





Infection Prevention in Hospitals: Designing Away The Risks



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- What are the risks in hospitals?
- Why is health planning so important in designing a new or refurbishing an existing residential aged care facility?
- How does the built environment help support appropriate Infection Control practices?
- Systems need to be designed to reduce and limit the possibility of infectious diseases being transmitted from patient to patient and patient to staff
- Control of infection needs to be "designed into" hospitals to deal with new diseases and support new medical techniques













What are the risks in hospitals?

- How are infections spread?
- Routes of Transmission
 - Contact- direct and indirect
 - Droplet
 - Airborne
 - Food and Water



Contact Transmission

- MRSA, VRE, (CRE eg NDM), C difficile
 Droplet
- Common cold, influenza,
 Airborne
- TB, measles, chicken-pox,
- ? SARS ? Bird flu ? MERS CoV



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Each patient room, examination

room, and procedure room needs at least one sink . Optimally, it should be as close to the entrance of the room as possible and be large enough to prevent splashing. Too shallow a sink may cause contamination of hands by bacteria residing in the drain, and make it impossible to do good handwashing

















Elements to Reduce Contact Transmission

Distance and space



Keeping your distance

Eg Meningococcal infection spread in service men during the First World War.

Glover demonstrated a close relationship between bed spacing and infection carriage.

This rate was found to increase dramatically when the distance between beds fell to below the peace time standard of 3ft (0.91m).

Health Building Note 4 (NHS Estates 1997) provides guidance on the bed space allowance in multibed bays of between 2.3m and 2.5m to allow sufficient space for nursing and patient activities.

This standard has changed little from the recommendations of Florence Nightingale (1859) for a minimum space between beds of 8ft (2.44m).



Keeping your distance

Impact of introducing a fifth bed into a conventional four bed bay, decreasing distance between beds from 2.5 to 1.9m increased transfer of MRSA 3.15 times



Kubbler, J Hosp Inf 1998

Contact Transmission

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Clostridium difficile

Patients with *Clostridium difficile*-associated disease (CDAD) shed spores into the environment. Spores survive for days, weeks

Traditional recommendation to keep in isolation room till diarrhea resolves.





Droplet Transmission

The size of large droplets produced during respiratory activities such as coughing can be larger than 50-100 µm. These droplets tend to evaporate quickly and contribute to both airborne and droplet transmission of disease. Large droplets from respiratory activities can travel up to 1.5 m, which agrees well with the established range of infection due to droplet transmission. The distance between beds should be greater than 1.5 m. Other factors such as temperature, humidity, wind currents can affect rate of evaporation, and distance travelled



The term droplet is often taken to refer to droplets >5 μ m in diameter that fall rapidly to the ground under gravity, and therefore are transmitted only over a limited distance (e.g. ≤ 1 m).

In contrast, the term droplet nuclei refers to droplets ≤ 5 µm in diameter that can remain suspended in air for significant periods of time, allowing them to be transmitted over distances >1 m

Other factors such as temperature, humidity, wind currents can affect rate of evaporation, and distance travelled

> Stetzenbach, Buttner & Cruz, 2004; Wong & Leung, 2004



Droplet Transmission



Settles, Department of Mechanical and Nuclear Engineering, Pennsylvania State University, PA, USA;



Davidhazy, School of Photographic Arts and Sciences, Rochester Institute of Technology Rochester, NY, USA,

Natural Ventilation for Infection Control in Health-Care Settings, WHO, 2009



Space and Isolation Rooms

Palmer (1999) stated that the space around beds in a multi bed ward is crucial in controlling infection spread to the environment.

If the allotted space around the single bed is insufficient, the equipment could become contaminated and, if subsequently relocated to another patient room, could lead to a risk of cross infection.

Sufficient space is also required around single patient beds for equipment.

Lawson and Phiri (2004) recommend that single patient rooms should be a minimum of 20m2 in area with recommended dimensions of 5m by 4m excluding ensuite facilities.

NHS Estates 2003 covers the design of critical care facilities and suggests that all beds should have a minimum floor area of 26 m2



Airborne Isolation

- a negative pressure differential of >2.5 Pa (0.01-inch water gauge);
- an airflow differential >125-cfm (56 l/s) exhaust versus supply;
- clean-to-dirty airflow;
- sealing of the room, allowing approximately 0.5 square feet (0.046 m2) leakage;
- >12 ACH for a new building, and >6 ACH in existing buildings (e.g. equivalent to 40 l/s for a 4×2×3 m3 room) for an old building; and
- an exhaust to the outside, or a HEPA-filter if room air is recirculated



Ventilation Requirements

AIIR with Anteroom



An anteroom should be at positive pressure with respect to the AIIR, and at either neutral or negative pressure with respect to the corridor.



Positive Pressure Room

- Facility dealing with very immune suppressed patients eg transplants, leukaemias
- Positive pressure rooms with HEPA filtered air





Ventilation

a sudden change with warm, moist ambient air may induce condensation when the surface temperature is lower than the dew-point temperature of the moist incoming air







WHO Publication/Guidelines

Natural Ventilation for Infection Control in Health-Care Settings

Edited by: James Atkinson, Yves Chartier, Carmen Lúcia Pessoa-Silva, Paul Jensen, Yuguo Li and Wing-Hong Seto



Natural Ventilation

- Natural ventilation is variable and depends on outside climatic conditions relative to the indoor environment.
- Natural ventilation may be difficult to control, with airflow being uncomfortably high in some locations and stagnant in others. There is a possibility of having a low air-change rate during certain unfavourable climate conditions.
- There can be difficulty in controlling the airflow direction due to the absence of a well-sustained negative pressure; contamination of corridors and adjacent rooms is therefore a risk.
- Natural ventilation precludes the use of particulate filters. Climate, security and cultural criteria may dictate that windows and vents remain closed; in these circumstances, ventilation rates may be much lower.
- Natural ventilation only works when natural forces are available; when a high ventilation rate is required, the requirement for the availability of natural forces is also correspondingly high.
- Natural ventilation systems often do not work as expected, and normal operation may be interrupted for numerous reasons, including windows or doors not open, equipment failure



Parameters	General respiratory ward	Drug- susceptible TB ward	MDR-TB ward	Isolation room	Procedures room
Floor area (m ²)	166	51	35	11.7	23
Ceiling height (m)	4.2	4.2	4.2	4.2	4.2
Total window area (m ²)	32.3	32.3	18.4	3.0	20.3
Openable window area (m ²)	12.5	22.0	12.3	3.0	19.6
Area of doors (m ²)	16.6 (n = 4)	9.2 (n = 2)	3.8 (n = 1)	2.0 (n = 1)	3.7
Mean ACH	25 (n = 26)	29 (n = 15)	33 (n = 42)	49 (n = 7)	51 (n = 7)

Table F.1 Ward data and measured air changes per hour



















- Hospitals generate vast amounts of waste material in the form of food, paper and plastics, the majority of which is not recycled
- Need space to keep dirty re-usables eg linen, waste before disposal
- Need to plan routes, with clear separation for 'clean' vs 'dirty'
- Waste disposal is integral to design of hospital (Biohazardous and Non-biohazardous)
- Eg ? Wash and re-use eg bed pans vs disposable



Poor design supports poor practice



Flett, Kaczmarski & Hinde



• What if we Don't Plan and Build Enough?





Infrastructure Requirements

- Limited negative pressure rooms
- Limited isolation rooms











Interior Design and Furnishings



- Ideally, walls and ceilings should have a smooth, impervious surface that is easy to clean with minimal likelihood of dust accumulation
- Surfaces that are porous or textured may be difficult to clean and might therefore harbor potentially pathogenic microbes





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Interior Design and Furnishings







- Designing of a safe, efficient and comfortable environment for patients and staff
 - Support and reinforce hand washing and PPE compliance
 - Increase protection for susceptible clients and ensure the ability to isolate with single rooms and no shared ensuites.
 - Designing appropriate storage and waste disposal spaces make it discrete but accessible
- Providing a logical progression and flow between different spaces
 Plan design in the ability to change room configuration with the ability to shut off
 parts of a facility and isolate infection.
 - Design appropriate storage and waste disposal spaces make it discrete but accessible
 - Plan for separate clean and dirty flows for waste including linen.
- Balancing the use of materials that are efficient and easy to clean



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