Chapter 10: Environmental considerations in infection control and prevention

Please refer to the relevant IUSS guidelines that can be found at www.iussonline.co.za as well as the SASA website

Operating theatre ventilation[263-265]

- Every operating theatre complex requires an effective central humidity ventilation and air-conditioning system (HVAC).
- Maintain at least 15–20 air changes per hour of which at least three such air changes should be with fresh air.
- Maintain positive pressure within the operating theatre compared to the corridors and adjacent areas. This is to facilitate the movement of air from the operating theatre along a pressure gradient towards adjacent areas. Air thus moves away from the sterile operating site, thus reducing the risk of contaminated air getting in contact with the operating field and sterile instruments.
- Ideally, air should come from the ceiling and move towards at least two air exhaust vents located close to the floor.
- Make sure that air exhaust vents are not obstructed or covered.
- All air (re-circulating and fresh air) should pass through filters before entering the operating theatre.
- Keep the doors to the operating theatres closed at all times.
- The air-conditioner system should operate continuously independent of whether there is a case on the table or not.

Rationale[263]

The quality of air in theatre is important both for the comfort of the personnel but more importantly to prevent contamination of the surgical wound and/or transmission of pathogens. Air in theatre can contain skin squames from both patient and healthcare workers, respiratory droplets and aerosols that may contain microorganisms, dust, lint and anaesthetic gasses. Airflow should be directed in such a fashion that it will cause the cleanest air to be closest to the surgical wound and dirty air to move away from the wound. Clean air coming from a ceiling pendant and moving towards air exhaust vents close to the floor can aid in this regard. The velocity of the air flow should be low to avoid drafts and swirls that can lead to the re-circulation of microbes. It should, however, be high enough to allow adequate air changes per hour. The air-conditioner system should operate continuously, even if there is no case being done. This is to prevent the theatre from being contaminated during down-time.

Forced-air warmers

- Consider using conductive fabric warmers over forced-air warmers for preventing intraoperative hypothermia, especially in high-risk surgery such as joint replacements.[265,266]
- Where conductive fabric warmers are not available, forced-air warmers should be used as the risk of hypothermia outweighs the possible risk of contamination of the surgical wound.

Rationale

The use of forced-air warming blankets is common practice to prevent intraoperative hypothermia. McGovern et al.[266] had looked at air currents in a simulated scenario in theatres with ultra-clean ventilation. They used neutral bubbles to allow visualisation of air currents. The use of a forced-air warming blanket was associated with contamination of the surgical field by mobilising particles from under the drapes. The machine that generates a forced-air current is usually placed on the floor. It creates a warm area that results in convection currents. It was shown that these convection currents cause an upward air current with mobilisation of particles from the floor. These particles contaminated the surgical site. A review of the literature by Kellam et al.[267] found that current evidence is inconclusive with regards to the actual risk of surgical site infections. It is also unclear whether the type of ventilation makes a difference with Sessler et al.[268] finding that air currents are not affected by a forced-air warming device when used in a laminar flow theatre. More high quality studies are needed before a definitive recommendation can be made.

Operating theatre temperature and humidity[264,269]

- Keep ambient theatre temperature between 18–24 ºC.
- The ambient temperature should be uniform throughout the space.
- Keep humidity levels between 30–60%.

Rationale[263]

The international standard for ambient theatre temperature is between 20–24 ºC. The South African IUSS standards recommend temperatures to be between 18–24 °C. There may be certain cases where temperatures outside of this range may be indicated. Higher ambient temperatures are needed in theatres where burns cases or paediatric cases are being done. It should be noted that this is a trade-off with an increased risk of infection. Cases that may require a lower temperature include cardiac theatres and orthopaedic theatres, especially theatres where arthroplasty cases are done.

Humidity should be maintained within the recommended range. Humidity has a direct influence on thermal comfort. In addition, it influences the quality of air with regards to the microbial load.

Low humidity environments increase the risk that microorganisms especially Gram-positive cocci and fungi that can persist with dust particles or on surfaces.[270] Enterococci can persist on dry areas for between seven days to four months.[271] High humidity can be uncomfortable to theatre staff and it also promotes the growth of microorganisms, especially Gram-negative bacilli and fungi. Microorganisms trapped in the water molecules can become airborne and carried over larger areas.[263]

Environmental cleaning of the operating theatre[70,269,272]

Definitions:

Cleaning	• The physical removal of foreign material, e.g. dust, soil, and organic material such as: blood, secretions, excretions and microorganisms. Cleaning physically removes rather than kills microorganisms. • It is accomplished with water, detergents and mechanical action.
Contact time/ Dwell time	• The defined time for which surfaces are exposed to a chemical or thermal disinfection process to achieve the appropriate level of disinfection. • Inadequate contact time may lead to incomplete disinfection.
Disinfectant	• Product used on inanimate objects to reduce the quantity of microorganisms to an acceptable level. • Hospital-grade disinfectants require a drug identification number (DIN). • High-level disinfectants should not be used to clean environmental or inanimate objects.
Disinfection	• The inactivation of disease-producing microorganism with the exception of bacterial spores. • Hospital-grade disinfectants are used on inanimate objects. • Medical equipment must be cleaned properly before effective disinfection can take place.
Preliminary cleaning	• Damp dust horizontal surfaces prior to first case. Do not clean with dry materials as that causes dust to become airborne. • Use a clean, lint-free cloth moistened with low-level disinfectant. • Avoid spraying or misting methods. • Start at higher surfaces and work down in a clockwise manner. • Damp dust equipment before it is brought into or out of the operating theatre. • Inspect operating theatre lights for cleanliness before the first case of the day. • Floors should always be considered contaminated even after proper cleaning.
Intraoperative cleaning	• The responsibility for verifying disinfection of a contaminated surface rests with the perioperative team member who is first aware of the contamination. • All contaminated (blood, body fluids, or other potentially infectious material) items or surfaces occurring intraoperatively are to be promptly cleaned/disinfected as required using facility-approved disinfectant. • Equipment leaving the operating theatre is cleaned and disinfected with hospital approved disinfectant. • Chemical spills occurring intraoperatively are to be managed as per site/regional policy/procedure.
Between procedures	• Each operating theatre must be cleaned and disinfected immediately after each case. • Do not start the process before the patient has left the area. • Prior to cleaning, remove all trash, linen, and recycling from the room, including soiled anaesthesia equipment and supplies. • All surfaces that have been in direct or indirect contact with the patient or body fluids are considered to be contaminated and therefore are to be cleaned/disinfected with a hospital-approved disinfectant. • Contaminated linen should be handled as little as possible.
Terminal cleaning	• Cleaning staff should adhere to standard precautions with regards to PPE. • Staff preforming cleaning may be required to wear additional PPE during terminal cleaning after procedures with additional precautions such as the highly infectious patient. • Operating theatres are to be terminally cleaned at minimum once every 24 hours during a regular workweek regardless of whether the theatre has been used. • All floors should be cleaned using a wet vacuum or single-use mop and a disinfectant (follow dwell time indicated on manufacturer's instructions). • Floor cleaning should progress from cleanest area to dirtiest, from perimeter of the room to the centre. • Care must be taken to ensure the floor under the theatre bed and trolleys are also cleaned.

Cleaning of surfaces and instruments with detergents is needed before disinfection and decontamination can take place. The presence of organic matter, salts and obvious contamination can compromise the efficacy of the terminal reprocessing procedures.

Use EPA-approved disinfectants such as a quaternary ammonium compound to clean all areas that could have been contaminated during the procedure. Avoid methods that can lead to mist, aerosols or dispersion of dust.

Some centres use hydrogen peroxide automated fogging machines. The operating theatre is sealed and locked while the machine is in use. The theatre can be entered once the hydrogen peroxide level has decreased to less than 1 ppm. Decreases in microbial load are in the region of 4 logs.[273,274] Ultraviolet light is also being used and seems to have a log reduction of 1–2 logs.

Surgical attire[269,275-278]

Scrubs

- Scrubs should be made from material that is tightly woven, low-linting, stain-resistant and non-flammable.
- It should not be 100% fleece but rather a mixture of cotton with 10–20% polyester.
- Change scrubs that are visibly soiled or contaminated with potentially infectious material.
- Reusable scrubs should be washed at a healthcare-accredited laundry.
- For procedures at high risk of contamination from blood or bodily fluids, a waterproof apron should be worn under the surgical gown.
- Surgical scrubs should not be worn outside the operating theatre complex due to the risk of spreading microorganisms.

- Home laundering of scrubs is not recommended as it does not meet specified criteria to reduce microbial load.
- Maintaining good personal hygiene is as important as wearing appropriate theatre attire.

Other theatre attire

- Wear a surgical mask when packs are open and for the duration of the procedure.
- The surgical mask must cover all facial hair, the mouth and the nose.
- Wear a theatre cap that covers all hair on the head and sideburns.
- Shoe covers do not protect against SSIs.
- Shoe covers can be replaced with dedicated theatre shoes that are easily washable and washed at the end of the day.
- Outside shoes should not be worn inside the operating theatre.
- PPE use should be based on the most likely mode of transmission of organisms.

Rationale

Members of the surgical team entering the operating theatre when an operation is about to begin or already underway should wear a mask and headgear that fully covers hair, sideburns, and neckline. Experimental studies using tracer particles have shown that bacteria can be shed from hair, exposed skin, and mucous membranes of both operating theatre personnel and the patient's skin. This is why we use barriers (masks, gowns, hood, and drapes) in the operating theatre. Besides sterile gloves and impervious surgical gowns, no clinical studies have proved that the use of these barriers has led to a decrease in SSI rates.[279] They are nonetheless recommended not only for the purpose of reducing the shedding of microorganisms in the operating theatre but also as part of standard precautions. Barriers are most important when the procedure implies the insertion of an implant/prosthesis.

The type of surgical headgear (bouffant or skull caps) has been called into question. A 2017 study showed that disposable bouffant hats had greater permeability and microbial shed and increased passive microbial shed compared to disposable skull caps and cloth caps.[280] Multiple studies have shown the hair of personnel to be contaminated with microorganisms, especially *Staphylococcus Aureus* and *Coagulase-negative staphylococcus*.[281-283]

Floors are rapidly re-contaminated after being washed. Shoes and shoe covers subsequently become contaminated and these microorganisms can then be transferred from patient to bed sheets or to hands when shoe covers are removed.[284,285] Shoe covers can be replaced by ordinary shoes dedicated exclusively to the operating theatre because no significant difference was found in floor contamination whether personnel wear shoe covers or dedicated theatre shoes. These shoes must be easy to wash. Shoes worn outside theatre can be visibly contaminated and should be changed for dedicated theatre shoes. The practice of wearing plastic/paper shoe covers for the purpose of decreasing SSIs should be abandoned.

Personal protective equipment

- Different types of protective clothing are needed in different parts of the perioperative environment.
- PPE are different barriers that are used in a combination to protect skin, mucosa, breathing ways, and clothes from coming into contact with blood-borne pathogens, other potentially infected materials, and chemicals. PPE includes gown or apron, gloves, mask, goggles, and visor.
- Standard precautions should always be applied, and additional precautions should be based on mode of transmission.
- They are also used to protect the instruments from getting contaminated by bacteria and other particles from the human body. Due to the shedding of bacteria from the human body, the use of protective clothing, as well as personal hygiene, are of great importance when it comes to the control of cross-infection risks.