Chapter 27

Health Care Facility Design, Construction, and Renovation

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Key Points
• Recommendations for construction of health care facilities must be based mainly on experience and assessment of infection risks, considering available local resources, as published evidence is scarce. • Patients' vulnerability to air and water contaminants while in or near a construction site must be taken into account. • Several factors might influence transmission of infection, some of which are listed below: ∗ Vulnerability of patients in ICUs, operation theatres, in common wards and in out-patients´ clinics where patients are at different stages of susceptibility to infection. ∗ Numbers and types of rooms ∗ Number of beds in a room ∗ Numbers of patients, staff, and visitors ∗ Numbers and types of procedures and examinations ∗ Storage of equipment and textiles ∗ Available space and adequate equipment ∗ Floors, finishes, and surfaces ∗ Water, electricity, and sanitation ∗ Ventilation and air quality ∗ Space for handling used and unused medical equipment ∗ Space for handling food, laundry, and waste

Background

The design and construction of the built environment influences the prevention of healthcare-associated infections (HAI) and reduction of stress on staff.[1-3] A recent review and expert consensus article identified several key components related to health-care structures, such as bed occupancy, staffing, workload, and access to materials and equipment, as important for the organisation of effective infection prevention and control (IPC) programmes.[4]

The influence of design and construction on HAIs is difficult to evaluate and scientifically prove since HAIs have a complex multi-factorial aetiology. To identify environmental contributions to a risk-adjusted rate, such as surgical site infections (SSI) for example, is even more challenging, since there are many patient-related and practice confounders. Secondary variables, such as microbial counts in air or water, are often used for bench-marking and quality control.

Infection Risks

Construction as an independent risk factor for HAIs is not clear. In order to identify the ideal design of operating theatres for decreasing the incidence of SSIs, a researcher will consider only clean surgeries; any study will require impractically large numbers in order to demonstrate significant differences. Lidwell[5] in the 1970s reviewed data for over 8,000 clean procedures. Even then his findings did not resolve some questions on the best design required to reduce SSIs.

Two well-designed studies demonstrated the impact of the environment involving respiratory pathogens and suggested practical design lessons. The severe acute respiratory syndrome (SARS) study[6], involving a virus primarily transmitted by droplet/contact, highlights the importance of short-range aerosols; the *M. tuberculosis* study[7] considers alternate designs to control airborne transmission.

In 2007, Yu, et al.[6] conducted a study during the SARS epidemic of 2003. They found two risk factors related to construction: distance between beds of <1 metre (Odds Ratio 6.9) and availability of washing or changing facilities for staff (OR 0.12). Escombe, et al.[7] investigated the influence of natural and mechanical ventilation and found that in countries with limited resources where costly and maintenance-requiring mechanical ventilation is difficult to implement, window and door ventilation may be effective to prevent the spread of tuberculosis. This was a modelling study using a surrogate for *M. tuberculosis*; however it helped define space requirements when considering natural ventilation in specific climates. In countries where multi-resistant tuberculosis is common, planning should include ventilation.[8,9]

Recommendations for Prevention of HAIs by Design

Recommendations for health care design and construction must be based on experience and applicability, considering local resources and cultural conditions, together with a review of current scientific literature. Table 27.1 outlines general IFIC special interest group (SIG) recommendations for countries with low, middle, and high resources. Important factors to consider for construction and renovation include design, ventilation, patient placement or relocation, and effective construction barriers to protect susceptible patients from airborne pathogens.

Risks related to construction and renovation work are associated with reduced air quality and environmental contamination from fungi (e.g., *Aspergillus* spp.) or contaminated water (e.g., *Legionella* spp.). Newly constructed or renovated areas should be thoroughly cleaned before patients are allowed in them.

Design issues are outlined in Table 27.1. They include:

1. Numbers and types of rooms
2. Patient placement and basic room design

3. Numbers of patients, staff, and visitors
4. Fixtures, e.g., sink numbers, placement of hand washing stations; dispensers for hand hygiene products and associated materials (soap, waterless alcohol-based hand rub [ABHR], paper towels, lotion, and similar items)
5. Air and drinking water quality, e.g., heating, ventilating, and air-conditioning systems
6. Sharps and waste disposal container placement
7. Utility rooms, e.g., soiled, clean, instrument processing
8. Storage areas, including patient care supplies and personal protective equipment
9. Surfaces, e.g., ceiling tiles, walls, counters, floor coverings, furnishings, and equipment
10. Laboratory space

Numbers and types of rooms[10,11]

A maximum of 40 beds on a ward should not be exceeded because of very long distances for the staff to walk. There may be more than one baby/child in a cot/bed. Visitors often sleep with the patient. Therefore, during renovation the aim should be more rooms with fewer beds in each room. Single rooms for isolating infectious patients should be available, especially in countries where communicable diseases are endemic.

There is growing evidence that single rooms are helpful to prevent HAIs.[12] Single rooms with conventional ventilation do not prevent transmission *per se*, however these rooms are an efficient barrier between patient-zones and a reminder for staff to perform hand hygiene.[13]

Patient placement and basic room design

Wards should be planned and equipped so that transmission can be prevented. Methods to prevent spread of infections include the following concepts.

- Prevention of contact or droplet transmission requires enough bed distance or single-patient rooms.[13]
- Prevention of airborne transmission requires care of patients in single-patient rooms with anteroom / airlock or in rooms with negative pressure.[14]
- Prevention of intestinal infection requires enough toilets and good facilities for food preparation.[15]
- Prevention of transmission in the operating room requires special equipment and ventilation.[16]
- Prevention of indirect transmission via instruments or objects requires enough space for cleaning, disinfection, and sterilisation.
- Prevention of infection in severely immunocompromised patients, such as bone marrow transplanted patients, requires a single room. Ideally the room should have positive pressure relative to the corridor and other rooms in the ward in order to prevent microorganisms entering the room through the air. Supply air should be filtered by a high efficiency particulate air (HEPA) filter to prevent mould spores from the outdoor air or ventilation ducts entering the room.[17]

Numbers of patients, staff, and visitors

Overcrowding and understaffing are key determinants for transmission of microorganisms in health-care settings because a high workload reduces the possibilities to perform hand hygiene and to clean rooms due to stress.[4] Visitors must not be allowed to move freely in the ward. They should not be allowed to use the patients´ kitchen and storage rooms.

Hand hygiene facilities

ABHRs are critical, especially if wash basins are limited and water supply interrupted. There should be space and dispensers for ABHR, liquid soap, and paper towels for staff use. Jet air and warm air dryers should be avoided.[18] Reusable dispensers should be maintained, cleaned and disinfected before being refilled.

Sinks and drains

Sinks and drains are risk areas for HAIs since they are colonised with hospital flora. Floor drains in bathrooms and operating theatres, sinks, etc., are probably the most contaminated areas in a hospital; staff should be aware of this when using or cleaning these areas. Sinks, toilets, and sewage lines in wards with high numbers of patients may be contaminated with multi-resistant intestinal bacteria, such as extended-spectrum beta-lactamase-producers and vancomycin-resistant Enterococci, especially if patients have diarrhoea.[19,20]

When water from faucets splash into a drain or the sink it can contaminate the floor, equipment stored close to sinks, and staff's uniforms.[21] Therefore, the number of sinks should be kept to the absolute minimum required.

Water, electricity, and sanitation[22]

Every ward should have enough toilets for both sexes to prevent faeco-oral transmission. Toilets and wash basins must be maintained and cleaned daily. Showers should be available. A clean water supply and electricity should be available 24 hours a day.

Each hospital should ideally have a water safety plan to provide safe drinking water and water for showers. The infection control team (ICT) should lead and advise janitors, technicians, and representatives of hospital management in the development of the water plan.

Drinking water must be controlled and regularly checked for quality and safe levels of contaminants, such as *E. coli*, *Legionella* spp. and *Pseudomonas aeruginosa*. The World Health Organization (WHO) has launched a practical water safety plan for health care premises with the title "Legionella and the prevention of legionellosis" that can be downloaded from the WHO website (www.who.int). It includes several practical recommendations to keep contaminants at a safe level in the hospital water system. Showers allow for the greatest risk of transmission of Legionella; the aim should be to keep water bacterial counts in wards with immunocompromised patient at a zero level. It is important to prevent bacterial growth during any construction period by regularly flushing outlets during this time.

Ventilation and air quality[8,9]

Ventilation is addressed in the WHO's *Policy on TB infection control in health-care facilities, congregate settings and households 2009.* Natural ventilation can be complemented with ultraviolet germicidal irradiation (UVGI) in areas where adequate ventilation is difficult to achieve. The choice of ventilation system should be based on facility assessment and informed by local climatic and socioeconomic conditions. Practical details for design are outlined in a WHO monograph.[8] Part 2 of the monograph includes the basic principles of how to design, operate, and maintain an effective natural ventilation system for IPC.

Space for handling of used and unused medical equipment

There should be separate rooms or areas for clean and dirty equipment. Proper handling of used and unused medical equipment requires separation of clean and dirty procedures to prevent clean equipment from becoming contaminated by dirty equipment. Designated areas are needed, as well as good cleaning and disinfection procedures. Dirty procedures, such as cleaning of soiled bedpans, should preferably be performed in a separate room.

Preparation of infusions and injections should take place in a separate clean room/area. Clean medical devices should be stored in a designated room or a defined place. Wrapped, sterile goods should be stored in

closed lockers or cabinets and, ideally, not on open shelves.

Space for handling food, laundry, and waste

Food for patients should be prepared by trained staff in a kitchen where all the surfaces are smooth and easily cleaned. Bed linen and working clothes of staff become contaminated with hospital flora and must be washed regularly. Laundry facilities are needed, as well as storage for clean and dirty linen. Clean linen should be stored in lockers or cabinets. Damp textiles must be aired and heat dried/ironed to prevent re-growth of microorganisms.

The WHO[23] has technical guidance for assessing waste production, creating national action plans, developing national healthcare waste management guidelines, and building capacity at a national level.

Floors and surfaces

Surfaces and furniture need to be cleaned and disinfected to prevent indirect contact transmission. Therefore, surfaces should be smooth for ease in cleaning and withstand exposure to water and detergents; this means no unlacquered wood and no carpets. The goal is to prevent collection of moisture, microorganisms from secretions and excretions, and chemicals. Carpets should be avoided everywhere since they accumulate dust and dirt and make cleaning difficult.

Several antibacterial coatings for surfaces have been introduced[24], however documentation of the effect of these products is still not confirmed. There is an ongoing debate about metallic ions and the development of antimicrobial resistance by collateral damage, i.e., promotion of antibacterial resistance.[25] Planning of generous space for storage of equipment should be included so that corridors, sinks, and shelves are free from too many objects to decrease contamination and improve cleaning.

Laboratory space

Each hospital should have some basic laboratory capacity to support the diagnosis of infectious diseases. A dedicated room with a microscope, a centrifuge, and dyes for microbiologic diagnosis is a minimum. The same requirement applies for access to blood gases and other biochemical diagnostic methods, for example blood and spinal sugar in case of meningitis. A more sophisticated and properly equipped laboratory with capacity to conduct advanced microbiological and biochemical diagnosis is recommended for middle and high income countries.

Resource Considerations

Design and construction planning relies on available resources; different levels of resources are outlined in Table 27.1.

Low resources

Countries with low resources should focus on basic factors to facilitate the following:

- Staff performing hand hygiene
- Availability of running water
- Safe sanitary environment
- Clean environment for storage of equipment and textiles
- Safe disposal of sharp items, waste, and linen
- Natural ventilation with ability to open windows

Medium resources

Factors /developments[26] that should be considered for construction and renovation projects in health care facilities in medium income countries consider:

- The number of day-care and out-patients will increase.
- Patients will stay in hospitals for shorter periods. On the other hand, patients in hospitals will be very sick and susceptible to infection and will need more care and more protection.

- The number of diagnostic procedures will increase. Therefore, at the end of the day, the patient may require more rest and privacy.
- People will become more obese. Therefore, health care facilities need longer and broader beds and stretchers, more square footage for rooms, doorways, and beds, and larger operating tables for heavy-weight persons.
- Water purification plants for special units, such as haemodialysis and transplant wards, need careful maintenance to prevent growth of *Legionella, Pseudomonas*, moulds, and other environmental microorganisms which should be taken into account when planning such specialized wards.

High resources

In high-income countries, health care facilities should be provided with a high percentage of single bed rooms.[13, 27] This allows for better sleep, more privacy, less noise, reduced bacterial transmission and increased capacity for isolation/precautions, fewer medication errors, and increased protection of patient-specific data.

ICT involvement

Advice on construction must be an important activity for IPC staff.[3] The ICT should have a broad understanding of disease transmission and experience related to construction and renovation. In addition, staff must have knowledge about the process of construction in order to provide the right kind of advice during each stage of the building process. IPC staff must know the risks for patients of contracting infections with *Aspergillus* ssp. and other spore-forming microorganisms in building dust during demolition and renovation.[28]

A structural risk assessment should be undertaken before planned demolition and renovation so that adequate interventions to protect immunocompromised patients can be prepared in advance. Examples of interventions are moving patients to other parts of the hospital, sealing windows permanently, putting up impermeable plastic barriers, damp mopping of floors and horizontal surfaces, putting up HEPA filters on incoming air and so on.

The ICT must remind planners that good IPC planning consists of keeping the flow of patients, staff, and equipment separated with well-defined borders between contaminated/dirty zones and clean zones. Finally, IPC staff must respect that renovation and redevelopment of existing premises will require compromising and is often not as ideal as the construction of entirely new buildings.

Most countries provide little or no training for engineers and architects in prevention of infection, and health care staff has limited experience with construction planning. IPC staff can serve as a link between medical personnel, architects, and engineers.

Meetings for planning take up time, so the ICT needs to prioritise. Areas where IPC input is particularly important are those where many procedures are carried out and patients are prone to infection (operating and delivery rooms, intensive care units), and also those where many patients are congregated (emergency rooms).

Involvement with facility management staff during the initial design phase is the key to preventing and controlling airborne and waterborne contamination.

Design and Construction Activities by IFIC

In 2007, the IFIC SIG “Design, construction and renovation” was founded. Its goal is to outline good practices for design, construction, and renovation. Another goal is to provide recommendations for low, medium, and high income countries. The SIG develops recommendations using the following guide:

- Basic: even with severely limited resources, “this is what you should do as a minimum”.
- Standard: “this is what you should aim for in less wealthy countries”.
- Ideal: “if you have the resources, this is what you could do”.

Draft practice recommendations are sent to all SIG members and each member can take part in preparing and discussing drafts. The final version of the recommendation is reviewed by the IFIC board before publication.

Table 27.1. Recommendations for design of a general hospital ward created by the IFIC Special Interest Group "Design, construction and renovation".

Room	Basic	Standard	Ideal
Patients´ rooms/bays Each room must have a sink for hand washing and space for gloves and aprons.	If you must have wards with many beds, you should also have some bays or, ideally, single rooms to cohort or isolate infectious patients. Each room must have a sink for hand washing and space for gloves and aprons. Each room must be equipped with alcohol-based hand rub.	Patients´ rooms/bays Each room must have a sink for hand washing and space for gloves and aprons.	One bed per room. The room should be big enough to house 2 beds, for family member or another patient. Each room must have a sink for hand washing and space for gloves and aprons. Each bed must be equipped with alcohol-based hand rub.
Isolation rooms for infectious patients	Recommended, preferably with en-suite wash and separate toilet.	Some single rooms with en-suite wash/shower and toilet.	Some single rooms with en-suite wash/shower and toilet. At least 2 of these rooms should have >12 HEPA-filtrated air changes per hour and anterooms with negative pressure
Distance between beds	Minimum 1 metre.	2 metres recommended.	More than 2 metres recommended.
Patients´ toilets	Toilets on each ward.	Sex-specific toilets on each ward, at least en-suite toilets in single rooms	En-suite toilets for each room.
Wash/shower/bathroom One shower room per ward should be big enough for a shower bed or bathtub	At least one wash/shower or bathroom on each ward in combination with toilet.	En-suite wash/shower for each patient room, recommended in combination with toilet.	En-suite wash/shower/ toilet room for each patient room.

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Room	Basic	Standard	Ideal
Other toilets	Separate toilets for both healthcare workers (HCW) and visitors.	Separate sex-specific toilets for both HCWs and visitors.	Separate sex-specific toilets for both HCWs and visitors.
Nurses´ workrooms (preparing care)	At least one room for both clean and dirty work. Organise a maximum distance between clean and dirty work areas to ensure separation.	Sharps must be collected in containers that can be properly closed One room for clean work (preparing medications) and one room for dirty work (cleaning/ disinfection of medical products, bedpans and perhaps instruments). On large wards more rooms may be necessary to reduce walking distances.	Sharps must be collected in containers that can be properly closed One room for clean work (preparing medications) and one room for dirty work (cleaning/ disinfection of medical products, bedpans and perhaps instruments). On large wards more rooms recommended to reduce walking distances.
Nurses` rooms	One room for organising work and breaks.	One room for organising work and one for breaks.	One room for organising work and one for breaks.
Doctors´ treatment/ examination rooms	One room desirable.	At least one room.	At least one room.
Waste room	There should be a specific area, preferably outside the ward, for the storage of waste awaiting collection. Waste sacks should be kept in large containers for collection.	Separate room for waste disposal. May be combined with room for dirty work.	One special room for waste storage.
Kitchen	Small kitchen with sink and refrigerator.	Small kitchen with sink and refrigerator.	Small kitchen with sink and refrigerator.

Table 27.1. Recommendations for design of a general hospital ward created by the IFIC Special Interest Group "Design, construction and renovation".

Room	Basic	Standard	Ideal
Storage of clean equipment and products	At least one great storage room.	At least one great storage room.	At least one great storage room.
Bed reprocessing (including cleaning of mattress and bedstead) Sheets, blankets, pillows sent to laundry	Bed reprocessing in patient room, not in corridor.	Bed reprocessing in patient room or in a reserved room on the floor.	Bed reprocessing in patient room or centralised.
Changing room for staff (if uniform is from the hospital)		Centralised or one room only for changing on the ward.	Centralised or one room only for changing on the ward.
Housekeeping and laundry room	Separate area for storing agents for cleaning and disinfection. Sacks for dirty laundry.	One room with sink, disinfectants, cleaning agents and cleaning cart. Sacks for dirty laundry.	One room with sink, disinfectants, cleaning agents and cleaning cart. Sacks for dirty laundry.

Conclusion

Advice on building design, construction, and renovation is a critical task for the ICT. Well-constructed facilities are needed to enable staff to follow IPC guidelines. Essential requirements for a health care facility include constant, reliable supplies of clean water and electricity, adequate numbers of beds and space between beds, good ventilation, sufficient sanitation for patients, visitors, and staff, and surfaces that can be cleaned and if needed, disinfected.

References

1. Sehulster L, Chinn RY. Guidelines for environmental infection control in health-care facilities. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). MMWR Recommendations and reports. *MMWR* 2003;52(RR-10):1-42. http://www.cdc.gov/hicpac/pdf/guidelines/eic_in_HCF_03.pdf [Accessed July 9, 2015]
2. Dettenkofer M, Seegers S, Antes G, Motschall E, Schumacher M, Daschner FD. Does the architecture of hospital facilities influence nosocomial infection rates? A systematic review. *Infect Control Hosp Epidemiol* 2004;25(1):21-5.
3. Wilson AP, Ridgway GL. Reducing hospital-acquired infection by design: the new University College London Hospital. *J Hosp Infect* 2006;62(3):264-9.
4. Zingg W, Holmes A, Dettenkofer M, Goetting T, Secci F, Clack L, et al. Hospital organisation, management, and structure for prevention of health-care-associated infection: a systematic review and expert consensus. *Lancet Infect Dis* 2015;15(2):212-24.
5. Lidwell OM, Lowbury EJ, Whyte W, Blowers R, Stanley SJ, Lowe D. Infection and sepsis after operations for total hip or knee-joint replacement: influence of ultraclean air, prophylactic antibiotics and other factors. *J Hygiene* 1984;93(3):505-29.
6. Yu IT, Xie ZH, Tsoi KK, Chiu YL, Lok SW, Tang XP, et al. Why did outbreaks of severe acute respiratory syndrome occur in some hospital wards but not in others? *Clin Infect Dis* 2007;44(8):1017-25.

7. Escombe AR, Oeser CC, Gilman RH, Navincopa M, Ticona E, Pan W, et al. Natural ventilation for the prevention of airborne contagion. *PLoS Med* 2007;4(2):e68.
8. WHO Guidelines. In: Atkinson J, Chartier Y, Pessoa-Silva CL, Jensen P, Li Y, Seto WH, editors. Natural *Ventilation for Infection Control in Health-Care Settings*. Geneva: World Health Organization: 2009. http://www.who.int/water_sanitation_health/publications/natural_ventilation/en/ [Accessed July 9, 2015]
9. WHO Guidelines. *WHO Policy on TB Infection Control in Health-Care Facilities, Congregate Settings and Households*. Geneva: World Health Organization; 2009. http://whqlibdoc.who.int/publications/2009/9789241598323_eng.pdf [Accessed July 9, 2015]
10. Mahmood A, Chaudhury H, Valente M. Nurses' perceptions of how physical environment affects medication errors in acute care settings. *App Nurs Res: ANR* 2011;24(4):229-37.
11. Detsky ME, Etchells E. Single-patient rooms for safe patient-centered hospitals. *JAMA* 2008;300(8):954-6.
12. Teltsch DY, Hanley J, Loo V, Goldberg P, Gursahaney A, Buckeridge DL. Infection acquisition following intensive care unit room privatization. *Arch Int Med* 2011;171(1):32-8.
13. Cheng VC, Tai JW, Chan WM, et al. Sequential introduction of single room isolation and hand hygiene campaign in the control of methicillin-resistant *Staphylococcus aureus* in intensive care unit. *BMC Infect Dis* 2010;10:263.
14. Ayliffe GA, Lowbury EJ. Airborne infection in hospital. *J Hosp Infect* 1982;3(3):217-40.
15. Ransjo U, Lytsy B, Melhus A, et al. Hospital outbreak control requires joint efforts from hospital management, microbiology and infection control. *J Hosp Infect* 2010;76(1):26-31.
16. Lidwell OM, Lowbury EJ, Whyte W, Blowers R, Stanley SJ, Lowe D. Effect of ultraclean air in operating rooms on deep sepsis in the joint after total hip or knee replacement: a randomised study. *Brit Med J* (Clinical research ed) 1982;285(6334):10-4.
17. Eckmanns T, Ruden H, Gastmeier P. The influence of high-efficiency particulate air filtration on mortality and fungal infection among highly immunosuppressed patients: a systematic review. *J Infect Dis* 2006;193(10):1408-18.
18. Best EL, Parnell P, Wilcox MH. Microbiological comparison of hand-drying methods: the potential for contamination of the environment, user, and bystander. *J Hosp Infect* 2014;88(4):199-206.
19. Kerr KG, Snelling AM. *Pseudomonas aeruginosa*: a formidable and ever-present adversary. *J Hosp Infect* 2009;73(4):338-44.
20. Starlander G, Melhus A. Minor outbreak of extended-spectrum beta-lactamase-producing *Klebsiella pneumoniae* in an intensive care unit due to a contaminated sink. *J Hosp Infect* 2012;82(2):122-4.
21. Hota S, Hirji Z, Stockton K, et al. Outbreak of multidrug-resistant Pseudomonas aeruginosa colonization and infection secondary to imperfect intensive care unit room design. *Infect Control Hosp Epidemiol* 2009;30(1):25-33.
22. WHO. *Guidelines for drinking-water quality*. http://www.who.int/water_sanitation_health/dwq/fulltext.pdf 2008;3rd edition. [Accessed July 9, 2015]
23. WHO. *Safe management of wastes from health-care activities,* 2008. http://whqlibdoc.who.int/publications/9241545259.pdf. [Accessed July 9, 2015]
24. Grass G, Rensing C, Solioz M. Metallic copper as an antimicrobial surface. *Appl Environ Microbiol* 2011;77(5):1541-7.
25. Sutterlin S, Edquist P, Sandegren L, et al. Silver resistance genes are overrepresented among Escherichia coli isolates with CTX-M production. *Appl Environ Microbiol* 2014;80(22):6863-9.
26. McKee M, Healy J. The role of the hospital in a changing environment. *Bull World Health Organization* 2000;78(6):803-10.
27. Chaudhury H, Mahmood A, Valente M. *The Use of Single Patient Rooms versus Multiple Occupancy Rooms in Acute Care Environments. Coalition for Health Environments Research*, 2004. https://www.healthdesign.org/sites/default/files/use_of_single_patient_rooms_v_multiple_occ._rooms-acute_care.pdf [Accessed July 9, 2015]
28. Kanamori H, Rutala WA, Sickbert-Bennett EE, Weber DJ. Review of Fungal Outbreaks and Infection Prevention in Healthcare Settings During Construction and Renovation. *Clin Infect Dis* 2015 Apr 13. pii:

civ297. http://cid.oxfordjournals.org/content/early/2015/04/13/cid.civ297.full.pdf+html [Accessed July 9, 2015]

Additional Resources

1. Bartley, JM. APIC State-of-the-Art Report: The role of infection control during construction in health care facilities. *Am J Infect Control* 2000;28:156-69 http://www.apic.org/Resource_/TinyMceFileManager/Practice_Guidance/IC-During-Construction-HC-Fac.pdf [Accessed July 9, 2015]
2. E Avis. *Patient-centered construction*, 2014. http://www.hfmmagazine.com/display/HFM-news-article.dhtml?dcrPath=/templatedata/HF_Common/NewsArticle/data/HFM/Magazine/2014/July/co-patient-safety-during-construction [Accessed July 9, 2015]
3. *Infection Control Principles for the Management of Construction, Renovation, Repairs and Maintenance within Health Care Facilities*, 2003 (reviewed 2005). http://www.ihea.org.au/files/InfectionControlManual.pdf[Accessed July 9, 2015]
4. *Infection Control Risk Assessment Matrix of Precautions for Construction & Renovation*, 2009. http://www.ashe.org/advocacy/organizations/CDC/pdfs/assessment_icra.pdf [Accessed July 9, 2015]
5. *Infection control risk assessment*. http://www.premiersafetyinstitute.org/safety-topics-az/building-design/infection-control-risk-assessment-icra/ [Accessed July 9, 2015]
6. American Society for Healthcare Engineering Resource Library. http://www.ashe.org/resources/library.dhtml [Accessed July 9, 2015]
7. Construction-related infection resources. IPAC – Canada. http://www.ipac-canada.org/links_construction.php [Accessed July 9, 2015]
8. Kanamori H, Rutala WA, Sickbert-Bennett EE, Weber DJ. Review of Fungal Outbreaks and Infection Prevention in Healthcare Settings During Construction and Renovation. *Clin Infect Dis* 2015; 61: 433-444.

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