



INTERNATIONAL
SOCIETY
FOR INFECTIOUS
DISEASES

GUIDE TO INFECTION CONTROL IN THE HEALTHCARE SETTING

Patient Areas and Environmental Cleaning

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INTRODUCTION

Since the writings of Florence Nightingale in the 19th century the need for a clean patient care environment is unquestioned. However, the exact extent to which environmental reservoirs contribute to hospital-acquired infections (HAI) remains uncertain.

Environment reservoirs have been linked with outbreaks of hospital acquired infections, e. g. sinks, air filters, heater cooler units, insulation materials, cleaning materials, alcohol-based handrub dispensers or other surfaces. Other objects and surfaces known to harbour bacteria, such as toilets, and medical waste have not been convincingly linked to HAI.

KEY ISSUE

The patient's environment serves as a major reservoir of microorganisms. The presence of multiple-drug resistant bacteria in the environment, both Gram-negative bacilli and Gram-positive cocci, is an important contributing factor to healthcare-associated infections (HAI). Microorganisms such as methicillin-resistant *Streptococcus aureus* (MRSA), glycopeptide-resistant enterococci (GRE), *Clostridium difficile*, *Acinetobacter* species, fungi, and noroviruses, can survive on environmental surfaces for weeks to months. The lack of budgetary constraints and contracting out cleaning services have resulted in an overall deterioration in hospital hygiene practices in healthcare facilities (HCFs).

KNOWN FACTS

- Patients need a clean environment to prevent HAI. The environment becomes contaminated from hands, droplets from coughing, sneezing,

or splashing and therefore a systematic and structured approach of high quality cleaning and disinfection when required, is essential.

- Medical devices (especially those containing water) can get contaminated during manufacturing or while being used and serve as a continuous source in the patient environment (e.g., heater cooler units)
- Reducing bacterial contamination in the environment reduces the risk for acquiring HAI.
- The process of cleaning is both variable and inconsistent and even well established cleaning programs total elimination of microorganisms such as *Acinetobacter* from the environment is difficult to achieve. Reasons for this include: poor cleaning methods, missing high-touch surfaces, tolerance to, or misuse of, disinfectants, and a heavy bioburden. Lack of high-level (managerial) support for cleaners, poor understanding of the importance of environmental cleanliness, housekeeping budget cuts, and absence of well-designed studies to evaluate the cost versus benefit of cleaning are major problems. In addition to reducing environmental reservoirs for microorganisms, environmental cleaning has an important aesthetic purpose and is crucial for patient confidence.

Controversial Issues

- The extent to which environmental reservoirs contribute to nosocomial infections remains controversial but recent evidence suggests it might have a significant role to play.
- The routine use of disinfectants applied to environmental surfaces as opposed to non-disinfectants (detergents) alone, remains unclear but cross-resistance between extensive use of disinfectants and antibiotics has been described.
- Influence of climate on environmental contamination (temperature and humidity). In countries with excessive dust or damp, the environment is difficult to keep clean.

- The hand washbasins in clinical patient rooms as a source of multidrug-resistant Gram-negative bacteria especially *Acinetobacter* spp., *Pseudomonas aeruginosa*, and others is recently been highlighted.
- Routine use of automated area decontamination (AAD) technologies (e.g., using hydrogen peroxide, peracetic acid, or UV irradiation) especially in low-and middle-income countries (LMICs).
- Microbial sampling of the environment.

Antimicrobial surfaces such as copper, silver, or other heavy metals

SUGGESTED PRACTICE

General Principles

The environment should be kept dry, clean, well ventilated, and ideally exposed to sunlight to prevent microbial multiplication and the spread of multidrug-resistant (MDR) pathogens.

Patient areas should be cleaned regularly especially high touch surfaces (e.g., beds, mattresses, infusion pumps, bed railings, touch screens, keyboards and medical equipment). Disinfection with an appropriate product could be considered in exceptional circumstances such as high dependency units. Terminal cleaning after a patient colonized or infected with a multidrug resistant bacteria leaves a room should be first cleaned thoroughly and then disinfected with an appropriate disinfectant.

Surfaces

- Housekeeping surfaces (floors, walls tabletops) have been associated with outbreaks of vancomycin-resistant Enterococci and methicillin-resistant *Staphylococcus aureus* (MRSA), *C. difficile*, noroviruses, and Gram-negative bacilli (extended-spectrum beta-lactamases or carbapenemase-positive isolates). Routine cleaning of housekeeping surfaces with detergents is sufficient in most circumstances. In case of

outbreaks, especially when due to resistant microorganisms known to be harbored in the environment, additional cleaning with a disinfection solution may be indicated (infection prevention and control (IPC) teams to advise). Environmental contamination with microorganisms may be due to the lack of adherence to facility procedures for cleaning, however, surface disinfection is not a substitute for standard infection control measures. Spills of blood and body substances should be promptly cleaned and decontaminated according to the hospital policy.

- Antimicrobial surfaces such as copper and silver have shown to maintain a reduced level of environmental contamination. Studies using copper coating for high touch surfaces have shown to be effective in reducing bacterial counts and healthcare associated infection in intensive units.

Monitoring of quality and compliance to protocols

- Monitoring for adherence to recommended environmental cleaning practices is an important component for success in cleaning practices and requires good record keeping which is regularly inspected by the IPC team preferably using checklists.
- Visual inspections on cleanliness have only limited value in evaluating the risk of environmental contamination since a visually clean surface is not necessarily free of microorganisms. Additional tools are available to make such an assessment. Reflective surface markers, adenosine triphosphate analysis, and microbiological analysis can all be used to determine the process or outcome of the decontamination. The ideal assessment tool has yet to be developed since all the tools mentioned have weaknesses (e.g., costs, turnaround time, sensitivity, specificity, and applicability).

Training

Cleaning and disinfection is performed by domestic services, nurses, and care-assistants. Often it is unclear who cleans what, how, and when. It is

crucial that a training and evaluation process of the cleaning and disinfection is in place. It has been shown training and feedback of practices can significantly improve the quality of the cleaning and disinfection. Records of content of training and the number of training and refresher courses should be kept.

- Education and training of both managers and staff undertaking environmental cleaning should be clearly defined in written policies and evaluated regularly using checklists during inspection.
- Cleaning procedures should be defined, applied consistently, and compliance to these validated. Cleaning personnel should be properly trained and responsibility for implementation of cleaning practices needs to be assigned. Cleaning schedules should be adapted in accordance to clinical risk, location, type of site, and hand-touch frequency.
- Contaminated near-patient hand-touch sites (e.g., drip stands, overbed tables, monitors, etc.) are likely to provide the greatest risk to patients as healthcare personnel frequently touch them. As ward cleaners infrequently clean hand-touch sites, nursing personnel should assume responsibility to ensure that they are regularly decontaminated.
- Products used for cleaning and decontamination of the environment should be used according to the hospital policy, manufacturer's instructions, and available scientific information.
- Infrequently touched ("non-hand-contact") environmental surfaces should be cleaned with a detergent when visibly soiled and as required to maintain an aesthetically pleasing environment. Dedicated, non-critical equipment should be used on patients infected with antibiotic-resistant organisms. If this is not possible, shared non-critical items must be cleaned and disinfected between patient uses.

Carpeting and cloth furnishing

Carpeting and cloth furnishings may be a source of dust containing microorganisms and should not be present in clinical or patient areas as these are difficult to keep clean. These types of surfaces should be avoided

were spills are likely, in patient rooms and in areas housing immunosuppressed patients. Where carpets are used such as in offices, routine cleaning should be performed with well-maintained equipment designed to minimize dust dispersion.

Bed and window curtains

- Curtains made of woven material used for patient privacy get easily contaminated by hands, equipment, and direct contact with staff and visitors. If woven material is used, it should be changed along with the bed linen at the end of each patient admission. Curtains made of non-woven material can be cleaned more easily by wiping with a detergent but require changing regularly, usually every month.
- In countries where impregnated mosquito nets are widely used in healthcare facilities, these are rarely changed. A system must be in place that allows regular laundry, change, and replacement of mosquito nets to avoid exposure of already vulnerable patients.

Hospital toilets

- Hospital toilets in facilities where adequate cleaning protocols are adhered to, are expected to have low levels of contamination. However, on units for mentally impaired adults, young children, or neurologically impaired patients heavy soiling with feces may occur resulting in cross infections between patients.
- Hospital toilets should be cleaned thoroughly with a detergent solution. The bowl should be cleaned with an ammonia based detergent and a firm nylon brush. Disinfectants should not be poured in the bowl as these become diluted with the water in the S-bend, most are inactivated by organic matter and it is wasteful unless clearly indicated. When flushing the toilet it is best to keep the lid closed to prevent aerosolization of faecal pathogens -- this is particularly relevant when nursing patients with multidrug-resistant Gram-negative bacteria.

Flowers and plants

The water containing cut flowers may yield high numbers of microorganisms including *Acinetobacter*, *Klebsiella* spp., *Enterobacter* spp., *Pseudomonas* spp., *Serratia marcescens*, and *Flavobacterium*.

Microorganisms from cut flowers or potted plants were linked with hospital-acquired infections. Cut flowers and potted plants should be avoided in rooms of immunocompromised and intensive care unit patients. Flowers should be either handled by support staff who have little or no patient contact or nursing staff should clean their hands thoroughly after they handle flowers.

Laundry

- Patients should have clean, freshly laundered bed linens. During the handling of used bed linen there may be an increase of airborne microorganisms, mainly arising from the patient's skin scales and surroundings.
- Soiled linen should be handled as little as possible and with minimum agitation and should not be sorted or pre-rinsed in patient care areas. Linens soiled with blood or body fluids should be carefully placed in the correct colour coded, leak proof bags and transported with care to an area where it is safely stored awaiting collection. Porters and support staff handling linen must wear domestic gloves and a water resistant apron. Transport of linen should be in containers that can be easily washed down with water and detergent, and dried, at the end of each day's collection.

Construction projects

Construction projects have been linked to healthcare associated fungal infections and Gram-positive bacilli outbreaks. Therefore, careful control measures should be planned well in advance and implemented for hospital construction projects. These measures should include erection of physical barriers and temporary shut down of ventilation systems. If possible, air

flow of ventilation systems should re-routed to protect sensitive areas. Traffic flow patterns for construction personal should be defined and separated from those of patients and health care workers. After the construction is completed, a thorough cleaning of the site is required prior to handing over the project.

Healthcare waste management

- Healthcare waste arising from patients on, or rooms with, transmission-based precautions, laboratories (microbiology, biochemistry, and pathology) should be treated as infectious. Routinely, paper, wrapping, food, and other material that has not been in contact with blood or body fluids is regarded as domestic waste. Human parts, chemicals from pharmacy, and toxic waste from radiology and oncology must be discarded safely and appropriately, according to national or local agreed guidelines.
- Healthcare waste should be segregated at source using a colour coding system. Clinical or infectious waste should be clearly labelled and sent for appropriate final disposal in fluid proof closed containers. Non-clinical or domestic waste should be stored awaiting collection and usually goes to land fill. All those handling healthcare waste must wear appropriate personal protective equipment including domestic gloves, overalls, and closed boots.
- The safe disposal of sharps and blood and body fluids is essential since these are considered potentially infectious. Safety of those handling sharps containers or blood and body fluids must be clearly laid out in policy. Accidental injury must be reported to the supervisor and the occupational health department so that the healthcare worker can be protected with post exposure prophylaxis after blood samples have been taken from source and self, for laboratory tests (HIV, hepatitis B and C).

Ventilation

- Ventilation to healthcare facilities can either be provided via natural air circulating through or via mechanical ventilation (air handling units). A maintenance programme should be in place and filters should be replaced periodically. Air-related outbreaks of legionellosis or aspergillosis, particularly in immunocompromised patients, prompt immediate investigation and consultation with a competent engineer.
- Patients with an airborne communicable disease (e.g., tuberculosis - TB) should be isolated in a single room preferably with en suite ablution facilities or cohorted. Isolation rooms under negative pressure are ideal but not affordable in some low to middle income countries. Rooms with good natural airflow (open windows in many rural hospitals, use of extractor fans to the outside environment, or high-volume ventilation greater than six air changes per hour including a good fresh air mix) lead to a reduced risk of TB transmission. While the use of ultraviolet germicidal irradiation is still being debated, its use together with ceiling mounted paddle fans (“whirlybirds”) may be considered in designated enclosed areas or booths for sputum induction. In rural healthcare facilities, where engineering controls are lacking, collection of sputum in sunny, open-air environments (outside the building) is advocated.

Water

- Legionellosis is an important disease for which an environmental reservoir (hot water in buildings) has been identified and for which specific preventive measures (e.g., water system management, superheating and/or use of biocides such as chlorine) are well described and advocated. Water temperatures should be above 55 C (131 F) (hot water) or below 22 C (71.6 F) (cold water) at point of delivery. Air conditioners should be fitted with drift prevention devices to prevent contaminated water vapour from entering the air supply.
- Hydrotherapy pool water should be adequately filtered and chlorinated, hydrotherapy tanks should be cleaned thoroughly between each

treatment and sharing of facilities by patients with open skin lesions should be avoided.

- Haemodialysis water should be free Gram-negative bacterial endotoxin as these can cause pyrogenic reactions. Water used to prepare dialysis fluid and the dialysate should be sampled monthly. The microbiologic limits for haemodialysis fluids vary in different countries, however, the more stringent standards become the more difficult and impractical they become to implement in developing countries.
- Healthcare facilities should develop a routine maintenance programme for water filtration equipment to prevent bacterial overgrowth in filters and replace faulty ones. Water used for hand washing in oncology wards, diluting disinfectants, haemodialysis units, and rinsing semi-critical items, may be heavily contaminated with organisms such as *Pseudomonas* and may pose a risk.
- Facilities should be prepared for situations where water is inaccessible (e.g., disaster situations, disruptions in water supply) or where the source water is from boreholes or rain tanks. A supply of ready-to-use disinfecting products such as alcohol based handrub that do not require rinsing must be available.
- Water in under-resourced areas can be made safer by solar disinfection using solar box cookers that reach pasteurisation temperatures, boiling (10 minutes), chemical disinfectants, or filtration.

Dealing with the Controversies

- **Detergent or disinfectant?**
 - Cleaning with detergent and water is usually adequate for surfaces and items remote from the patient or in contact with healthy, intact skin ("non-critical" items). Thorough cleaning renders most items free of infection risk and safe to handle.
 - Disinfectants should only be used on environmental surfaces where potential risks are identified (e.g., decontamination of potentially infectious spills or of isolation rooms). Terminal cleaning (when

patient is discharged from the room or when isolation is discontinued) should be cleaned thoroughly and the surfaces wiped over with the appropriate disinfectant.

- **Biocide rotation and antimicrobial resistance:**

- Cross-resistance between [biocides](#) and [antibiotics](#) has been described, and may be due to efflux pumps causing reduced susceptibility to both categories of [antimicrobial](#) agents; cell envelope changes (reduction in porins, changes in lipopolysaccharide and other lipids); and, [bacterial biofilms](#) that confer resistance to both antibiotics and biocides.
- Although there is laboratory evidence that low-level biocide resistance can be associated with cross-resistance to other biocides and some antibiotics, the significance of these phenomena in the clinical setting remains controversial.
- Rotation of biocides is unnecessary. Greater attention directed to environmental cleanliness, hand washing and personal hygiene is much more important.

- **Environmental cultures:**

Routine culturing of the environment is not advocated; it should only be performed when there is an epidemiological indication and for educational or research purposes. Because environmental sampling is costly, overused and misused, it should be conducted only with the approval and under the guidance of a competent infection control practitioner.

- **Use of automated area decontamination (AAD) technologies:**

The contribution of the environment in healthcare-associated infections has been increasingly recognized in recent years. Manual cleaning and disinfection are carried out inadequately in many settings making the introduction of AAD technologies, *as an adjunct and not a replacement to routine cleaning*. Most studies have measured the impact of this technology on lowering environmental bioburden but the outcomes are not yet definitive.

SUGGESTED PRACTICE IN UNDER-RESOURCED SETTINGS

Recommendations listed above are also feasible for application in resource-poor settings.

SUMMARY

- All environmental surfaces of the healthcare facilities must be kept clean and dry. Inappropriate use of disinfectants, excessive microbiological sampling of the hospital environment, and excessive and complex cleaning policies are neither cost-effective nor conducive to compliance in countries with limited resources.
- Training of manager and staff involved with cleaning including those from outsourced companies, is paramount. The IPC teams along with the housekeeping staff, should define the cleaning policies and train on these procedures. The use of Standard Operating Procedures is helpful. Monitoring and regular inspections should be done using checklists.

KEY REFERENCES

1. CDC. Guidelines for Environmental Infection Control in Health Care Facilities: Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). MMWR Recomm Rep. 2003; 52(RR-10):1–42.
2. van Ingen J, Kohl TA, Kranzer K, et al. Global Outbreak of Severe *Mycobacterium chimaera* Disease after Cardiac Surgery: a Molecular Epidemiological Study. Lancet Infect Dis. 2017; 17(10):1033–41. doi: 10.1016/S1473-3099(17)30324-9; available at [http://www.thelancet.com/journals/laninf/article/PIIS1473-3099\(17\)30324-9/fulltext](http://www.thelancet.com/journals/laninf/article/PIIS1473-3099(17)30324-9/fulltext)

3. Hopman J, Tostmann A, Wertheim H, et al. Reduced Rate of Intensive Care Unit Acquired Gram-Negative Bacilli after Removal of Sinks and Introduction of 'Water-Free' Patient Care. *Antimicrob Resist Infect Control*. 2017; 6:59. doi: 10.1186/s13756-017-0213-0; available at <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5466749/>.
4. Hopman J, Hakizimana B, Meintjes WA, et al. Manual Cleaning of Hospital Mattresses: an Observational Study Comparing High- and Low-Resource Settings, *J Hosp Infect*. 2016; 92(1):14-8. doi: 10.1016/j.jhin.2015.09.017; available at <https://www.ncbi.nlm.nih.gov/pubmed/26607236>.
5. Salgado CD, Sepkowitz KA, John JF, et al. Copper Surfaces Reduce the Rate of Healthcare-Acquired Infections in the Intensive Care Unit. *Infect Control Hosp Epidemiol*. 2013; 34(5):479–86. doi: 10.1086/670207.
6. WHO. Infection Prevention & Control Guidelines on Best Practices and Procedures to Prevent and Control the Spread of: Carbapenem-resistant Enterobacteriaceae (CRE), *Acinetobacter baumannii* (CRAB), and *Pseudomonas aeruginosa* (CRPsA) in Health Care Facilities. 2017; available at <http://apps.who.int/iris/bitstream/10665/259462/1/9789241550178-eng.pdf>.

REFERENCES

1. Babb J. Decontamination of the Environment, Equipment and the Skin. In: *Guide to Infection Control in the Hospital* (4th Edition), GAJ Ayliffe, AP Fraiese, AM Geddes, K Mitchell, (Eds). London: Arnold, 2000; 92–129.
2. Boyce JM. Environmental Contamination Makes an Important Contribution to Hospital Infection. *J Hosp Infect* 2007; 65 (Suppl 2):50–4.
3. Dancer SJ. Mopping up hospital infection. *J Hosp Infect* 1999; 43:85–100.

4. Dancer SJ. The role of environmental cleaning in the control of hospital acquired Infection. *J Hosp Infect* 2009; 73(4):378–85. doi: 10.1016/j.jhin.2009.03.030.
5. Dancer SJ. Controlling Hospital-Acquired Infection: Focus on the Role of the Environment and New Technologies for Decontamination. *Clin Microbiol Rev.* 2014; 27(4):665–90. doi: 10.1128/CMR.00020-14; available at <http://cmr.asm.org/content/27/4/665.long>.
6. Daschner F. The Hospital and Pollution: Role of the Hospital Epidemiologist in Protecting the Environment. In: *Prevention and Control of Nosocomial Infections (2nd Edition)*, RP Wenzel (Ed). Baltimore: Williams and Wilkins, 1993; 993–1000.
7. Department of Health, United Kingdom. Standard Principles for Preventing Hospital-Acquired Infections. *J Hosp Infect* 2001; 47(Suppl):S21–S37.
8. Dharan S, Mouroga P, Copin P, et al. Routine Disinfection of Patient's Environmental Surfaces. Myth or Reality? *J Hosp Infect* 1999; 42(2):113–7.
9. Global Consensus Conference on Infection Control Issues Related to Antimicrobial Resistance. *Global Consensus Conference: Final Recommendations.* *Am J Infect Control* 1999; 27(6):503–13.
10. Lederer W. Infection control in a small rural hospital in Uganda. *J Hosp Infect* 1997; 35(2):91–5.
11. Lynch P, Jackson M, Preston GA, Soule BM. *Infection Prevention with Limited Resources.* Chicago, Illinois: Etna Communications; 1997; 71–4.
12. CDC. Guidelines for Environmental Infection Control in Healthcare Facilities. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). *MMWR Recomm Rep.* 2003; 52(RR-10):1–42.
13. Murtough SM, Hiom SJ, Palmer M, Russell AD. Biocide Rotation in the Healthcare Setting: Is There a Case for Policy Implementation? *J Hosp Infect* 2001; 48(1):1–6.

14. Phillips G. Microbiological Aspects of Clinical Waste. *J Hosp Infect* 1999; 41(1):1–6.
15. Rhame FS. The Inanimate Environment. In: *Hospital Infections* (4th Edition), JV Bennett and PS Brachman (Eds). Philadelphia: Lippincott-Raven, 1998; 299–324.
16. Rutala WA, Weber DJ. Surface Disinfection: Should We Do It? *J Hosp Infect* 2001; 48(Supp A):S64–8.
17. Talon D. The Role of the Hospital Environment in the Epidemiology of Multi-Resistant Bacteria. *J Hosp Infect* 1999; 43(1):13–7.
18. Vesley D, Streifel AJ. Environmental Services. In: *Hospital Epidemiology and Infection Control* (2nd Edition), CG Mayhall, (Ed). Philadelphia: Lippincott Williams and Wilkins, 1999; 1047–1053.