Chapter 26
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.
- Several factors might influence transmission of infection, some of which are listed below:
    - Numbers of patient and staff
    - Numbers and types of procedures and examinations
    - Available space
    - Numbers and types of rooms
    - Number of beds in a room
    - Floors and surfaces
    - Water, electricity, and sanitation
    - Ventilation and air quality
    - Handling of used and unused medical equipment
    - Handling of food, laundry, and waste

Background[1-3]

The influence of design and construction on healthcare-associated infections (HAI) is difficult to evaluate. To identify environmental contributions to a risk-adjusted rate, such as surgical site infection (SSI), 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.

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, and any study will require impractically large numbers in order to show significant differences. Lidwell[4] 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 recent studies demonstrated the impact of the environment involving respiratory pathogens and suggested practical design lessons. The severe acute respiratory syndrome (SARS) study, involving a virus primarily transmitted by droplet/contact, highlights the importance of short-range aerosols; the *M. tuberculosis* study considers alternate designs to control airborne transmission.

Yu, et al.[5] conducted a case-control study in Guangzhou and Hong Kong, China, during the SARS epidemic of 2003 on 124 wards in 26 hospitals. Cases were on wards with super-spreading events of SARS; controls were on wards with SARS cases admitted but without HAI outbreaks. They found six significant risk factors, two of which were influenced by construction: distance between beds of <1 m (Odds Ratio 6.9) and availability of washing or changing facilities for staff (OR 0.12).

Escombe, et al.[6] investigated the influence of natural and mechanical ventilation and found that in countries with limited resources, window 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.[7-8]

Prevention

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. Important factors include design, ventilation, patient placement or relocation, and effective construction barriers to protect susceptible patients from airborne pathogens.

Risks related to construction/renovation work are primarily associated with reduced air quality and environmental contamination from fungi (e.g., *Aspergillus* spp.) or with 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 26.1. They include:

1. Air and water quality, e.g., heating, ventilating, and air-conditioning systems
2. Fixtures, e.g., sink numbers, placement of hand washing stations; dispensers for hand hygiene products and associated materials (soap, waterless alcohol-based hand rub, paper towels, lotion, and similar items)
3. Sharps and waste disposal placement
4. Surfaces, e.g., ceiling tiles, walls, counters, floor coverings, and furnishings
5. Utility rooms, e.g., soiled, clean, instrument processing
6. Storage areas, including patient care supplies and personal protective equipment
7. Patient placement and basic room design

Numbers and types of rooms[9, 10]

Patient care units or wards may be overcrowded. 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. Single rooms for isolating infectious

patients should be available, especially in countries where communicable diseases are endemic.

Laboratory space

Each hospital should have some laboratory capacity to support the diagnosis of infectious diseases. A side room with microscope, centrifuge, and dyes is the minimum.

Hand hygiene facilities

Alcohol-based hand rubs (ABHR) are critical, especially if wash basins are limited and water supply interrupted. There should be enough dispensers for ABHR, liquid soap, and paper towels for staff use. Reusable dispensers must be maintained, cleaned and then refilled.

Floors and surfaces

Surfaces and furniture need to be cleaned and disinfected to prevent indirect contact transmission. Surfaces should be smooth for ease in cleaning; this means no unlacquered wood and no carpets. The goal is to prevent collection of moisture, microorganisms from secretions and excretions, and chemicals.

Water, electricity and sanitation[11]

Drinking water must be controlled and regularly checked for quality and safe levels of contaminants. Every ward should have enough toilets for both sexes. Toilets and washbasins must be maintained and cleaned daily. Showers should be available. Clean water supply and electricity should be available 24 hours a day.

Ventilation and air quality [7-8]

Natural ventilation is addressed in the World Health Organization's *Policy on TB infection control in health-care facilities, congregate settings and households 2009*. 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 the WHO's monograph, *Natural ventilation for infection control in health-care settings*.

Handling of used and unused medical equipment

Proper handling of used and unused medical equipment requires separation of clean and dirty procedures. Designated areas are needed, as well as good cleaning and disinfection procedures.

Preparation of infusions and injections should take place in a separate clean room/area. Dirty procedures, such as cleaning of soiled bedpans, should be performed in another room.

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 not on open shelves.

Handling of 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. Hot food must be consumed immediately or chilled before storage.

Bed linen and working clothes of staff become contaminated and should be washed in the health care facility. Laundry facilities are needed, as well as storage for clean and dirty linen. Damp textiles must be aired and heat dried/ironed to prevent re-growth of microorganisms.

The WHO[12] has technical guidance for assessing waste production, creating national action plans, developing national healthcare waste management guidelines, and building capacity at a national level.

Resource Considerations

Medium to high resources

Factors /developments[13] that should be considered for health care planning in medium and high income countries include:

- 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 get larger and more obese. Therefore, health care facilities need longer 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.

High-level resources

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

Infection Control Team Involvement

Advice on construction must be a main focus for infection prevention and control (IPC) staff. They should have a broad understanding of disease transmission and experience related to construction and renovation. Most countries have 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 IPC staff need 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 Special Interest Group (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.

- 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 26.1 provides an example of recommendations from the SIG based on this approach. This table details the principles for a general ward. Additional recommendations may be found on the IFIC website: www.theific.org

Conclusion

Advice on building design, construction, and renovation is a critical task for IPC staff. Well-constructed localities 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, and sufficient sanitation for patients, visitors and staff, and surfaces that can be cleaned and if needed, disinfected.

References

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Table 26.1 Recommendations for design of a general hospital ward

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 be equipped with alcohol-based hand rub.	2 beds, maximum 4 beds. There should also be some single rooms for infectious patients. Each bed must be equipped with alcohol-based hand rub.	One bed per room. The room should be big enough to house 2 beds, for family member or another patient.
Isolation rooms for infectious patients	Recommended, preferably with en-suite wash and separate toilet.	Some single rooms with en-suite wash/ shower and toilet.	At least 2 of these rooms should have >12 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.
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.

Room	Basic	Standard	Ideal
Nurses´ workrooms (preparing care) Sharps must be collected in containers that close	At least one room for both clean and dirty work. Organise a maximum distance between clean and dirty work areas to ensure separation.	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.	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.	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.

Room	Basic	Standard	Ideal
Storage of clean equipment and products		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 cleaning and disinfection agents in some area. 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.

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Further Reading

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