: identify the areas surrounding the project area, assessing potential impact.

Unit Below	Unit Above	Lateral	Lateral	Behind	Front
Risk group	Risk group	Risk group	Risk group	Risk group	Risk group

Step 5: identify specific site of activity; for example, patient rooms, medication room, and so forth.

Step 6: identify issues related to ventilation, plumbing, electrical (in terms of the occurrence of probable outages).

Step 7: identify containment measures, using prior assessment. What types of barriers (eg, solids wall barriers)? Will HEPA filtration be required? (Note: renovation/construction area will be isolated from the occupied areas during construction and will be negative with respect to surrounding areas).

Step 8: consider potential risk of water damage. Is there a risk from the compromising of structural integrity (eg, wall, ceiling, roof)?

Step 9: work hours. Can or will the work be done during non–patient-care hours?

Step 10: do plans allow for an adequate number of isolation/negative airflow rooms?

Step 11: do the plans allow for the required number and type of handwashing sinks?

Step 12: do the infection prevention and control staff agree with the minimum number of sinks for this project? Verify against FGI design and construction guidelines for types and area.

Step 13: do the infection prevention and control staff agree with the plans relative to clean and soiled utility rooms?

Step 14: plan to discuss containment issues with the project team; eg, traffic flow, housekeeping, debris removal (how and when).