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Best Practices for Environmental Cleaning for Prevention and Control of Infections in All Health Care Settings, 3rd Edition

April 2018

PIDAC Provincial Infectious Diseases Advisory Committee

Infection Prevention and Control

Public Health Ontario

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About PIDAC-IPC

The Provincial Infectious Diseases Advisory Committee on Infection Prevention and Control (PIDAC-IPC) is a multidisciplinary scientific advisory body that provides evidence-based advice to Public Health Ontario (PHO) regarding multiple aspects of infectious disease identification, prevention and control.

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Disclaimer

This document was developed by the Provincial Infectious Diseases Advisory Committee on Infection Prevention and Control (PIDAC-IPC). PIDAC-IPC is a multidisciplinary scientific advisory body that provides evidence-based advice to Public Health Ontario (PHO) regarding multiple aspects of infectious disease identification, prevention and control. PIDAC-IPC's work is guided by the current best available evidence at the time of publication and updated as required. Best Practice documents and resources produced by PIDAC-IPC reflect consensus positions on what the committee deems prudent practice and are made available as a resource to public health and health care providers.

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Table of Contents

Figures

Tables

Abbreviations

ATP	adenosine triphosphate
CPE	carbapenemase-producing *Enterobacteriaceae*
CSA	Canadian Standards Association
DIN	drug identification number
IPAC-Canada	Infection Prevention and Control-Canada
MRSA	methicillin-resistant *Staphylococcus aureus*
OAHPP	Ontario Agency for Health Protection and Promotion
ORNAC	Operating Room Nurses Association of Canada
PHO	Public Health Ontario
PIDAC	Provincial Infectious Diseases Advisory Committee
ppm	parts per million
VRE	vancomycin-resistant enterococci
WHMIS	Workplace Hazardous Materials Information System

Glossary of Terms

Additional Precautions: Precautions (i.e., Contact Precautions, Droplet Precautions, Airborne Precautions) that are necessary in addition to Routine Practices for certain pathogens or clinical presentations. These precautions are based on the method of transmission (e.g., contact, droplet, airborne).

Alcohol-based hand rub: A liquid, gel or foam formulation of alcohol (e.g., ethanol, isopropanol) which is used to reduce the number of microorganisms on hands in clinical situations when the hands are not visibly soiled. Alcohol-based hand rubs contain emollients to reduce skin irritation and are less time-consuming to use than washing with soap and water.

Antibiotic-resistant organism: A microorganism that has developed resistance to the action of several antimicrobial agents and that is of special clinical or epidemiological significance.

Antiseptic: An agent that can kill microorganisms and is applied to living tissue and skin.

Audit: A systematic and independent examination to determine whether quality activities and related results comply with planned arrangements, are implemented effectively and are suitable to achieve objectives.[1]

Biomedical waste: Contaminated, infectious waste from a health care setting that requires treatment prior to disposal in landfill sites or sanitary sewer systems. Biomedical waste includes human anatomical waste; human and animal cultures or specimens (excluding urine and faeces); human liquid blood and blood products; items contaminated with blood or blood products that would release liquid or semi-liquid blood if compressed; body fluids visibly contaminated with blood; body fluids removed in the course of surgery, treatment or for diagnosis (excluding urine and faeces); sharps; and broken glass which has come into contact with blood or body fluid.[2,3]

Broad-spectrum virucide: An environmental (low-level) disinfectant demonstrated to irreversibly inactivate, at a minimum, one representative hard-to-kill non-enveloped virus and which would be expected to inactivate most enveloped and non-enveloped viruses.[4]

Canadian Association of Environmental Management (CAEM): A national, non-profit organization representing environmental management professionals within the health care sector and other industry professionals responsible for environmental cleaning.

Cleaning: The physical removal of foreign material (e.g., dust, soil) and organic material (e.g., blood, secretions, excretions, microorganisms). Cleaning physically removes rather than kills microorganisms. It is accomplished with water, detergents and mechanical action.

Client/patient/resident: Any person receiving care within a health care setting.

Cohorting: The sharing of a room or ward by two or more clients/patients/residents who are either colonized or infected with the same microorganism; or the sharing of a room or ward by colonized or infected clients/patients/residents who have been assessed and found to be at low risk of dissemination, with roommates who are considered to be at low risk for acquisition.

Complex continuing care: Complex continuing care provides continuing, medically complex and specialized services to both young and old, sometimes over extended periods of time. Such care also includes support to families who have palliative or respite care needs.

Construction clean: Cleaning performed at the end of a workday by construction workers that removes gross soil and dirt, construction materials and workplace hazards. Cleaning may include sweeping and vacuuming, but usually does not address horizontal surfaces or areas adjacent to the job site.

Contact Precautions: Precautions that are used in addition to Routine Practices to reduce the risk of transmitting infectious agents via contact with an infectious person.

Contact time: The time that a disinfectant must be in contact with a surface or device to ensure that appropriate disinfection has occurred. For most disinfectants, the surface should remain wet for the required contact time.

Contamination: The presence of an infectious agent on hands or on a surface such as clothes, gowns, gloves, bedding, toys, surgical instruments, patient care equipment, dressings or other inanimate objects.

Continuum of care: Across all health care sectors, including settings where emergency (including pre-hospital) care is provided, hospitals, complex continuing care, rehabilitation hospitals, long-term care homes, outpatient clinics, community health centres and clinics, physician offices, dental offices, offices of other health professionals, public health and home health care.

Cytotoxic waste: Waste cytotoxic drugs, including leftover or unused cytotoxic drugs and tubing, tissues, needles, gloves and any other items which have come into contact with a cytotoxic drug.[2]

Detergent: A synthetic cleansing agent that can emulsify oil and suspend soil. A detergent contains surfactants that do not precipitate in hard water and may also contain protease enzymes (see Enzymatic Cleaner) and whitening agents.

Discharge/transfer cleaning: The thorough cleaning of a client/patient/resident room or bed space following discharge, death or transfer of the client/patient/resident, in order to remove contaminating microorganisms that might be acquired by subsequent occupants and/or staff. In some instances, discharge/transfer cleaning might be used when some types of Additional Precautions have been discontinued.

Disinfectant: A product that is used on surfaces or medical equipment/devices which results in disinfection of the equipment/device. Disinfectants are applied only to inanimate objects. Some products combine a cleaner with a disinfectant.

Disinfection: The inactivation of disease-producing microorganisms. Disinfection does not destroy bacterial spores. Medical equipment/devices must be cleaned thoroughly before effective disinfection can take place. See also, Disinfectant.

Drug Identification Number (DIN): In Canada, disinfectants are regulated as drugs under the *Food and Drugs Act* and regulations. Disinfectant manufacturers must obtain a drug identification number (DIN) from Health Canada prior to marketing, which ensures that labelling and supporting data have been provided and that it has been established by the Therapeutic Products Directorate that the product is effective and safe for its intended use.

Environment of the client/patient/resident: The immediate space around a client/patient/resident that may be touched by the client/patient/resident and may also be touched by the health care provider when providing care. The client/patient/resident environment includes equipment, medical devices, furniture (e.g., bed, chair, bedside table), telephone, privacy curtains, personal belongings (e.g., clothes, books) and the bathroom that the client/patient/resident uses. In a multi-bed room, the client/patient/resident environment is the area inside the individual's curtain. In an ambulatory setting, the client/patient/resident environment is the area that may come into contact with the client/patient/resident within their cubicle. In a nursery/neonatal setting, the patient environment is the isolette or bassinet and equipment outside the isolette/bassinet that is used for the infant. See also, Health care environment.

Enzymatic cleaner: A pre-cleaning agent that contains protease enzymes that break down proteins such as blood, body fluids, secretions and excretions from surfaces and equipment. Most enzymatic cleaners also contain a detergent. Enzymatic cleaners are used to loosen and dissolve organic substances prior to cleaning.

Fomites: Objects in the inanimate environment that may become contaminated with microorganisms and serve as vehicles of transmission.[3]

Fungicide: An environmental (low-level) disinfectant capable of inactivating fungi (including yeast) and fungal spores on environmental surfaces and inanimate items.[4]

Hand hygiene: A general term referring to any action of hand cleaning. Hand hygiene relates to the removal of visible soil and removal or killing of transient microorganisms from the hands. Hand hygiene may be accomplished using soap and running water or an alcohol-based hand rub. Hand hygiene includes surgical hand antisepsis.

Hand washing: The physical removal of microorganisms from the hands using soap (plain or antimicrobial) and running water.

Hawthorne effect: A short-term improvement caused by observing staff performance.

Health care-associated infection: A term relating to an infection that is acquired during the delivery of health care (also known as nosocomial infection).

Health care environment: People and items which make up the care environment (e.g., objects, medical equipment, staff, clients/patients/residents) of a hospital, clinic or ambulatory setting, outside the immediate environment of the client/patient/resident. See also, Environment of the client/patient/resident.

Health care facility: A set of physical infrastructure elements supporting the delivery of health-related services. A health care facility does not include a client/patient/resident's home or physician/dental/other health offices where health care may be provided.

Health care provider: Any person **delivering care** to a client/patient/resident. This includes, but is not limited to, the following: emergency service workers, physicians, dentists, nurses, respiratory therapists and other health professionals, personal support workers, clinical instructors, students and home health care providers. In some non-acute settings, volunteers might provide care and would be included as health care providers. See also, Staff.

Health care setting: Any location where health care is provided, including settings where emergency care is provided, hospitals, complex continuing care, rehabilitation hospitals, long-term care homes, mental health facilities, outpatient clinics, community health centres and clinics, physician offices, dental offices, offices of other health professionals and home health care.

High-touch surfaces: High-touch surfaces are those that have frequent contact with hands. Examples include doorknobs, call bells, bedrails, light switches, wall areas around the toilet and edges of privacy curtains.

Hoarding: A temporary fence or wall enclosing a construction site.

Hospital clean: The measure of cleanliness routinely maintained in client/patient/resident care areas of the health care setting.[5] Hospital Clean is "Hotel clean" with the addition of disinfection, increased frequency of cleaning, auditing and other infection control measures in client/patient/resident care areas.

Hospital disinfectant: A low-level disinfectant that has a drug identification number (DIN) from Health Canada indicating its approval for use in Canadian health care settings. Hospital disinfectants were referred to as "hospital-grade disinfectants" in previous editions of this document.

Hotel clean: A measure of cleanliness based on visual appearance that includes dust and dirt removal, waste disposal and cleaning of windows and surfaces. Hotel clean is the basic level of cleaning that takes place in all areas of a health care setting.

Improved hydrogen peroxide: A formulation of hydrogen peroxide that contains surfactants, wetting agents and chelating agents. Improved hydrogen peroxide was referred to as "hydrogen peroxide enhanced action formula" in the previous editions of this document. The resulting synergy makes it a powerful oxidizer that can rapidly achieve broad-spectrum disinfection for environmental surfaces and noncritical devices. In high concentrations (2%-7%) it has a sporicidal claim.

Infection: The entry and multiplication of an infectious agent in the tissues of the host. Asymptomatic or subclinical infection is an infectious process running a course similar to that of clinical disease but below the threshold of clinical symptoms. Symptomatic or clinical infection is one resulting in clinical signs and symptoms (disease).

Infection prevention and control: Evidence-based practices and procedures that, when applied consistently in health care settings, can prevent or reduce the risk of infection in clients/patients/residents, health care providers and visitors.

Infection prevention and control professional(s): Trained individual(s) responsible for a health care setting's infection prevention and control activities.

Infectious agent: A microorganism, i.e., a bacterium, fungus, parasite, virus or prion, which is capable of invading body tissues, multiplying and causing infection.

IPAC Regional Support Teams: Public Health Ontario has situated teams of infection prevention and control specialists serve five regions covering the entire province of Ontario. These teams support health care stakeholders across all health care settings in their efforts to improve infection prevention and control practices. This is achieved via promoting a common approach to infection prevention and control through opportunities for networking and support in the use of evidence-based tools and resources.

Long-term care: A broad range of personal care, support and health services provided to people who have limitations that prevent them from full participation in the activities of daily living. The people who use long-term care services are usually the elderly, people with disabilities and people who have a chronic or prolonged illness.

Low-level disinfectant: A chemical agent that achieves low-level disinfection when applied to environmental surfaces, inanimate items, or noncritical medical devices.[4]

Low-level disinfection: Level of disinfection required when processing non-invasive medical equipment (i.e., noncritical equipment) and some environmental surfaces.

Low-touch surfaces: Surfaces that have minimal contact with hands. Examples include walls, ceilings, mirrors and window sills.

Manufacturer: Any person, partnership or incorporated association that manufactures and sells medical equipment/devices under its own name or under a trade mark, design, trade name or other name or mark owned or controlled by it.

Medical equipment/device: Any instrument, apparatus, appliance, material, or other article, whether used alone or in combination, intended by the manufacturer to be used for human beings for the purpose of diagnosis, prevention, monitoring, treatment or alleviation of disease, injury or handicap; investigation, replacement, or modification of the anatomy or of a physiological process; or control of conception.

Methicillin-resistant *Staphylococcus aureus* (MRSA): MRSA is a strain of *Staphylococcus aureus* that has a minimal inhibitory concentration (MIC) to oxacillin of ≥ 4 mcg/ml and contains the *mecA* gene coding for penicillin-binding protein 2a (PBP 2a). MRSA is resistant to all of the beta-lactam classes of antibiotics, such as penicillins, penicillinase-resistant penicillins (e.g., cloxacillin) and cephalosporins. MRSA has been associated with health care-associated infections and outbreaks.

Monitoring: A planned series of observations or measurements of a named parameter[6] (e.g., monitoring cleaning of client/patient/resident rooms).

Mycobactericide: An environmental (low-level) disinfectant capable of irreversibly inactivating mycobacteria present on environmental surfaces and inanimate items.

Noncritical medical equipment/device: Equipment/device that either touches only intact skin (but not mucous membranes) or does not directly touch the client/patient/resident. Reprocessing of noncritical equipment/devices involves cleaning and may also require low-level disinfection (e.g., blood pressure cuffs, stethoscopes).

Non-enveloped virus: Non-enveloped viruses such as Norovirus lack an outer lipid membrane. As a result, non-enveloped viruses are less susceptible to drying and heat, and are more resistant to disinfectants. These viruses can survive for longer on environmental surfaces than enveloped viruses.

Occupational health and safety: Preventive and therapeutic health services in the workplace provided by trained occupational health professionals, e.g., nurses, hygienists, physicians.

Ontario Agency for Health Protection and Promotion (OAHPP): A Crown corporation dedicated to protecting and promoting the health of all Ontarians and reducing inequities in health. OAHPP was created by legislation in 2007 and began operations in July 2008 with a mandate to provide scientific and technical advice to those working to protect and promote the health of Ontarians. Its vision is to be an internationally recognized centre of expertise dedicated to protecting and promoting the health of all Ontarians through the application and advancement of science and knowledge. OAHPP's operating name is Public Health Ontario (PHO).

Ontario Healthcare Housekeepers' Association (OHHA): An organization representing professional health care housekeepers and providing management and leadership education, training and representation in the Ontario Hospital Association. More information is available at: http://ohha.org.

Personal protective equipment: Clothing or equipment worn by staff for protection against hazards.

Precautions: Interventions to reduce the risk of transmission of microorganisms (e.g., patient-to-patient, patient-to-staff, staff-to-patient, contact with the environment, contact with contaminated equipment).

Pre-hospital care: Acute emergency client/patient/resident assessment and care delivered in an uncontrolled environment by designated practitioners, performing delegated medical acts at the entry to the health care continuum.

Provincial Infectious Diseases Advisory Committee (PIDAC): A multidisciplinary scientific advisory body which provides to Public Health Ontario evidence-based advice regarding multiple aspects of infectious disease identification, prevention and control.

Public Health Agency of Canada: A national agency which promotes improvement in the health status of Canadians through public health action and the development of national guidelines.

Public Health Ontario (PHO): Public Health Ontario is the operating name for the Ontario Agency for Health Protection and Promotion.

Relative light unit (RLU): A measurement of bioluminescence or output of light.

Reprocessing: The steps performed to prepare used medical equipment for use (e.g., cleaning, disinfection, sterilization).

Reservoir: Any person, animal, substance or environmental surface in or on which an infectious agent survives or multiplies, posing a risk for infection.

Routine Practices: The system of infection prevention and control practices recommended by the Public Health Agency of Canada to be used with all clients/patients/residents during all care to prevent and control transmission of microorganisms in all health care settings. For a full description of Routine Practices, refer to PIDAC's *Routine Practices and Additional Precautions for all Health Care Settings*.[7]

Safety data sheet: A document that contains information on the potential hazards (health, fire, reactivity and environmental) and how to work safely with a chemical product. It also contains information on the use, storage, handling and emergency procedures all related to the hazards of the material. Safety data sheets are prepared by the supplier or manufacturer of the material.

Safety-engineered medical device: A non-needle sharp or a needle device used for withdrawing body fluids, accessing a vein or artery, or administering medications or other fluids, with a built-in safety feature or mechanism that effectively reduces exposure incident risk. Safety-engineered devices shall be licensed by Health Canada.

Sharps: Objects capable of causing punctures or cuts (e.g., needles, lancets, sutures, blades, clinical glass).

Sporicide: An environmental (low-level) disinfectant capable of inactivating bacterial spores on environmental surfaces and items.

Staff: Anyone conducting activities in settings where health care is provided, including health care providers. See also, Health care provider.

Surge capacity: The ability to provide adequate services during events that exceed the limits of the normal infrastructure of a health care setting. This includes providing additional environmental cleaning (materials, human resources) when required, e.g., during an outbreak and when over capacity.

Terminal cleaning: See Discharge/transfer cleaning.

Vancomycin-resistant enterococci (VRE): VRE are strains of *Enterococcus faecium* or *Enterococcus faecalis* that have a minimal inhibitory concentration (MIC) to vancomycin of ≥ 32 mcg/ml. and/or contain the resistance genes *vanA* or *vanB*.

Virucide: An environmental (low-level) disinfectant capable of inactivating viruses on environmental surfaces and items. Virucides may be active against a limited number of viruses. See also, Broad-spectrum virucide.

Workplace Hazardous Materials Information System (WHMIS):[8] The Workplace Hazardous Materials Information System (WHMIS) is Canada's national hazard communication standard. The key elements of the system are cautionary labelling of containers of WHMIS "controlled products", the provision of safety data sheets and staff education and training programs.

Preamble

Health care-associated infections are infections that occur within any setting where health care is delivered. Health care-associated infections affect 4% to 10% of patients and result in significant harm to patients/residents/clients.[9-12] Maintaining a safe, clean and hygienic environment and minimizing microbial contamination of surfaces, items and equipment within the health care environment is increasingly recognized as an essential approach to reducing the risk of health care-associated infections for all patients/residents/clients, visitors and staff within health care settings.[13,14]

Reducing the risk of transmission of infection from the health care environment requires the cooperation of all staff in the health care setting. It also requires an appropriately staffed, trained, educated and supervised environmental services program.[14-17] The cornerstone of efforts to reduce the risk of transmission of microorganisms from the environment requires the cleaning and disinfection of all surfaces and items in the health care setting on a regular basis.[18]

The best practices set out in this document provide criteria for cleanliness in health care settings that may be adopted by environmental service managers for their use or for the use of contracted services. This document is intended to provide best practice for environmental cleaning for all health care settings (see below). While the client/patient/resident population, acuity of illness, intensity of care and the nature of medical and surgical procedures vary in different practice settings, the fundamental principles and requirement for routine cleaning and disinfection do not.

About This Document

This document is a thorough revision of the Provincial Infectious Diseases Advisory Committee's (PIDAC) previous best practices document on environmental cleaning and disinfection published in 2012. It deals with the cleaning and disinfection of the physical environment in health care as they relate to the prevention and control of infections. It also deals with the cleaning and disinfecting of noncritical equipment (i.e., equipment that only comes into contact with intact skin). This document does not address disinfection and/or sterilization of critical or semicritical devices, or the use and disposal of chemicals or medications (e.g., chemotherapy).

- For information about high-level disinfection and sterilization of medical equipment, see PIDAC's *Best Practices for Cleaning, Disinfection and Sterilization in All Health Care Settings*.[19]
- For information about handling and using chemotherapy chemicals and equipment, see Cancer Care Ontario's *Safe Handling of Cytotoxics*.[20]
- For information about cleaning practices in dental settings, see also the Royal College of Dental Surgeons of Ontario's *Infection Prevention and Control in the Dental Office*.[21]

This document is intended for those who have a role in the management of cleaning or environmental services for the health care setting. This includes administrators, supervisors of environmental service departments, infection prevention and control professionals, and supervisors of construction and maintenance projects in health care facilities; public health; and those responsible for overseeing environmental cleaning in the clinical office setting (e.g., community health centres, clinics, independent health facilities, and out-of-hospital premises, and dental offices).

In revising this document, which is widely used at Ontario health care facilities, PIDAC's goal was to update the document based on advances in the field while maintaining a practical and evidence-based approach. Since the original publication of the document, the evidence linking the health care environment to the transmission of infectious pathogens continues to increase and these new data are discussed in the document (see Chapter 1). There are also new research findings evaluating the impact of a variety of audit and feedback methodologies (see Chapter 9) and new disinfection strategies, including the use of no-touch disinfection methods and the use of antimicrobial surfaces (see Chapter 8).

As the 2018 edition contains substantial revisions in many sections and topics, new information will not be highlighted individually. Each recommendation, however, is labelled as new, modified, or reviewed and not changed.

In developing this document, PIDAC reviewed all queries directed to PIDAC and PHO regarding environmental cleaning registered since the previous version of this document was published. Broad stakeholder consultation was sought, workshops were held at the Canadian Association of Environmental Management 2014 conference to identify key issues in environmental cleaning and to seek input on the strengths and weaknesses of the document, and the draft document was presented at subsequent meetings of both the Canadian Association of Environmental Management and the Ontario Healthcare Housekeepers' Association. Members of both associations joined with PIDAC and were present at all stages of guideline development. Subsequently, the document was posted for 30-day public review and revisions made based on the feedback received. Feedback from stakeholders resulted in changes and additions to the document.

For Recommendations in This Document:

Shall indicates mandatory requirements based on legislated requirements or national standards (e.g., Canadian Standards Association—CSA).

Must indicates best practice, i.e., the minimum standard based on current recommendations in the medical literature.

Should indicates a recommendation or that which is advised but not mandatory.

May indicates an advisory or optional statement.

Evidence for Recommendations

In developing this revised best practices guideline, PIDAC reviewed the method for ranking recommendations. Since the original document was developed, many health care organizations and guideline developers have switched to the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) methodology for guideline development.[22,23] In the guideline development process, PIDAC piloted the use of GRADE for the recommendations on new technology, and specifically with respect to antimicrobial surfaces and no-touch disinfection. Systematic reviews were conducted on these topics using the GRADE methodology to rate the strength of the evidence. These systematic reviews are intended for publication in peer-reviewed journals and support the recommendations made

in this document related to antimicrobial surfaces and no-touch disinfection.[24] PIDAC did not use the GRADE methodology to evaluate the quality of the evidence or the strength of the recommendation for the document as a whole. However, on reviewing the GRADE system,[22,25-29] PIDAC has adopted one key concept from GRADE which PIDAC believes is an improvement on its approach to producing best practices guidelines: the quality of the evidence of efficacy for an intervention is not the sole consideration when making recommendations; risks, adverse effects, and stakeholder perspectives must also be considered. Although cost is also an important consideration, it was beyond the scope of this document to formally evaluate the cost of each recommended intervention. Ultimately, strong recommendations should be made when the evidence of benefit clearly outweighs the risks of the recommendation; a conditional recommendation is made when there is less certainty that benefits outweigh risks and costs.[23]

Incorporating this concept, PIDAC has modified its approach to ranking recommendations (see Table 1: Assessment of the Quality of Evidence Supporting a Recommendation and Table 2: Determination of the Strength of a Recommendation). Specifically, PIDAC separates the assessment of the quality of evidence supporting a recommendation from the strength of the recommendation. While the quality of the evidence (Table 1) will continue to be based primarily on the study designs of the evidence evaluating the efficacy of the intervention, the strength of the recommendation (Table 2) will take into account PIDAC's assessment of the quality of the evidence and the potential risks associated with the intervention, and will make recommendations as follows:

- **Category A Recommendations** for an intervention are those where PIDAC determined that the benefit of the intervention clearly outweighs the risks. PIDAC intends that category A recommendations are best practices that must be followed in all applicable health care settings. Note that for interventions with no or trivial associated risks (e.g., always move from cleaner to dirtier areas when cleaning; perform hand hygiene prior to contact with the client/patient/resident's environment), weak supportive evidence can result in a category A recommendation as benefits will clearly outweigh risks.
- **Category B Recommendations** for an intervention are those which benefits most likely outweigh the risk in most settings. PIDAC intends that category B recommendations are best practices that should be followed in most applicable health care settings.

Categories A and B recommendations may also be made against an intervention if the risks of the intervention clearly or most likely outweigh the benefits.

Table 1: Assessment of the Quality of Evidence Supporting a Recommendation

Grade	Definition
I	Evidence from at least one properly randomized, controlled trial.
II	Evidence from at least one well-designed clinical trial without randomization, from cohort or case-controlled analytic studies, preferably from more than one centre, from multiple time series, or from dramatic results in uncontrolled experiments.
III	Evidence from opinions of respected authorities on the basis of clinical experience, descriptive studies, or reports of expert committees.

Table 2: Determination of the Strength of a Recommendation

Category	Definition
A	Best practices that must be followed in all health care settings. The benefits of these practices outweigh the risks.
B	Best practices that should be followed in most health care settings. The benefits of these practices likely outweigh the risks in most, but not all, settings and situations

NOTE: When a recommendation is based on a regulation, no grading will apply.

How and When to Use This Document

The cleaning practices set out in this document must be practised in all settings where care is provided, across the continuum of health care, with the exception of cleaning of the client's home in home health care. This includes settings where emergency (including pre-hospital) care is provided (e.g., ambulances, patient transfer vehicles), hospitals, complex continuing care facilities, rehabilitation facilities, long-term care homes, mental health facilities, outpatient clinics, community health centres, public health clinics, physician offices, dental offices and offices of other health professionals. For guidance on environmental cleaning in clinical office practice:

- See Chapter 7 of PIDAC's *Infection Prevention and Control for Clinical Office Practice*.[30]

Assumptions and Best Practices in Infection Prevention and Control

The best practices in this document are based on the assumption that health care settings in Ontario already have basic infection prevention and control systems and programs in place, such as those outlined in the following document:

- See PIDAC's *Best Practices for Infection Prevention and Control Programs in Ontario in All Health Care Settings*.[31]

These settings should work with organizations that have infection prevention and control expertise, such as academic health science centres, IPAC Regional Support Teams with Public Health Ontario, public health units that have professional staff certified in infection prevention and control and local infection prevention and control associations (e.g., IPAC–Canada chapters), to develop evidence-based programs.

In addition to the general assumption (*above*) about basic infection prevention and control, these best practices are based on the following additional assumptions and principles:

1. Best practices to prevent and control the spread of infectious diseases are routinely implemented in all health care settings, including PIDAC's *Routine Practices and Additional Precautions in All Health Care Settings*.[7]

2. Adequate resources are devoted to infection prevention and control in all health care settings. See PIDAC's *Best Practices for Infection Prevention and Control Programs in Ontario*.[31]

3. Programs are in place in all health care settings that promote good hand hygiene practices and ensure adherence to standards for hand hygiene. See:

    a) PIDAC's *Best Practices for Hand Hygiene in All Health Care Settings*[32]
    b) Ontario's hand hygiene improvement program, Just Clean Your Hands[33]

4. Programs are in place in all health care settings that ensure effective disinfection and sterilization of used medical equipment according to PIDAC's *Best Practices for Cleaning, Disinfection and Sterilization in All Health Care Settings*.[19]

5. Regular education (including orientation and continuing education) and support is provided in all health care settings to help staff consistently implement appropriate infection prevention and control practices. Effective education programs emphasize:

    - The risks associated with infectious diseases, including acute respiratory infection and gastroenteritis.
    - Hand hygiene, including the use of alcohol-based hand rubs and hand washing.
    - Principles and components of Routine Practices as well as additional transmission-based precautions (Additional Precautions).
    - Assessment of the risk of infection transmission and the appropriate use of personal protective equipment, including safe application, removal and disposal.
    - Appropriate cleaning and/or disinfection of health care equipment, supplies and surfaces or items in the health care environment.
    - Individual staff responsibility for keeping patients, themselves and co-workers safe.
    - Collaboration between professionals involved in infection prevention and control and occupational health and safety.

    NOTE: *Education programs should be flexible enough to meet the diverse needs of the range of health care providers and other staff who work in the health care setting. The local public health unit and IPAC Regional Support Teams may be a resource and can provide assistance in developing and providing education programs for community settings.*

6. Collaboration between professionals involved in occupational health and safety and infection prevention and control is promoted in all health care settings, to implement and maintain appropriate infection prevention and control standards that protect workers.

7. There are effective working relationships between the health care setting and local public health. Clear lines of communication are maintained and public health is contacted for information and advice as required and the obligations (under the *Health Protection and Promotion Act*, R.S.O 1990, c.H.7)[34] to report reportable and communicable diseases is fulfilled. Public health provides regular aggregate reports of outbreaks of reportable diseases in facilities and/ or in the community to all health care settings.

8. Access to ongoing infection prevention and control advice and guidance to support staff and resolve differences are available to the health care setting.

9. There are established procedures for receiving and responding appropriately to all international, national, regional and local health advisories in all health care settings. Health advisories are communicated promptly to all affected staff (e.g., those responsible for reprocessing medical equipment/devices) and regular updates are provided. Current advisories are available from local public health units, the Ministry of Health and Long-Term Care, Health Canada and Public Health Agency of Canada websites and local regional IPAC networks.

10. Where applicable, there is a process for evaluating personal protective equipment in the health care setting, to ensure it meets quality standards.

11. There is regular assessment of the effectiveness of the infection prevention and control program and its impact on practices in the health care setting. The information is used to further refine the program.

OCCUPATIONAL HEALTH AND SAFETY REQUIREMENTS SHALL BE MET:

- Health care facilities are required to comply with applicable provisions of the *Occupational Health and Safety Act*, R.S.O. 1990, c.O.1 and its Regulations. Employers, supervisors and workers have rights, duties and obligations under the *Occupational Health and Safety Act*. Specific requirements under the *Occupational Health and Safety Act* and its regulations are available at: www.e-laws.gov.on.ca/index.html

- The *Occupational Health and Safety Act* places duties on many different categories of individuals associated with workplaces, such as employers, constructors, supervisors, owners, suppliers, licensees, officers of a corporation and workers. A guide to the requirements of the *Occupational Health and Safety Act* is available at: www.labour.gov.on.ca/english/hs/pubs/ohsa/index.php.

- The *Occupational Health and Safety Act* section 25(2)(h), the "*general duty clause"*, requires an employer to take every precaution reasonable in the circumstances for the protection of a worker.

- Specific requirements for certain health care and residential facilities may be found in the *Health Care and Residential Facilities* regulation. Under that regulation there are a number of requirements, including:

    - Requirements for an employer to establish written measures and procedures for the health and safety of workers, in consultation with the joint health and safety committee or health and safety representative, if any. Such measures and procedures may include, but are not limited to, the following:

- safe work practices
- safe working conditions
- proper hygiene practices and the use of hygiene facilities
- the control of infections
- immunization and inoculation against infectious diseases

- The requirement that at least once a year the measures and procedures for the health and safety of workers shall be reviewed and revised in the light of current knowledge and practice.
- A requirement that the employer, in consultation with the joint health and safety committee or health and safety representative, if any, shall develop, establish and provide training and educational programs in health and safety measures and procedures for workers that are relevant to the workers' work.
- A worker who is required by his or her employer or by the regulation for *Health Care and Residential Facilities* to wear or use any protective clothing, equipment or device shall be instructed and trained in its care, use and limitations before wearing or using it for the first time and at regular intervals thereafter and the worker shall participate in such instruction and training.
- The employer is reminded of the need to be able to demonstrate training, and is therefore encouraged to document the workers trained, the dates training was conducted, and the information and materials covered during training.
- Under the *Occupational Health and Safety Act*, a worker must work in compliance with the Act and its regulations, and use or wear any equipment, protective devices or clothing required by the employer.
- The *Needle Safety Regulation* (O.Reg 474/07) has requirements related to the use of hollow-bore needles that are safety-engineered needles.

➢ Additional information is available at the Ministry of Labour, Health and Community Care Page.

Section One:

Best Practices for Environmental Cleaning for Infection Prevention and Control in All Health Care Settings

1. Principles of Cleaning and Disinfecting Environmental Surfaces in a Health Care Environment

Health care settings are complex environments where the provision of care to large numbers of clients/patients/residents results in the contamination of surfaces and equipment with harmful microorganisms. Contaminated surfaces and equipment contribute to the transmission of microorganisms and to the burden of health care-associated infection.

Routine and effective cleaning and disinfection of surfaces, items and equipment is an essential activity that protects clients/patients/residents, staff and visitors from infection. Because of the increased risks and consequences of infection transmission in this setting, the approach and intensity of cleaning required differs from that of non-health care settings.

In the first section of this best practice document, we present the evidence supporting the role of environmental cleaning in preventing infection and describe the principles of safe and effective environmental cleaning in the health care setting.

1.1 Evidence for Cleaning

Since these guidelines were previously published, the evidence that the environment plays a role in the transmission of microorganisms in the health care setting has increased.[16,35-39] There has also been an expansion of the evidence demonstrating that effective cleaning and disinfection reduces this risk.[15-18,39-41]

From a theoretical perspective, all of the following steps are required for environmental contamination to result in infection (Figure 1). Effective environmental cleaning will interrupt direct client/patient/ resident to surface to client/patient/resident transmission of microorganisms, and minimize (along with effective hand hygiene) surface to health care provider to client/patient/resident transmission (Figure 1).

The health care environment is frequently contaminated with microorganisms, including clinically important bacteria, viruses and fungi.[42-45] Contamination of most frequently touched surfaces and items within the client/patient/resident and/or health care environment has been documented.[42,43,46-50] Additionally, viable microorganisms can persist on surfaces and items for prolonged periods of time (e.g., months),[47-54] particularly for organisms such as *C. difficile*, vancomycin-resistant enterococci (VRE) or methicillin-resistant *Staphylococcus aureus* (MRSA).[45,46]

Contamination of health care providers' hands or gloves occurs frequently following contact with environmental surfaces in patient rooms.[51,55-63] Health care providers that come in contact with surfaces in the room of a patient colonized with MRSA or VRE have a 42% to 52% risk of subsequent hand or glove contamination with the same organism; this risk is similar to the risk seen following direct contact with the patient.[56,58,62] After contact with a VRE contaminated surface, health care providers transmit VRE to the next clean surface or skin site they come in contact with approximately 10% of the time.[59]

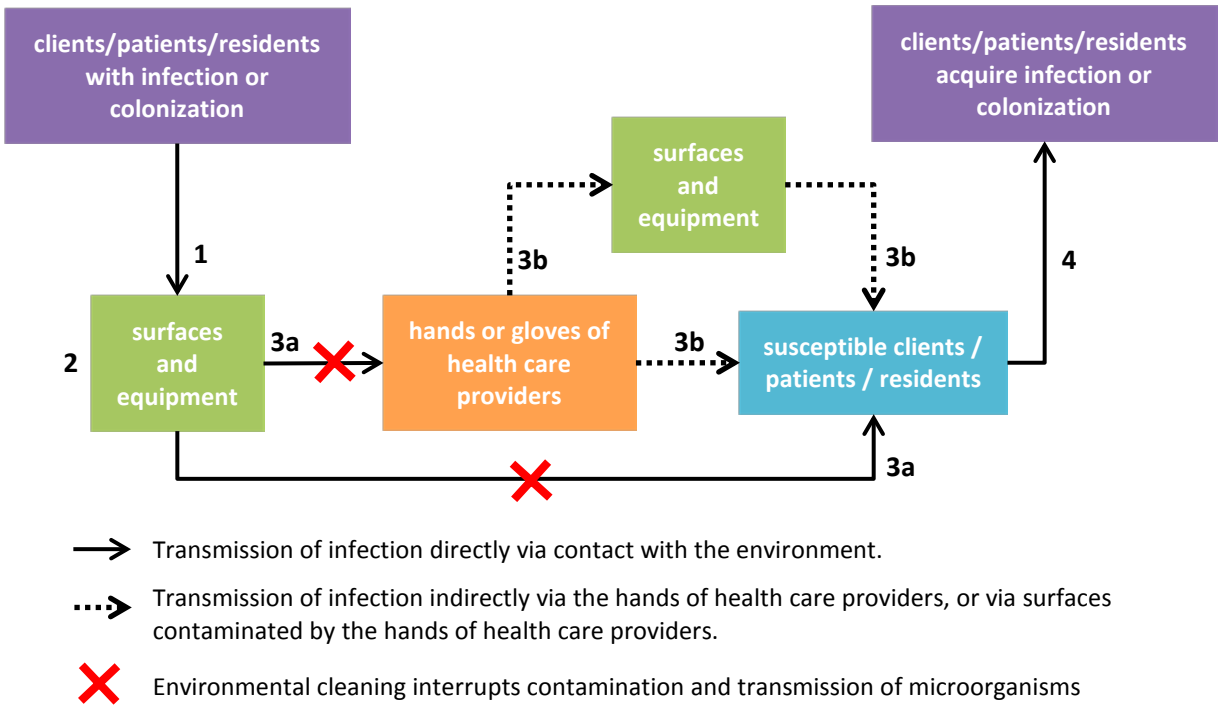


Figure 1: How Environmental Contamination Results in Infection

1. The environment becomes contaminated with microorganisms.
2. The microorganisms survive for a sufficient duration to allow transmission.
3. Clients/patients/residents*
    a) Acquire the microorganism through direct contact with the environment.
    OR
    b) Hands or gloves of health care providers or equipment becomes contaminated through direct contact with the environment and then transmit the microorganism to another client/patient/resident due to lapses in hand hygiene and/or disinfection of shared equipment.
4. Acquisition of a microorganism that results in infection.

* Note: health care providers can also acquire infection through contact with a contaminated environment.

These data demonstrate the ease with which health care providers' hands, gloves and equipment become contaminated with organisms from the environment, suggesting that transfer of microorganisms from surface to provider/equipment is a common occurrence. There is not as much data directly demonstrating transfer from health care providers' hands (following contamination from an environmental source) to a subsequent client/patient/resident but transfer from health care providers' hands to clients/patients/residents is considered the primary mechanism for the transfer of microorganisms in health care.[64]

In addition to the data documenting each step in the transmission pathway (Figure 1), there is indirect but convincing evidence linking the environment to the acquisition of antibiotic-resistant organisms and health care-associated infections in patients admitted to rooms previously occupied by a patient with a

known antibiotic-resistant organism. Specifically, patients admitted to a room that was previously occupied by a patient colonized or infected with a variety of clinically important organisms (i.e., *C. difficile*, MRSA, VRE, *Pseudomonas* species, *Acinetobacter* species and ESBL-producing *Enterobacteriaceae*) are twice as likely to acquire that specific microorganism as to patients admitted to other rooms at the same time.[37] This provides additional evidence that environmental contamination can result in the transmission of microorganisms to patients.

Additionally, there are multiple studies demonstrating the control of antibiotic-resistant organism outbreaks following the adoption of enhanced cleaning and disinfection approaches.[65-70] While many of these studies describe multiple intervention strategies, and it is therefore difficult to confirm that outbreak control was a direct result of enhanced environmental cleaning, there are several studies where outbreaks could not be controlled until enhanced environmental cleaning was implemented.[68-70] Whereas there are significant limitations to these studies, their results are consistent with other evidence supporting the role of environmental contamination in microorganism transmission and outbreak propagation.

Finally, reports of reductions in antibiotic-resistant organism transmission or health care-associated infection incidence have been associated with efforts to enhance routine cleaning[71-75] or through the adoption of novel cleaning technologies.[76,77] See 8. New and Evolving Technologies for Environmental Cleaning for a discussion of antimicrobial surfaces and no-touch disinfection methods, and see 9. Assessment of Cleanliness and Quality Control for a discussion on the use of audit and feedback to improve environmental cleaning.

Gaps in our understanding of antibiotic-resistant organism transmission persist, and the etiology of health care-associated infection is complex and multifactorial. Programs to reduce health care-associated infection incidence will likely be most effective when combined with other evidence-based interventions for health care-associated infection prevention (e.g., hand hygiene).[78] Taken together, however, there is evidence supporting the role of a contaminated environment in the transmission of antibiotic-resistant organisms and the incidence of health care-associated infections and this evidence has increased since the original publication of this guideline. Thus, routine environmental cleaning and disinfection remains an essential and required practice to reduce infection risk.

1.2 Health Care Design and Product Selection

It is essential that all surfaces, items and equipment installed or used within a health care environment are cleanable. This must be a central consideration when health care facilities are designed, redesigned, or renovated and when new equipment is obtained. Surfaces or equipment that is difficult or impossible to clean and disinfect should not be purchased, installed or used in the health care setting. Environmental services, infection prevention and control, and occupational health and safety should be consulted as key stakeholders at the planning stage of construction and renovation and prior to the purchase of new equipment to ensure that this principle is followed.

> **If you can't clean it, don't buy it.**

1.2.1 SELECTION OF SURFACES, FINISHES, FURNISHINGS AND EQUIPMENT FOR AREAS WHERE CLIENT/PATIENT/RESIDENT CARE IS DELIVERED

Health care settings should have policies that include the criteria to be used when choosing surfaces, finishes, furnishings and equipment for client/patient/resident care areas. These policies should ensure that all surfaces, finishes, furnishings, and equipment meet infection prevention and control requirements for cleaning and disinfection. The policies should establish a decision making process for the selection and approval of furnishings and equipment that includes infection prevention and control, occupational health and safety, and environmental services.[79] These policies should be applied universally regardless of whether the furnishings or equipment are purchased, loaned, borrowed or donated.

> **Infection prevention and control, occupational health and safety and environmental services must be involved in decision-making regarding choices of equipment, furniture and finishes in health care settings.[79]**

All health care settings must have a process in place to ensure that all selected surfaces, finishes, furnishings and equipment are:[79,80]

- cleanable
- compatible with the hospital disinfectant used by the health care setting*

  * Ideally, surfaces and equipment should be compatible with all or most commonly used cleaning agents and disinfectants. This minimizes the need for health care settings to stock multiple products and increases flexibility in selecting surfaces and equipment. Manufactures should list all compatible cleaning and disinfectant products. When there are doubts about product compatibility, the manufacturer of the item should be consulted.

Additionally, all health care settings must have a process in place to ensure that damaged finishes, furnishings, or equipment are:[79]

- identified
- repaired, replaced or removed from use within clinical areas

➢ See CSA Group's *Z8000-11 (R2016) Canadian Health Care Facilities*.[80]

➢ See CSA Group's *Z8002-14 Operation and Maintenance of Health Care Facilities*.[79]

> **If equipment, furnishings, finishings, or surfaces are damaged and cannot be effectively cleaned, they must be repaired, replaced or removed from use within clinical areas.**

1.2.1.1 Surfaces in Health Care Settings

When selecting surfaces for use in clinical areas within health care settings, surfaces with the following characteristics are recommended, as these characteristics minimize the risk of microbial contamination:[80]

- cleanable[80-82]

  Surfaces, finishes, furnishings and equipment shall be cleanable.[80,81] For example, surfaces or equipment with crevasses that cannot be reached, or surfaces or equipment that cannot withstand cleaning and disinfection with any hospital cleaning products are not appropriate for the health care setting. Furnishings, surfaces, finishes, and equipment shall be able to withstand repeated cleaning and be compatible with hospital detergents, cleaners and disinfectants.[80,83,84]

- easy to maintain and repair[80,81]

  Finishes and furnishings should be durable and easy to maintain and repair. Fabrics that are torn allow entry of microorganisms, cannot be properly cleaned, and must be repaired or discarded. Items that are scratched or chipped allow accumulation of microorganisms and are more difficult to clean and disinfect.[85]

- resistant to microbial growth[80,81,86]

  Materials differ in their ability to prevent or promote microbial growth.[87] Materials that hold moisture should be avoided as they support microbial growth.[80,81,86,88] Wood is an example of an organic material that contains moisture, and should be avoided in care areas, particularly care areas for immunocompromised patients.[86,89] Metals and hard plastics are less likely to support microbial growth than most other materials. Materials with intrinsic antimicrobial properties also exist, and are discussed in 8.2.1 Antimicrobial Surfaces.

- nonporous[80-82]

  Microorganisms survive more easily on porous surfaces. Microorganisms have been shown to survive on porous fabrics such as cotton, cotton terry, nylon and polyester and on porous plastics such as polyurethane and polypropylene.[48,49,90]

- seamless[80-82]

  Seams may harbour microorganisms and are difficult to clean.

1.2.1.2 Finishes in Health Care Settings (Walls, Flooring)

When selecting finishes for use in clinical areas within health care settings, surfaces with the following characteristics are recommended, as these characteristics minimize the risk of microbial contamination:[80,81]

- cleanable
- easy to maintain and repair
- resistant to microbial growth
- nonporous (smooth)
- seamless

Additional characteristics for finishes that are important to consider, although not directly affecting infection risk, include (but are not limited to) the following:[80,81]

- good sound absorption/acoustics
- nonflammable (Class I fire rating)
- durable
- sustainable
- low levels of volatile organic compounds to reduce off-gassing
- low smoke toxicity
- initial and life cycle cost-effectiveness
- slip-resistant
- easy to install, remove and replace
- resilient and impact resistant
- nontoxic and non-allergenic

1.2.1.3 Cloth and Soft Furnishings in Health Care Settings

Cloth furnishings harbor higher concentrations of fungi than nonporous furnishings.[91-94] Additionally, bacteria cannot be effectively removed from the surfaces of upholstered furniture.[80,95]

An alternative to cloth surfaces must be used in care areas.[80,81] Upholstered furniture and furnishings and other cloth items that cannot be cleaned shall not be used in care areas,[80] and they should not be used in nursing stations that support clinical activity. Upholstered furniture that is used in care areas shall be covered with fabrics that are fluid-resistant, nonporous, and can withstand cleaning with hospital disinfectants.[81,83] These recommendations do not apply to the home health care environment, or to those long-term care homes where furnishings are supplied by the resident.

Stuffing and foam cannot be effectively disinfected if breaks in fabric or leaks of body fluids or spills have occurred.

If cloth furnishings or items are used within any health care environment, the following is required until these furnishing or items can be replaced:

- A plan and schedule for the replacement cloth furnishings with non-cloth furnishings and items should be in place, prioritizing removal from areas where immunocompromised patients are cared for.[92]
- A regular cleaning regimen should be in place.
- Any item visibly contaminated with blood or body fluids must be immediately removed from the clinical setting and cleaned and disinfected.
- Items should be assessed for damage on a regular basis, and worn, stained or torn items should be replaced as soon as possible. These items should not be redirected to nonclinical areas before being cleaned, disinfected and repaired.

When cloth surfaces such as curtains, pillows, mattresses or soft furnishings are used in clinical areas, cloth surfaces with the following characteristics are preferred, as these characteristics minimize the risk of microbial contamination:[96]

- seamless (where possible) or have double-stitched seams
- easy to access (e.g., removable covers) for cleaning
- have foam cores that are resistant to mould
- durable and able to tolerate repeated cleaning with detergents and disinfectants, without damage
- quick drying
- easy to maintain, repair or replace
- covered with fluid-resistant fabric

Cloth privacy curtains are commonly used in health care settings, and they rapidly become contaminated with microorganisms.[48,61,97-104] Use of privacy curtains with antimicrobial properties has not been proven to reduce infection risk and does not eliminate the risk of contamination with microorganisms.[105] Although it is recognized that changing cloth privacy curtains frequently is challenging, it does not make sense to clean and disinfect all room surfaces at patient/resident discharge while leaving contaminated cloth privacy curtains in place.

Solutions that address the need to change cloth privacy curtains and the challenge of doing so on a routine basis include the use of alternatives to cloth privacy curtains such as wipeable privacy screens, or single-use or tear-away curtains.[81,106-108] In some settings (e.g., where the bed cannot be seen from the hallway) privacy curtains may not be required at all and should be removed. If cloth privacy curtains (including those with antimicrobial properties) are used, health care settings must ensure the following:

- Cloth privacy curtains shall be washable at a temperature that ensures disinfection.[80]
- Cloth privacy curtains must be removed, cleaned and disinfected immediately if they become contaminated with blood or body fluids, or are visibly soiled.[109]
- Cloth privacy curtains used for patients/residents requiring Additional Precautions must be removed, cleaned and disinfected following discharge or transfer of the patient/ resident and before a new patient/resident is admitted to that room or bed space.[109]
- Cloth privacy curtains used for all patients/residents should be changed following discharge or transfer of the patient/resident and before a new patient/resident is admitted to that room or bed space.
- For patients/residents with extended stays, health care facilities should consider changing privacy curtains regularly (e.g., monthly).[109]

1.2.1.4 Carpeting

Carpeting has been associated with an increased risk of health care-associated infection rates in immunocompromised populations.[92,110,111] Carpeted floors become more contaminated with *C. difficile* as compared to noncarpeted floors.[112] Carpeting shall not be used in areas that house immunocompromised patients at risk of invasive fungal infections (e.g., transplantation units, high risk oncology units).[80,111,113-121] In addition, carpeting must not be used in care areas where:

- The patient population is at increased risk of infection following exposure to dust or particulates harbouring microorganisms (e.g., transplant units, burn units, intensive care units, operating and procedure rooms).[80,92]
- Spills of water, body fluids or other liquids occur (e.g., intensive care units, laboratory areas, procedure rooms, areas around sinks, bathrooms).[80]

- Spills of alcohol-based hand rub may occur, creating a fire hazard (e.g., corridors outside patient rooms in acute care.)[64,122]
- The risk of *C. difficile* exists, e.g., in patient rooms in acute care.[80,112]

The use of carpeting in other areas should be minimized. If carpeting is used in other care areas, it shall be cleanable with hospital cleaners and disinfectants, and shall be easily removed (e.g., carpet tiles), discarded and replaced.[80] In addition, for facilities that continue to have carpeting in place within care areas, the following is recommended:

- Carpeting located in high risk areas (see above) should be removed in a safe manner as soon as possible; clients/patients/residents should not be present during the removal process.[86]
- A plan to gradually remove (and not replace) carpeting located in low risk care areas should be developed. Older carpets should be prioritized for removal.[123]
- Wet carpets should be dried as soon as possible. The risk of mould increases if carpets remain wet for 48 hours or longer.[124-126] Carpeting that remains wet after 48 hours shall be removed and should not be replaced.[86]
- Carpets must be cleaned on a regular basis by trained environmental service workers using specialized cleaning equipment and procedures,[92] as the specific type of material used in the carpet will influence the efficacy of disinfectants.[83]

1.2.2 NEW EQUIPMENT/PRODUCT PURCHASES

The administration of the health care setting is responsible for ensuring and verifying that any item used in the provision of care to clients/patients/residents is capable of being cleaned and disinfected according to current standards and guidelines. This includes purchased, borrowed, or donated equipment, and equipment used for research purposes if such equipment will be used within the care environment. Equipment that is used to clean and disinfect must also meet these standards.

- This document deals only with equipment that requires low-level disinfection. For high-level disinfection, see PIDAC's *Best practices for Cleaning, Disinfection and Sterilization in All Health Care Facilities*.[19]

1.2.2.1 Selection of Noncritical Medical Equipment

Equipment and devices that either touches only intact skin (but not mucous membranes) or do not directly touch the client/patient/resident are classified as noncritical.[127] For all noncritical medical equipment purchased, loaned, donated or otherwise used within a health care setting the following is required:

- Do not purchase medical equipment that cannot be cleaned and disinfected according to the recommended standards.[19]
- All noncritical medical equipment that will be purchased or obtained for use within the health care setting must include written item-specific manufacturer's cleaning and disinfection instructions. If disassembly or reassembly is required, detailed instructions with pictures must be included. Staff training must be provided on these processes before the medical equipment is placed into circulation[19] (e.g., patient lifts, specialized chairs and beds).
- Items that are provided by outside agencies and returned to the agency for cleaning and disinfection are subject to the same standards as in-house equipment.[128]

- See PIDAC's *Best Practices for Cleaning, Disinfection and Sterilization in All Health Care Settings*[19] for more information regarding the purchase of new medical equipment.

Equipment used for cleaning also requires regular, routine cleaning and disinfection and all of the above requirements apply to cleaning equipment as well. Additionally:

- Products used for cleaning and disinfection must be approved by infection prevention and control, occupational health and safety, and environmental services.[19]
- All cleaning equipment must be compatible with the cleaning and disinfecting agents used in the health care setting and manufacturer's recommendations for cleaning must be followed.
- When purchasing cleaning agents or cleaning equipment, consideration must be given to occupational health requirements, patient safety, infection prevention and control and environmental safety concerns.[19]

1.2.2.2 Plastic Coverings

Plastic covers may be recommended to protect difficult to clean items or equipment within the health care environment from contamination. It is essential that plastic covers are selected, used and maintained appropriately. Outbreaks of health care-associated infections, such as VRE and *Acinetobacter* species, have been linked to improper use or maintenance of plastic covers on beds.[88,128,129]

If plastic covers are used within a health care setting, including mattress and pillow covers, the following practices should be adhered to:

- Plastic covers should be cleaned on a regular basis, between patients and when visibly soiled.
- Plastic covers should be inspected for damage on a regular basis and a clear process must be in place to ensure reporting of, removal and replacement of damaged plastic coverings.[129]
- Mattress and pillow covers, as well as other plastic covers, should be repaired or replaced if they are torn or cracked, visibly stained, or if there is evidence of liquid penetration.[92,129,130] Repairs should be completed appropriately and should then allow effective cleaning and disinfection; the practice of placing tape over tears is not sufficient. Plastic coverings (e.g., mattress covers, keyboard covers) should be cleaned with hospital disinfectants that are compatible with the covering.[131]

1.2.2.3 Electronic Equipment

Electronic equipment is no different than other equipment with respect to cleaning and disinfection. Electronic equipment becomes contaminated with microorganisms and can transmit organisms between patients, depending on how and where the equipment is used, cleaned and disinfected.[67,132-139]

There are some unique challenges with electronic equipment used within health care settings, however. Electronic equipment may be owned by the health care facility or by health care providers or staff; electronic equipment often has buttons, holes for plugs, and other complex surface elements that make cleaning difficult (or impossible); incorrect cleaning of electronic equipment may damage the equipment and/or void the warranty. Additionally, many types of electronic equipment were not designed for use in health care and there may not be appropriate manufacturer's recommendations for cleaning and disinfection (e.g., mobile phones, tablets, laptops).

When health care facilities purchase electronic equipment, as with all equipment purchases, the specific electronic items selected should be cleanable, and should be compatible with the health care setting's cleaning and disinfection products. Additionally, electronic equipment should be, whenever possible, designed for use in the health care setting and should come with manufacturer's instructions on cleaning and disinfection. Environmental services, infection prevention and control, and occupational health and safety should be consulted as key stakeholders prior to the purchase of new electronic equipment that will be used in care areas.

Some health care facilities have policies allowing "bringing your own device programs" in which health care providers are able to access confidential client/patient/resident information on their personal electronic devices. These facilities should ensure that guidance on appropriate disinfection practices for these devices are included within these policies, and should emphasize the user's responsibility for ensuring that disinfection is performed.

Recommendation:

1. **Health care settings shall only purchase, install, or use surfaces, finishes, furnishings and equipment that can be effectively cleaned and disinfected. [A III]** [modified 2018]

2. **Health care settings should have policies that specify the criteria to be used when choosing surfaces, finishes, furnishings, and equipment for the health care setting. [B III]** [modified 2018]

3. **Environmental services, infection prevention and control, and occupational health and safety must be involved in the selection of surfaces, finishes, furnishings and equipment in health care settings. [A III]** [modified 2018]

4. **Surfaces, finishes, furnishings, and equipment in health care setting shall be cleanable with hospital cleaners, detergents and disinfectants (except in those long-term care homes where the furniture is supplied by the resident) [A III]; and must be smooth, nonporous, and seamless. [A III]** [modified 2018]

5. **Surfaces that support or promote microbial growth must not be used in the health care setting. [A III]** [modified 2018]

6. **Cracked or torn furnishings must be removed from care areas until either repaired so that they can be effectively cleaned, or replaced. [A III]** [modified 2018]

7. **Cloth furnishings and upholstered furniture shall not be used in care areas housing immunocompromised patients and must not be used in other care areas. [A III]** [modified 2018]

8. **Privacy curtains must be removed, and replaced or cleaned and disinfected immediately if they become contaminated with blood or body fluids, or are visibly soiled. [A III]** [new 2018]

9. **Privacy curtains used for patients/residents requiring Additional Precautions must be removed, and replaced or cleaned and disinfected following discharge or transfer of the patient/resident and before a new patient/resident is admitted to that room or bed space. [A III]** [new 2018]

10. **Privacy curtains should be changed after all discharges. [B III]** [new 2018]

11. **Carpeting shall not be used in areas that house or serve immunocompromised patients and must not be used where there is a high likelihood of contamination with blood or body fluids. [A III]** [modified 2018]

12. **Carpeting must not be used in any care area within health care facilities.[80] [A III]** [new 2018]

13. **Noncritical medical equipment used in the health care setting, including purchased, borrowed or donated equipment and equipment used for research purposes, shall be able to be cleaned and disinfected with a hospital disinfectant. [A III]** [modified 2018]

14. **Facilities must have item-specific instructions from manufacturers for cleaning and disinfecting all noncritical medical equipment, including purchased, borrowed or donated equipment and equipment used for research purposes. [A III]** [modified 2018]

15. **Reusable equipment used for cleaning must itself be cleaned and disinfected with a hospital disinfectant. [A III]** [modified 2018]

16. **Plastic coverings used to cover equipment must be:**
    a. **Cleaned and disinfected (or discarded) between client/patient/resident (for patient care equipment) or on a regular basis (for nonpatient care equipment within the care environment.) [A III]** [modified 2018]
    b. **Replaced if damaged. [A III]** [modified 2018]

17. **Electronic equipment that cannot be cleaned and disinfected must not be purchased, installed or used in health care settings. [A III]** [modified 2018]

1.3 Cleaning Agents, Disinfectants, and Cleaning Equipment

Cleaning is the removal of foreign material (e.g., dust, soil, organic material such as blood, secretions, excretions and microorganisms) from a surface or object. Cleaning physically removes rather than kills microorganisms, reducing the organism load on a surface. It is accomplished with water, detergents and mechanical action. The key to cleaning is the use of friction to remove microorganisms and debris. Thorough cleaning is required for any equipment/device to be disinfected as organic material may inactivate a disinfectant. This may be accomplished through a two-step process involving the use of a cleaner followed by a disinfectant, or through a one-step process using a combined cleaner/disinfectant product.

Disinfection is a process used on inanimate objects and surfaces to kill microorganisms. Disinfection will kill most disease-causing microorganisms but may not kill all bacterial spores.

> **The key to cleaning is the use of friction to remove microorganisms and debris.**

1.3.1 DETERGENTS AND CLEANING AGENTS

Detergents remove organic material and suspend grease or oil. Equipment and surfaces in the health care setting must be cleaned with approved cleaners and hospital disinfectants.

Most environmental surfaces will be adequately cleaned with soap and water or a one-step cleaner/disinfectant, depending on the nature of the surface and the type and degree of contamination.[92]

A variety of products can be used to achieve effective cleaning. The process and products used for cleaning and disinfection of surfaces and medical equipment must be compatible with the surfaces/equipment.[19] It is important to follow the manufacturer's instructions when using cleaning agents. Cleaning products used in the health care setting:

- Must be approved by infection prevention and control, occupational health and safety, and environmental services.
- Must have a drug identification number (DIN) from Health Canada if it contains a disinfectant.
- Must be used according to the manufacturers' recommendations (e.g., for dilution, temperature, water hardness, contact time, etc.).
- Must be used according to the product's safety data sheet.

1.3.2 DISINFECTANTS

Disinfectants for use on noncritical medical devices and hard nonporous environmental surfaces and inanimate objects in hospitals are regulated by Health Canada and are commonly referred to as hard surface disinfectants.[4] A hospital disinfectant is a kind of hard surface disinfectant that carries efficacy claims against the bacteria *Pseudomonas aeruginosa* and *Staphylococcus aureus*.[140] In addition, hard surface disinfectants may carry label claims as bactericides, fungicides, virucides, mycobactericides, or sporicides.[140]

Disinfectants are only to be used to disinfect and must not be used as general cleaning agents, unless combined with a cleaning agent as a one-step cleaner/disinfectant.[141] Skin antiseptics must never be used as environmental disinfectants (e.g., alcohol-based-hand rub, chlorhexidine gluconate).

This document deals with disinfectants used on noncritical equipment and hard surfaces. For information about high-level disinfectants used on reusable semicritical and critical medical devices, see PIDAC's *Best Practices for Cleaning, Disinfection and Sterilization in All Health Care Facilities*.[19]

1.3.2.1 Choosing a Disinfectant

Ideally, facilities should select a single hospital disinfectant that meets all or most of the facilities cleaning and disinfection requirements. Although the complexity of the health care environment may require the use of more than one disinfectant product, every effort should be made to limit the total number of different products in use. This will simplify the cleaning process, minimize the training requirements for environmental service workers, and reduce the potential for errors.

The disinfectant must have a DIN from Health Canada (sodium hypochlorite and alcohol-based disinfectants are exceptions, and may be used within the health care setting in the appropriate concentration).

Manufacturers should assist facilities by listing all hospital disinfectants that are compatible with their items or equipment. Facilities should not purchase items and equipment that cannot be disinfected with the hospital disinfectants selected. In exceptional cases where essential equipment is required and where the manufacturer's instructions do not list the facilities' hospital disinfectant as an acceptable product, facilities should conduct their own risk assessment that considers:

- the risk of equipment damage or malfunction from disinfection
- the cost of replacing damaged equipment and the warranties

Using multiple disinfectants in a facility increases the risk of error and inadequate disinfection. Therefore, facilities may choose to use a disinfectant that is not listed by the manufacturer, or to purchase alternative items or equipment that is compatible with the facilities' hospital disinfectant. Hospitals should work with their suppliers to ensure the latter is aware of the facility's approved hospital disinfectants and disinfection process.

The following factors influence the choice of disinfectant:[92,142]

- The efficacy and spectrum of activity of the disinfectant – is it effective in inactivating all of the microorganisms most likely to cause healthcare-associated infections within the setting where it will be used.
- Ease of use.
  - The disinfectant should have a sufficiently short contact time and should keep surfaces wet long enough to ensure that the contact time is met (at the usual ambient temperature of the healthcare setting.
  - The disinfectant should be simple to prepare and use at the required concentration.
  - The ability of the disinfectant to act as a cleaner and disinfectant (e.g., one-step cleaner disinfectant.)
- Compatible with the items and surfaces requiring disinfection.
- Safe for use for both staff and patients:
  - Hospital disinfectants including quaternary ammonium compounds, phenolics, improved hydrogen peroxide, or sodium hypochlorite have been reported to cause respiratory and skin irritation and allergic reactions and are one of the leading allergens affecting health care providers. Furthermore, staff will be more likely to use products that are nontoxic, non-irritating and have an acceptable odour.[143-152]
  - Flammability and safe storage should be considered.
- Cost and the impact on the environment should also be considered.
  - Consider products that are biodegradable and safe for the environment.
  - Many disinfectants (e.g., quaternary ammonium compounds) may be hazardous both during manufacture and when they are discharged into the waste stream, as they are not readily biodegradable.[152]

➢ See Hospital Disinfectants for Disinfection of Environmental Surfaces for a list of common hospital disinfectants for disinfection of environmental surfaces.

➢ See Appendix 1 for the advantages and disadvantages of some common hospital disinfecting agents.

Hospital Disinfectants for Disinfection of Environmental Surfaces

Hospital disinfectants commonly used in all health care settings include:[92,153-155]

- Alcohol (ethyl or isopropyl)
- Improved hydrogen peroxide
- Iodophors
- Phenolics
- Quaternary ammonium compounds
- Sodium hypochlorite (bleach)

1.3.2.2 Using Disinfectants

When using a disinfectant:

- It is most important that an item or surface be free from visible soil and other items that might interfere with the action of the disinfectant, such as adhesive products, before a disinfectant is applied, or the disinfectant will not work.[156] Most disinfectants lose their effectiveness rapidly in the presence of organic matter.[154,157]
- A hospital disinfectant is appropriate for noncritical equipment (i.e., equipment that only touches intact skin).[140] Examples include intravenous pumps and poles, hydraulic lifts, blood pressure cuffs, apnoea monitors and sensor pads, electrocardiogram machine/cables and crutches.
    - Refer to Appendix 2 for a list of items that require cleaning followed by disinfection (or application of a cleaner/disinfector).
- It is important that the disinfectant be used according to the manufacturer's instructions for dilution and contact time.[16,85,158,159] Where dispensing systems are used, health care facilities should verify regularly that the systems are functioning properly (e.g., use of manufacturers' test strips, calibration of dispensers).[160]
    - Refer to Appendix 1 for disinfectants commonly used in health care settings with their recommended concentrations and contact times.
- Minimize the contamination levels of the disinfectant solution and equipment used for cleaning.[161] This can be achieved by ensuring proper dilution of the disinfectant,[162] frequently changing the disinfectant solution and wiping cloths, not dipping a soiled cloth into the disinfectant solution (i.e., no "double-dipping"),[163] and regular cleaning and disinfection of cleaning equipment.[164] (See Figure 2)
- Personal protective equipment must be worn appropriate to the product(s) used.
- There should be systems in place to ensure the efficacy of the disinfectant over time (e.g., frequent testing of product, review of expiry date).[161]

* High-level disinfectants for use on semicritical devices are discussed in PIDAC's *Best Practices for Cleaning, Disinfection and Sterilization of Medical Equipment/Devices in All Health Care Settings*.[19]

Figure 2: Culture Plates Showing Contamination of Surface by Contaminated Disinfectant Solution[161,164]

Two contact agar plates were taken from a patient's overbed table before (left) and after (right) cleaning. The environmental surface had a higher level of bacterial growth after cleaning as a result of using contaminated quaternary ammonium disinfectant. The pail holding the disinfectant solution had been used repeatedly for months without being emptied and dried between uses.

(Source: Boyce JM. Modern technologies for improving cleaning and disinfection of environmental surfaces in hospitals. Antimicrob Resist Infect Control. 2016;5:10. Figure 1, Contact agar plate cultures showing bacterial colonies recovered from a patient's overbed table before (left) and after (right) the surface was cleaned by a housekeeper using contaminated quaternary ammonium disinfectant. Available from: https://aricjournal.biomedcentral.com/articles/10.1186/s13756-016-0111-x. Creative Commons Attribution 4.0 International License.)

1.3.2.3 Disinfectant Wipes

Adequate disinfection of equipment requires that sufficient quantity of an effective hospital disinfectant be applied to all surfaces for the appropriate contact time. This may be achieved using either a cloth and sufficient quantities of a disinfectant, or a large, pre-prepared (ready-to-use) wipes saturated with an appropriate disinfectant product. Both approaches have advantages and disadvantages, and neither approach is effective unless performed correctly.[165-170] There is limited data comparing these two methods.[165,171-176] Concerns with ready-to-use wipes include a lack of data on efficacy,[172,175,177-179] the limited contact times, and the potential for wipes to dry out prior to use (if incorrectly stored) or rapidly during use.[169] Facilities may select either a cloth with disinfectant or large, pre-prepared wipes for use by environmental services to clean surfaces and equipment.

Mobile equipment that moves from patient/client/resident to patient/client/resident (e.g., stethoscopes, vital signs monitors) must be cleaned by the user between patient/client/resident. In this circumstance, smaller pre-prepared disinfectant wipes (i.e., NOT small antiseptic wipes used for skin preparation) may be used by health care providers for cleaning and disinfection. These wipes should be stored near the point-of-care in a sealed container and should not be used if dry. These small disinfectant wipes should NOT be confused with the larger pre-prepared wipes described above and should NOT be used to clean or disinfect surfaces or large or complex pieces of equipment.

When selecting and using disinfectant wipes:

- Infection prevention and control, occupational health and safety, and environmental services should be involved in the selection of ready-to-use wipes.
- The wipes selected should be approved by Health Canada and have a DIN number.
- The detergent and disinfectant properties of the wipes, efficacy data, and the manufacturer's instructions for use should be reviewed.
- The active ingredient must be an appropriate hospital disinfectant.
- Wipes must be kept wet (by keeping the lid closed) and discarded if they become dry.
- Follow manufacturers' recommendation for storing wipes and reprocessing containers. Containers that are not properly cleaned and disinfected may become a reservoir for microorganisms such as *Pseudomonas aeruginosa*,[169] *Serratia marcescens*,[180] *Achromobacter* species[180,181] which may develop tolerance to the disinfectant being used.[169]

- Follow the manufacturers' recommendations when using wipes, and ensure that the correct contact time required to achieve adequate disinfection is used.
- Care must be taken to avoid introducing contamination to the container when preparing the disinfectant solution.[182]
- Wipes must have a safety data sheet and be used according to the safety data sheet (e.g., wear gloves when handling, if recommended).
- Small disinfectant wipes must only be used for:
  - Items in the care environment that will not tolerate soaking.
  - Small, mobile items that must be disinfected between clients/patients/residents at the point-of-care (e.g., stethoscopes, vital signs monitors).

1.3.3 MICROFIBRE AND ULTRAMICROFIBRE CLEANING PRODUCTS

Microfibre cleaning products are woven with very fine split fibres of hydrophilic polyamide and hydrophobic polyester in various combinations that differ across manufacturers.[183,184] These cleaning products can hold more water than conventional cleaning cloths (up to 6 times their weight).[184] Ultramicrofibre cleaning products comprise even thinner fibres,[185] and are designed to be used with low volumes of water without detergent or disinfectant.[185] The positively charged fibres attract dirt and bacteria by statics and capillary action.[16,184,186] As a result, microfibre and ultramicrofibre cleaning products are supposed to retain the particles picked up firmly during the cleaning process.[16,184,186] The fine size and split shape of the fibres also allow the cleaning products to pick up dirt and bacteria from very small or invisible irregularities of surface that conventional cleaning cloths or mops cannot reach.[183-185,187]

The use of microfibre and ultramicrofibre cleaning products can reduce the amount of water and cleaning disinfecting chemicals used and disposed in cleaning environmental surfaces and in reprocessing these cleaning products, resulting in lower cost and reduced exposure to disinfectant chemicals, and less time spent in preparing and replenishing the cleaning solution.[184,188] Due to their lighter weight, these cleaning products are more ergonomic to handle with a lower risk for musculoskeletal injuries.[184,188]

Microfibre and ultramicrofibre cleaning products come in different densities, fibre combinations, and weaving patterns, giving rise to different texture, absorbency, durability, and performance.[189] Although microfibre and ultramicrofibre cleaning products have been reported to clean and remove bacteria (including *C. difficile* spores) better than other common cleaning tools (e.g., cotton cloths, J-cloths, paper towel) when used wet on surfaces without disinfectants,[185,186,190-193] their performance varies with the brands,[194] the presence of soil,[183,194] the number of times they have been washed, [194,195] the kind of microorganisms on the surface,[194] and the surface type;[194] and they do not always decontaminate environmental surfaces better than cloths of other materials.[189,195,196] In addition, their potential in spreading microorganisms from surface to surface during the cleaning process varies.[189,194,197] Environmental service workers should, therefore, be using a new cloth or mop head when moving from a patient environment to another patient environment, and when crossing between patient and health care environments.[190,197] Depending on the level of soiling, it may be necessary to change cloths between different areas within a patient environment.[190] In addition, although microfibre and ultramicrofibre cleaning products claim to deliver superior cleaning with water only, the use of disinfectants can be helpful to destroy any bacteria spread by these products during cleaning. However, many microfibre and ultramicrofibre cleaning products bind with quaternary ammonium compounds and lower the concentration of the disinfectant delivered to a surface.[198,199] Environmental service

workers must follow manufacturers' instructions in selecting compatible cleaning and disinfecting agents. Although the cleaning efficacy of microfibre cleaning products used dry does not surpass that of other commonly used cleaning materials,[189] dusting with microfibre products may be better due to its electrostatic properties.[184]

The fibres in most of these cleaning products can also be destroyed by chlorine-based disinfectants (e.g., bleach).[185,199,200] Health care settings that use these cleaning products should consult with the manufacturers' instructions on using and regenerating these cleaning products which may be contaminated by *C. difficile* spores during the cleaning process.[16,194,200] Cleaning and disinfection protocols must be established to reprocess these cleaning products, as their ability to absorb water and hold on to microorganisms may also provide a niche for microbial growth.[189,195] Besides, fabric softeners or cleaning together with organic fibres (e.g., cotton) that produce lint will clog the fibres and reduce efficacy.[199] Microfibre cloths are also damaged by high temperature.[193] Health care settings should ensure that training is provided to those who use and reprocess these products,[193] and manufacturers' recommendations on the laundry conditions (e.g., optimal temperature, launder detergents) must be followed.[190]

Recommendations:

18. **Cleaning and disinfecting products:**
    a. **Must be approved by environmental services, infection prevention and control and occupational health and safety. [A III]** [reviewed and not changed 2018]
    b. **Disinfectants must have a DIN from Health Canada. [A III]** [reviewed and not changed 2018]
    c. **Should be compatible with surfaces, finishes, furnishings, items and equipment to be cleaned and disinfected. [B III]** [modified 2018]
    d. **Must be used according to the manufacturer's recommendations. [A III]** [reviewed and not changed 2018]

19. **Disinfectants chosen for use in health care:**
    a. **Must be active against the microorganisms encountered in the health care setting. [A III]** [modified 2018]
    b. **Should require little or no mixing or diluting, i.e., be dispensed through an appropriate effective proportioner. [B III]** [modified 2018]
    c. **Should be active at room temperature with a short contact time. [B III]** [reviewed and not changed 2018]
    d. **Should have low irritancy and allergenic characteristics. [B III]** [reviewed and not changed 2018]
    e. **Should be safe for the environment. [B III]** [reviewed and not changed 2018]

20. **Health care facilities should select a limited number of hospital disinfectants to minimize training requirements and the risk of error. [B III]** [new 2018]

21. **Hospital disinfectants used on noncritical equipment and surfaces:**
    a. **Must only be applied after visible soil and other impediments to disinfection have been removed. [A III]** [modified 2018]
    b. **Must follow the manufacturer's instructions for dilution and contact time. [A III]** [modified 2018]

22. **Cloths must not be repeatedly immersed into disinfectant (i.e., no "double-dipping" of cloths.) [A III]** [modified 2018]

23. **Where personal protective equipment is recommended for use to prevent exposure to a specific disinfectant, such personal protective equipment shall be worn. [Legislation]** [new 2018]

2. Principles of Infection Prevention and Control for Environmental Service Workers

Environmental service workers work in a health care environment where there are risks of infectious diseases transmission through exposure to clients/patients/residents, contaminated items and surfaces, and via exposure to blood and body fluids. These risks can be minimized by the correct and consistent use of good infection prevention and control practices, most importantly the use of Routine Practices (see below) at all times when in the care environment. Health care facilities must ensure that all environmental service workers receive education and training with respect to infection prevention and control best practices, including the correct use of personal protective equipment.[31]

2.1 Routine Practices

Environmental service workers may be exposed to blood or body fluids and microorganisms that contaminate the health care environment. The principle of Routine Practices is that all clients/patients/residents may carry harmful microorganisms regardless of their isolation status or diagnosis. Routine Practices are essential practices that must be followed by all staff working in clinical areas and are intended to prevent the transmission of organisms and to protect both staff and clients/patients/residents.

Environmental service workers must adhere to Routine Practices when working in the care environment. Routine Practices include:

- hand hygiene
- use of personal protective equipment when indicated
- safe management of sharps
- cleaning and disinfection of equipment that moves from client/patient/resident to client/patient/resident
- environmental cleaning

➢ See PIDAC's *Routine Practices and Additional Precautions for All Health Care Settings*[7] for more information regarding Routine Practices.

2.1.1 HAND HYGIENE

Hand hygiene is the most effective measure to prevent the spread of health care-associated infections.[201-211] Hand hygiene must be practised:

- Before initial patient/patient environment contact (e.g., before coming into the client/patient/resident room or bed space).
- After potential body fluid exposure (e.g., after cleaning bathroom, handling soiled linen, equipment or waste).
- After patient/patient environment contact (e.g., after cleaning client/patient/resident room; after cleaning equipment such as stretchers; after changing mop heads).

It is necessary to **clean hands after removing gloves** as gloves do not provide complete protection against hand contamination.[32,64,212-214] The use of gloves does not replace the need for hand hygiene.

Alcohol-based hand rubs are recommended when hands are not visibly soiled as they rapidly kill microorganisms, and because it takes less time to perform hand hygiene with alcohol-based hand rubs than with soap and water. [32,64,214-216] Alcohol-based hand rubs are also easier on the hands and cause less skin breakdown than soap and water.

Environmental service workers must perform hand hygiene before entering and on leaving the client/patient/resident environment; alcohol-based hand rubs are the preferred method for hand hygiene after activities that do not result in visible soiling of the hands, such as dusting, mopping and vacuuming. When hands are visibly soiled, hand hygiene with soap and water is required.

Dedicated hand washing sinks are required for hand washing with soap and water, to avoid splash back of microorganisms from contaminated sinks onto clean hands during rinsing. Hand washing sinks shall not be used for other purposes, such as disposal of fluids or cleaning of equipment.[80]

> **The use of gloves does not replace the need for hand hygiene.**

For more information regarding hand hygiene:

- See the Public Health Ontario's *Just Clean Your Hands* hand hygiene improvement program for hospitals and long-term care homes.[33]
- See PIDAC's *Best Practices for Hand Hygiene in All Health Care Settings*.[32]

Recommendation:

24. **Environmental service workers must follow best practices for hand hygiene. [A II]** [reviewed and not changed 2018]

2.1.2 PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment for health care providers and other staff refers to a variety of barriers used alone or in combination to protect mucous membranes, airways, skin and clothing from contact with infectious agents and from chemical agents. Environmental service workers should wear personal protective equipment:

- for protection from microorganisms
- for protection from chemicals used in cleaning
- for prevention of transmission of microorganisms from one patient environment to another

Health care settings must ensure that:

- Personal protective equipment is sufficient and accessible for all environmental service workers for Routine Practices, Additional Precautions[7,217,218] and for personal protection from chemicals used in cleaning.[217]
- WHMIS training regarding appropriate handling of biohazardous material is provided.

- Individualized training is provided in the correct use, application and removal of personal protective equipment.[219,220]
- Environmental service workers who are required to wear N95 respirators for Airborne Precautions are fit-tested in accordance with a respiratory protection program that is compliant with the Ministry of Labour and Canadian Standards Association requirements.[221]

Personal protective equipment is used as part of Routine Practices to prevent contact with blood, body fluids, secretions, excretions, non-intact skin or mucous membranes. Personal protective equipment must be used in the following circumstances:

- Glove must be worn when there is a risk of hand contact with blood, body fluids, secretions or excretions or items contaminated with these.
- Gowns must be worn if contamination of uniform or clothing is anticipated (e.g., cleaning bed of incontinent client/patient/resident).
- Mask and eye protection or face shield must be worn where appropriate to protect the mucous membranes of the eyes, nose and mouth during activities involving close contact (i.e., within two metres) with clients/patients/residents likely to generate splashes or sprays of secretions (e.g., coughing, sneezing).

➢ For more information about personal protective equipment, see PIDAC's *Routine Practices and Additional Precautions for All Health Care Settings*.[7]

2.1.2.1 Glove Use in Environmental Services

Unnecessary or prolonged wearing of gloves is not recommended. Prolonged exposure to gloves increases the risk of irritant contact dermatitis from sweat and moisture within the glove and the risk of tears.[222,223]

Gloves must be removed immediately after the activity for which they were used and, if disposable, discarded.[7,32,218] Continuing to wear the same pair of gloves while moving from one patient environment to another, or between the patient and the health care environment, facilitates the spread of microorganisms.[7,224,225] Environmental service workers must not walk from patient environment to patient environment and between patient and health care environment wearing the same pair of gloves.[32,58] Disposable gloves should never be washed and re-used.[7,226,227]

Gloves are never a substitute for hand hygiene but should be used, when indicated, as an additional measure to reduce the risk of hand contamination with microorganisms and chemicals. Hand hygiene must be performed immediately before putting on gloves and immediately after gloves are removed.[7,32,64,216,218,228]

It is important to assess and select the most appropriate glove to be worn for the activity about to be performed. Selection of gloves should be based on a risk analysis of the type of setting, the task that is to be performed, likelihood of exposure to body substances, length of use and amount of stress on the glove.[218] The glove requirements identified in the safety data sheet must be followed when using a chemical agent. In general:

- Disposable gloves may be used for routine daily cleaning and disinfecting procedures in client/patient/resident care areas and public washrooms.

- Durable, polymer gloves compatible with the safety data sheet for the product(s) used are recommended for wet work of long duration when durability is required, for discharge/transfer cleaning and for contact with certain chemical powders and solutions.
- Household utility gloves are only acceptable for cleaning in noncare areas, with the exception of public washrooms.
- Puncture-resistant gloves are recommended if the task has a high risk for percutaneous injury (e.g., sorting linen, handling waste).

➢ See PIDAC's *Routine Practices and Additional Precautions in All Health Care Settings*[7] for more information about the use of gloves.

Gloves must be removed and hand hygiene performed upon leaving each client/patient/resident room or bed space.

Recommendations:

25. **Gloves must be removed and hand hygiene performed on moving from one patient environment to another, or between the patient and the health care environment. [A III]** [modified 2018]

26. **Gloves must not be worn when walking from room to room, from bed space to bed space, or in other areas of the health care facility. [A III]** [modified 2018]

2.1.2.2 Personal Protective Equipment in Environmental Services

A gown, respiratory protection and eye protection are not required for routine cleaning activities. However, personal protective equipment requirements identified on safety data sheets shall be followed when using chemical agents (e.g., wearing eye protection when mixing chemical agents or when there is a risk of splashing, wearing protective clothing or apron when the chemical may cause skin burns or irritation).[8,217] Additionally, personal protective equipment is required when cleaning in the patient/resident environment for patients on Additional Precautions. For staff working in laundry facilities, barrier gowns or fluid-resistant aprons and sleeves shall be worn with a face shield when there may be a risk of splashing.[7,218,229]

➢ See PIDAC's *Routine Practices and Additional Precautions in All Health Care Settings*[7] for more information about the use of gowns, masks and eye protection.

2.1.2.3 Removal of Personal Protective Equipment

Personal protective equipment, when worn, must be removed in a manner that will not contaminate the wearer and must be removed and discarded immediately after the task has been completed. Hand hygiene must be performed after removal of personal protective equipment.

➢ See PIDAC's *Routine Practices and Additional Precautions in All Health Care Settings*[7] for more information about correct removal of personal protective equipment.

2.2 Additional Precautions

Additional Precautions (i.e., Contact Precautions, Droplet Precautions and Airborne Precautions) are precautions that are necessary in addition to Routine Practices when caring for clients/patients/residents with certain microorganisms or clinical presentations. The specific type of Additional Precautions required is based on the method of transmission of the suspected infectious agent (e.g., Airborne Precautions for suspected tuberculosis, Droplet and Contact Precautions for influenza).[7]

Clients/patients/residents on Additional Precautions may be cohorted or placed in single rooms with appropriate signage affixed to the entrance to the room that indicates the personal protective equipment required when carrying out activities inside the room. All staff must comply with these precautions when entering the room.

- See PIDAC's *Routine Practices and Additional Precautions in All Health Care Settings*[7] for more information about Additional Precautions and the use of personal protective equipment.

Recommendations:

27. **Environmental service workers must adhere to Routine Practices and Additional Precautions. [A III]** [modified 2018]

28. **Personal protective equipment:**
    a. **Shall be sufficient and accessible for all environmental service workers. [Legislation]** [modified 2018]
    b. **Shall be worn as required by Routine Practices, Additional Precautions, and by safety data sheets when handling chemicals. [Legislation]** [modified 2018]
    c. **Must be removed immediately after the task for which it is worn. [A III]** [reviewed and not changed 2018]

3. Cleaning Best Practices for Client/Patient/Resident Care Areas

Good environmental cleaning practices are essential for reducing the risk of transmitting infectious diseases and minimizing the risk of patient or occupational injury.[18,230-234] These will contribute to a culture of safety by providing an atmosphere of cleanliness and order. A clean environment is also a basic expectation of clients/patients/residents,[235] their families, and staff, and is essential to providing a patient- and family-focused care environment and a positive work environment.[236]

Environmental cleaning in the health care setting should be performed on a routine basis to provide for a safe and sanitary environment. Processes should be in place to ensure that regular and effective cleaning is occurring consistently (see 9. Assessment of Cleanliness and Quality Control).

Recommendation:

29. **Environmental cleaning in the health care setting must be performed on a routine and consistent basis to provide for a safe and sanitary environment. [A III]** [modified 2018]

3.1 General Principles

To ensure that regular, effective cleaning is implemented and performed consistently and correctly:

- Health care facilities must ensure that an appropriately organized and resourced environmental service department is in place.
- Health care facilities must have up-to-date policies and procedures for environmental cleaning that are:
  - Designed to minimize the spread of infection within the health care setting.
  - Attainable and understandable to frontline environmental service workers.
  - Reviewed regularly and updated as advances and developments in environmental cleaning techniques and technology occur.
- The primary focus of the environmental service department must be the safety of clients/patients/residents, staff and visitors.

3.1.1 ORGANIZATION AND REQUIRED RESOURCES FOR EFFECTIVE ENVIRONMENTAL CLEANING

Environmental services should be organized and resourced appropriately for the type of health care setting.[79] The health care setting must ensure that environmental services has the human resources, education and equipment required to perform effective cleaning.[237]

All health care settings must have an environmental service program with:

- A single individual assigned overall responsibility for the care of the physical facility.
- A sufficient number of supervisors trained and knowledgeable in cleaning standards and practices to support all frontline environmental service workers.
- A primary focus on cleaning patient care areas, rather than administrative or public areas.
- Written policies and procedures for cleaning and disinfection of client/patient/resident areas and equipment that include:
  - Defined lines of accountability.
  - Defined responsibility for specific areas and items.
  - Procedures for routine (e.g., daily) and discharge/ transfer cleaning and disinfection.
  - Procedures for cleaning in construction/renovation areas.
  - Procedures for specific environmentally-hardy microorganisms such as VRE and *C. difficile.*
  - Procedures for outbreak management.
    - Cleaning and disinfection standards and frequency.
- Initial and continuing education for all environmental service workers.
- Monitoring of environmental cleanliness with:
  - Results reported back to become part of the employee's performance review.[31]
  - Aggregate results reviewed by environmental service leadership as well as the appropriate infection prevention and control and/or quality and safety committees.
- Ongoing review of all policies and cleaning procedures.

All health care settings must devote sufficient resources to environmental services to ensure that:

- Environmental service workers can adhere to the health care settings policy on cleaning and disinfection frequency.
- There is sufficient staffing and resources to allow thorough and timely cleaning and disinfection.
- There is sufficient staffing and resources to allow for provision of additional environmental cleaning capacity during outbreaks that does not compromise routine cleaning of any clinical areas or client/patient/resident rooms.[31,237]

These recommendations and cleaning practices apply to all health care settings regardless of whether cleaning is conducted by in-house staff, or contracted out. They are designed to be used as a standard against which in-house services can be benchmarked, as the basis for specifications if cleaning services are contracted out, and as the framework for auditing of cleaning services by cleaning supervisors and managers.

Recommendations:

30. **Sufficient resources must be devoted to environmental services to ensure effective cleaning at all times, including surge capacity for high-demand periods, e.g., outbreaks; high occupancy; or high turnover. [A III]** [modified 2018]

31. **Health care settings should design their environmental service organizational structure to ensure accountability at all levels and should have:**
    a. **A single individual with assigned responsibility for the cleaning of the physical facility. [B III]** [modified 2018]
    b. **Supervisors with responsibility for ensuring adherence to occupational health and infection prevention and control policies and protocols, including the correct use of personal protective equipment, maintaining a safe work environment, and ensuring adherence to cleaning schedules and protocols. [B III]** [new 2018]

32. **Audit and feedback results must be presented to the environmental service leadership of the health care facility and to the appropriate infection control and/or quality and safety committee (or equivalent). [A III]** [new 2018]

33. **Health care facilities must have written procedures for cleaning and disinfection of care areas and equipment that include:**
    - **defined responsibility for specific items and areas**
    - **routine and discharge/transfer cleaning**
    - **cleaning in construction/renovation areas**
    - **cleaning and disinfecting areas under Additional Precautions**
    - **outbreak management, and**
    - **cleaning standards and frequency. [A III]** [modified 2018]

34. **Health care facilities must review policies and procedures for environmental cleaning on a regular basis. [A III]** [modified 2018]

35. **Health care facilities must provide initial and continuing education for environmental service workers. [A III]** [modified 2018]

3.1.1.1 Contracted Services

Some health care facilities are using contracted out environmental services. If environmental services are contracted out, it is essential to ensure that infection control and occupational health-related priorities are clearly outlined in the contract.[238-241] Contract staff must work collaboratively with clinical staff, infection prevention and control, and occupational health and safety to ensure the safety of clients/patients/residents, staff and visitors; contractual barriers that prevent this from happening should be removed.[242]

If environmental services are contracted out, the following should be included in the legal agreement with the service provider/contracting agency:[242]

- The service provider's responsibility for employee health and mandatory training should be specified.[141]
- The occupational health and safety polices of the service provider must be consistent with the occupational health and safety policies of the health care facility as it relates to infection prevention and control, immunization (including annual influenza immunization), access to staff health policies and measures related to Additional Precautions, response to and sharing of

information related to work place exposure incidents, and outbreak investigation and management (as required under the *Communicable Disease Surveillance Protocols*)[243]

- It should be recognized that ever-changing activity levels and cleaning protocols will potentially impact the cost of service. Contracts should support (without penalty or financial barrier) a proactive and cooperative environment to consistently implement appropriate cleaning measures.
- There should be clear expectations regarding cleaning frequency, adherence to cleaning standards, and the need for routine audit, feedback, and ongoing education to ensure consistent and effective cleaning occurs.

Recommendation:

36. **If environmental services are contracted out, the occupational health and safety policies of the contracting services must be consistent with the facility's occupational health and safety policies. [A III]** [reviewed and not changed 2018]

3.1.1.2 Staffing Levels

Adequately staffed environmental service departments are one of the most important factors that govern the success of environmental cleaning in a health care setting.[69,74,234,237,242,244] Staffing levels must be appropriate to each department of the health care facility, with the ability to increase staffing in the event of outbreaks.[242] Environmental service departments of Canadian acute care facilities are frequently under-resourced, potentially increasing the risk of health care-associated infections, antibiotic-resistant organism transmission, and outbreaks.[245-248]

General staffing levels and human resource requirements may be estimated by determining the average time required for environmental service workers to adequately perform daily and terminal cleaning of client/patient/resident rooms. A variety of approaches have been taken to estimate average cleaning times that include basing estimates on past experience, conducting time/motion studies, adding up the time required for a series of individual tasks,[249] or using industry standards[250] or workload software. When estimating required staffing levels, it is essential to consider whether environmental service staff will have roles and responsibilities in addition to cleaning (e.g., patient transport, meal delivery, etc.).

Currently, the best method for determining average cleaning times, and therefore appropriate staffing levels, is unknown. There are few benchmarks available to use as guidance.[249,251] One survey of environmental service managers at 50 Canadian acute care hospitals identified that cleaning times varied significantly based on cleaning type (i.e., daily clean, discharge/terminal clean), room type (i.e., private, semi-private, ward), and the need for isolation.[249]

While this survey provides some preliminary data on room cleaning times at Canadian acute care hospitals, it is essential to recognize that there are numerous factors that must be considered when determining the appropriate staffing level for a specific health care setting or facility (see Factors to Consider When Determining Environmental Service Staffing Level).

Factors to Consider When Determining Environmental Service Staffing Level

- **facility type**
  - Acute care facilities, long term care facilities and specialized facilities will all have specific environmental cleaning needs and requirements.
  - Facilities with specialized areas (e.g., operating and procedure rooms, dialysis units, burn units, intensive care units) will require increased environmental cleaning resources.
- **building factors**
  - Age, design and size of facility (larger and older buildings are harder to clean).
  - Climate and season.
  - Exposure of facility to outside dust and soil, e.g., construction site.
  - Type of floors and walls.
  - Presence of carpet and upholstered furniture.
- **occupancy factors**
  - Occupancy rate and volume of cases.
  - Patient/resident mix and type of care in the area (e.g., acute care, long-term care, clinic) vs. no care in the area (e.g., public area).
  - Frequency of cleaning required in an area (e.g., once daily vs. after each case).
  - Square metres to be cleaned in patient care areas.
  - Square metres to be cleaned in nonpatient care areas.
  - Admissions, discharges, transfers by unit or area—more rapid turnover requires a shorter turnaround time for rooms and equipment and more frequent discharge or transfer cleaning.
- **infection control precautions**
  - Proportion of patients requiring Additional Precautions (due to time required to don or doff personal protective equipment and additional cleaning requirements for some organisms).
  - Frequency of outbreaks.
  - VRE and *C. difficile* rates as extra cleaning is required for both of these microorganisms.
- **equipment factors**
  - Type of cleaning tools/equipment available (e.g., automated floor cleaner vs. mop and bucket).
  - Methodology required for cleaning (i.e., equipment, chemicals, materials and physical ergonomics).
  - Placement of custodial closets.
- **training factors**
  - Amount and level of training given to new staff will influence supervisory staffing levels.
  - Staff training and experience (inexperienced and under trained staff will work slower than well trained, experienced staff).
- **legislative requirements**
  - Amount of regulatory responsibility a supervisor may have.
  - Environmental service worker role.
  - Whether the role of the environmental service worker is limited to cleaning or expanded to include other roles or tasks (e.g., patient transportation, food delivery).
- **role of environmental service staff**
  - Tasks assigned to environmental service workers.

It is also important to note that increased cleaning time alone is not necessarily associated with the thoroughness of cleaning.[252] Written procedures and checklists, as well as routine audit and feedback, are essential to standardize cleaning and disinfection times and to ensure that no surfaces and items are missed during cleaning (See 9. Assessment of Cleanliness and Quality Control).[158,253-258]

Supervisory staffing levels must be appropriate to the number of staff involved in cleaning (e.g., one supervisor to 15-20 workers in patient care areas of an acute care facility[259]). Supervisory staff has responsibilities under the *Occupational Health and Safety Act*[229] to ensure staff training and compliance when using personal protective equipment. Supervisors are also responsible for training and auditing staff on cleaning procedures. Adequate supervisory staffing levels will help ensure that these requirements are being met and, as increasingly complex auditing procedures are adopted, additional staffing may be required to ensure that audits are conducted and responded to appropriately (see 9. Assessment of Cleanliness and Quality Control).[260]

When environmental service staffing levels are being reviewed, decisions to reduce staffing levels should never be made based on comparison with peer health care facilities with lower staffing levels independent of a complete assessment of these facilities rates of health care-associated infection, particularly those health care-associated infections known to be associated with environmental transmission (e.g., *C. difficile* infection, vancomycin-resistant enterococci); and facility level factors that affect the resources needed for adequate environmental cleaning and disinfection (see Factors to Consider When Determining Environmental Service Staffing Level). Conversely, facilities with high rates of environmentally associated health care-associated infections should review their environmental service program, and consider adopting strategies to increase the effectiveness of environmental cleaning, including increasing staffing levels where low staffing levels may be contributing to inadequate cleaning and disinfection.[15,16,69,74,85,159,254,256]

Individual facilities will, therefore, need to consider all of these factors when determining staffing levels required for environmental services. Each health care setting is encouraged to perform their own time management studies to determine appropriate staffing levels for cleaning and supervisory staff, taking into consideration the factors discussed above.

In some health care facilities, environmental service workers may be assigned other tasks. This needs to be taken into account when determining staffing level, as these tasks takes away time available for cleaning duties and increase the risk of dropping environmental service tasks.[254,261]

- For more information about calculating cleaning times and staffing levels, see the ISSA booklet, *612 Cleaning Times*.[250]

Recommendations:

37. **Environmental service staffing levels must reflect the physical nature and the acuity of the facility as well as other factors that will impact environmental service workload. [A III]** [modified 2018]

38. **Dedicated environmental service workers are preferred. [B III]** [new 2018]

39. **If other tasks are assigned to environmental service workers, facilities need to recalculate staffing level, and environmental service tasks must be made a priority. [A III]** [new 2018]

40. **Levels of supervisory staff must be appropriate to the number of staff involved in cleaning and sufficient to ensure that**
    a. **All staff are appropriately trained. [A III]** [new 2018]
    b. **A safe workplace is maintained at all times, and occupational health and infection prevention and control procedures are routinely followed, including the correct use of personal protective equipment. [A III]** [new 2018]

3.1.2 HEALTH CARE CLEANING PRACTICES

3.1.2.1 Approach to Cleaning for Clinical and Nonclinical Areas within the Health Care Setting

In health care facilities, the approach to cleaning will vary depending upon the area to be cleaned. For nonclinical areas such as lobbies and administrative offices, a "hotel clean" is required. Clinical areas require a more thorough form of cleaning. All clinical areas require a "health care clean" in addition to a "hotel clean" (which is also still required). Clinical areas include but are not limited to areas where clients/patients/residents receive care but also include patient waiting areas, areas for storage of medical equipment and supplies, medication preparation areas, and other areas involved in the provision of health care. A risk assessment should be performed by environmental services and infection prevention and control at all facilities to designate those areas requiring a "health care clean". This risk assessment could be integrated with an assessment of the required frequency of cleaning, as discussed in Section 3.2.4 below and as illustrated in Appendix 21.

Hotel clean is an approach to cleaning that requires removal of dirt and dust, waste disposal, and the cleaning of windows and surfaces. A hotel clean should result in a visually clean environment. The **hotel component** of a health care facility includes all areas not involved in client/patient/resident care. This includes public areas such as lobbies; offices; corridors; elevators and stairwells; and service areas. Areas designated as part of the hotel component are cleaned with a hotel clean regimen.

Health care clean is an approach to cleaning that aims to reduce or eliminate microbial contamination within the environment.[5] A health care clean should result in the elimination of, or a significant reduction in, microbial contamination of all surfaces and items within the environment, in addition to providing a visually clean environment. This requires, in addition to the performance of a hotel clean, an increased frequency and thoroughness of cleaning, as well as the use of disinfectants. The **health care component** of a health care facility includes all areas involved in client/patient/resident care including all client/patient/resident wards or units and including nursing stations; procedure rooms; clinic and examination rooms; diagnostic and treatment areas; and washrooms*. Areas designated as part of the health care component are cleaned with a health care clean.

* Washrooms are considered part of the health care component even if located outside of care areas.

- See Components of Hotel Clean and Components of Health Care Clean for the components of a hotel and health care clean.

The health care component of the health care setting should be the priority for environmental cleaning. Areas that require a health care clean should have different cleaning protocols and additional environmental service human resources that are sufficient to allow the more intensive and frequent cleaning (and monitoring of cleaning) required for these areas.

Additional cleaning practices are practices that go beyond those routinely required as part of a health care clean. Additional cleaning practices may be required for clients/patients/residents known or suspected to be colonized or infected with a specific organism (or clients/patients/residents with a specific clinical syndrome).

Additional cleaning practices are often directed towards clients/residents/patient colonized or infected with organisms that can persist for a prolonged time within the care environment, and may be relatively resistant to standard disinfectants. Additional practices may differ between specific organisms. Refer to 11.1 Cleaning Rooms/Cubicles/Bed Space on Contact Precautions for special cleaning for specific microorganisms. Health care settings should ensure that the cleaning requirements for patients requiring Additional cleaning practices are clearly communicated to environmental services.

Additional cleaning practices may also be required for microorganisms that pose an extreme risk to clients/ patients/residents, staff and visitors such as Ebola Virus Disease. Protocols for cleaning and disinfecting areas potentially contaminated with Ebola Virus Disease are described in the Public Health Ontario document *Guidance for Patients with Suspect or Confirmed Viral Haemorrhagic Fevers (VHF) in Acute Care Settings*, and are beyond the scope of this guidance document.[262-264]

In addition to the above, enhanced cleaning and disinfection is often required during outbreaks of organisms when environmental contamination and subsequent transmission is known to be related to the type of organism suspected of causing the outbreak (e.g., norovirus, *C. difficile*). Although causality has not been definitively established, numerous reports describe enhanced environmental cleaning as a critical component of outbreak control measures for a variety of microorganisms.[69,74,234,265] Policies and procedures regarding staffing in environmental services should allow for *surge capacity* (i.e., additional staff, supervision, supplies, equipment) during outbreaks as determined by the outbreak management committee. The outbreak management committee should include, among other departments, representation from environmental services who will lead the coordination of the environmental service department's activities. Additional cleaning in an outbreak generally depends on the microorganism causing the outbreak. Refer to 11.1 Cleaning Rooms/Cubicles/Bed Space on Contact Precautions for special cleaning for specific microorganisms.

Components of Hotel Clean

- Floors and baseboards are free of stains, visible dust, spills and streaks.
- Walls, ceilings and doors are free of visible dust, gross soil, streaks, spider webs and handprints.
- All horizontal surfaces are free of visible dust or streaks (includes furniture, window ledges, overhead lights, phones, picture frames, carpets etc.)
- Bathroom fixtures including toilets, sinks, tubs and showers are free of streaks, soil, stains and soap scum.
- Mirrors and windows are free of dust and streaks.
- Dispensers are free of dust, soiling and residue and replaced/replenished when empty.
- Appliances are free of dust, soiling and stains.
- Waste is disposed of appropriately.
- Items that are broken, torn, cracked or malfunctioning are replaced.

Components of Health Care Clean

HOTEL CLEAN
+
High-touch surfaces in client/patient/resident care areas are cleaned and disinfected with a hospital disinfectant.
+
Noncritical medical equipment is cleaned and disinfected between clients/patients/residents.
+
CLEANING PRACTICES ARE PERIODICALLY MONITORED AND AUDITED WITH FEEDBACK AND EDUCATION.

Note: Frequency of health care clean is determined according to the Risk Stratification Matrix in Appendix 21: Risk Stratification Matrix to Determine Frequency of Cleaning

3.1.2.2 CLEANING AND DISINFECTION POLICIES AND PROCEDURES

All health care settings should have clearly defined cleaning policies and procedures that are reviewed and updated on a regular basis. Policies and procedures should ensure that:

- Cleaning is a continuous event in the health care setting.
- Cleaning procedures incorporate the principles of infection prevention and control (see Section Two).
- Cleaning standards, frequency and accountability for cleaning are clearly defined (i.e., who cleans, what do they clean and when do they clean it).
- Cleaning schedules, procedures, checklists and other tools ensure that no area or item is missed from routine cleaning.
- Statutory requirements are met in relation to:
  - the safe disposal of clinical waste:
    - *Guideline C-4: The Management of Biomedical Waste in Ontario*[2]
    - *Occupational Health and Safety Act* and regulations,[229] for safe disposal of waste
  - the safe handling of linen:
    - *Occupational Health and Safety Act* and regulations,[229] for staff safety when handling contaminated linen
    - Workplace Hazardous Materials Information System (WHMIS)[266]
    - Canadian Standards Association (CSA), for standards related to forklift operation, hoists, safety equipment, support equipment such as boilers, etc.
    - *Transportation of Dangerous Goods Act*[267] applicable to receipt of some laundry and waste water treatment chemicals
  - food hygiene:
    - *Food Premises, R.R.O. 1990, Reg. 562, under the Health Protection and Promotion Act*,[268] dealing with food premises
  - pest control:
    - *Pesticides Act. O. Reg. 63/09*,[269] for pest control
    - long-term care homes' requirements for handling waste, linen, food and dealing with pests:
    - *General, O. Reg. 79/10*,[270] section 229

3.2 Frequency of Routine Cleaning

Clients/patients/residents contaminate their immediate environment with microorganisms through direct contact, and through the shedding of skin squames.[271-274] Contamination of the environment is increased when clients/patients/residents are coughing, sneezing or having diarrhea;[63,275] have large or draining wounds; have extensive dermatitis;[275] or have other severe skin conditions. While this contamination is concentrated in the vicinity of the client/patient/resident and the areas used by the client/patient/resident (e.g., bed and bathroom for hospitalized patients), further spread of microorganisms occurs when the hands or gloves of staff become contaminated, either via direct contact with the client/patient/resident or through contact with the contaminated environment.[45,58,59,61-63,275] Staff can then transfer these microorganisms to other items and surfaces within the client/patient/resident environment, and if appropriate hand hygiene is not performed, may carry these microorganisms to other clients/patients/residents, to other client/patient/resident's environments or to other areas of the health care environment (e.g., nursing station) (see Figure 1).

Given the potential for surfaces and items to become contaminated with microorganisms, all areas, surfaces, and items within care areas of the health care setting require cleaning on a routine basis.

3.2.1 HIGH- AND LOW-TOUCH SURFACES

Although any surface may become contaminated, the risk and extent of contamination is greater for surfaces and items that are handled frequently by the hands or gloves of staff or client/patient/residents as compared to surfaces that are less frequently handled or touched.[55,276,277] Thus, surfaces within the health care setting and in particular within the patient's environment can be classified as high- and low-touch surfaces, as follows:

High-touch surfaces are those that have frequent contact with hands.[276,278] Examples include (but are not limited to) doorknobs, elevator buttons, telephones, call bells, bedrails, light switches, toilet flushes, monitoring equipment, IV infusion pump, end-of-bed table and the edges of the privacy curtains. The specific surfaces that should be considered high-touch will vary between health care settings.[278-282]

Low-touch surfaces are those that have minimal contact with hands. Examples include (but are not limited to) floors, walls, ceilings, mirrors and window sills.

Figure 3a and Figure 3b illustrate examples of items and sites that are high-touch and which may exhibit environmental contamination in health care settings.

High-touch surfaces in care areas require more frequent cleaning and disinfection than minimal contact surfaces.[244,276,280,283] Cleaning and disinfection should be performed at least daily and more frequently if the risk of environmental contamination is higher (e.g., intensive care units). Low-touch surfaces require cleaning on a regular basis, when soiling or spills occur, and when a client/patient/resident is discharged from the health care setting.[92] For many low-touch surfaces, cleaning may occur less frequently than once per day (e.g., every other day, weekly) as long as such surfaces are cleaned sooner if visibly soiled (e.g., client/patient/resident's mattress, in-room blood pressure cuff do not require daily cleaning but can be cleaned between clients/patients/residents and when soiled).

3.2.2 VULNERABILITY OF THE CLIENT/PATIENT/RESIDENT POPULATION

Different populations of clients/patients/residents have differing susceptibility to infection. In some populations, such as bone marrow transplant or burn patients, susceptibility to infection is very high and lower levels of environmental contamination are more likely to result in clinically significant infection than in other, lower risk populations.

Areas where vulnerable patients at risk for acquiring illness due to environmental microorganisms are cared for should receive more frequent environmental cleaning. In general, such areas include wards or units housing highly immunocompromised patients, and areas where patients frequently undergo invasive procedures, or both. Examples of such areas include:

- transplantation wards
- neonatal intensive care units
- burn units
- chemotherapy units
- dialysis units
- procedure and operating rooms

Other care areas and patient populations are considered "less susceptible". Routine regular cleaning and disinfection is still essential for these areas and populations but at a lower frequency than what is required for high-risk populations.

3.2.3 PROBABILITY OF CONTAMINATION OF ITEMS AND SURFACES IN THE HEALTH CARE ENVIRONMENT

The probability that a surface, piece of equipment or care area will be contaminated is also related to the types of activities occurring within the care area. Areas can be divided into those that are (likely to be) heavily, moderately or lightly contaminated, as follows:

Heavy-contamination area. Areas should be considered heavily contaminated if surfaces or equipment are regularly exposed to significant amounts of blood or other body fluids (e.g., birthing suite, autopsy suite, cardiac catheterization laboratory, burn unit, hemodialysis unit, emergency department, bathrooms of patients with diarrhea or incontinent).

Moderate-contamination area. Areas should be considered moderately contaminated if surfaces or equipment are regularly contaminated with blood or body fluids (e.g., patient/resident rooms, bathrooms of continent patients) and the blood or body fluids are contained or rapidly removed (e.g., wet sheets). All client/resident/patient rooms and all bathrooms should be considered moderately contaminated.

Light-contamination area. Areas can be considered lightly contaminated or not contaminated if surfaces are not exposed to blood or body fluids or items that have come in contact with blood or body fluids (e.g., lounges, libraries, offices).

Note: Regardless of the anticipated level of contamination for a given area or the frequency of routine cleaning and disinfection, if blood or body fluid spills or contamination occurs (e.g., vomitus in elevator, blood spill), the area must be cleaned and disinfected immediately (see 12. Cleaning Spills of Blood and Body Substances.)

3.2.4 DETERMINING REQUIRED FREQUENCY OF CLEANING

Surfaces and items at higher risk of transmitting microorganisms within the care setting should be cleaned and disinfected more frequently. When determining the appropriate frequency of cleaning and disinfection, the following principles apply:

- High-touch surfaces and items require more frequent cleaning and disinfection than low-touch surfaces and items.
- Surfaces and items in proximity to vulnerable client/patient/resident populations require more frequent cleaning and disinfection than surfaces and items in proximity to less vulnerable client/patients/resident populations.
- Heavily contaminated surfaces, items and equipment require more frequent cleaning than moderately contaminated surfaces, items and equipment, which in turn require more frequent cleaning and disinfection than lightly contaminated or noncontaminated surfaces, items and equipment.

Using these criteria, each area or department in a health care setting can be evaluated and assigned a risk score for cleaning purposes, as illustrated in Appendix 21. The score obtained will relate to a specific level of routine cleaning frequency. As the activity or vulnerability of clients/patients/residents in an area changes, the risk score will change as well, impacting on the cleaning frequency.

Recommendation:

41. **Cleaning schedules must be developed based on an assessment of the risk of contaminated surfaces resulting in infection in patients/residents/clients and staff [A II]** [modified 2018]

3.3 Equipment

This document addresses the cleaning and disinfection of noncritical equipment and devices that only come into contact with intact client/patient/resident's skin or the environment. For guidance on the appropriate cleaning and reprocessing of semi-critical and critical equipment, see PIDAC'S *Best Practices for Cleaning, Disinfection and Sterilization in All Health Care Settings*[19] for cleaning all other types of equipment.

Noncritical medical equipment that is within the client/patient/resident's environment and used between clients/patients/residents (e.g., imaging equipment, electronic monitoring equipment, commode chairs) requires cleaning and disinfection after each use.[277,279,284-290] Selection of new equipment must include considerations related to effective cleaning and disinfection (See 1.2.1 Selection of Surfaces, Finishes, Furnishings and Equipment for Areas Where Client/Patient/Resident Care is Delivered). A system should be in place to clearly identify equipment which has been cleaned and disinfected.

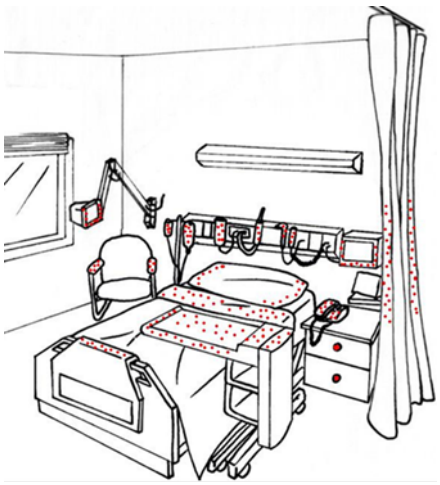
- Refer to Appendix 8 for a sample cleaning chart for noncritical medical equipment and other items.

> **The health care setting should have written policies and procedures for the appropriate cleaning and disinfection of equipment that clearly define the frequency and level of cleaning and assign responsibility for cleaning.**

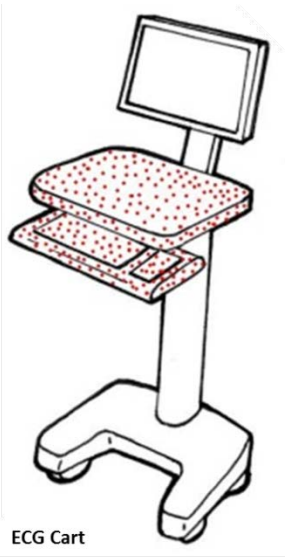
Recommendations:

42. **Noncritical medical equipment requires cleaning and disinfection after each use. [A II]** [reviewed and not changed 2018]

43. **Each health care setting should have written policies and procedures for the appropriate cleaning of noncritical medical equipment that clearly defines the frequency and level of cleaning, and which assigns responsibility for the cleaning. [A III]** [reviewed and not changed 2018]

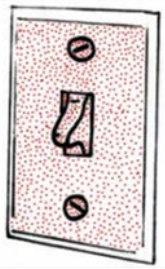


Patient Room



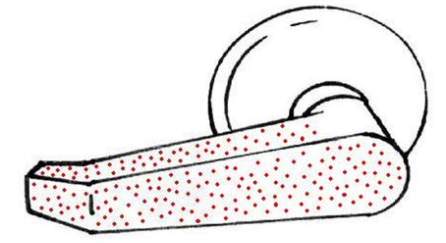
ECG Cart

Nursing Station

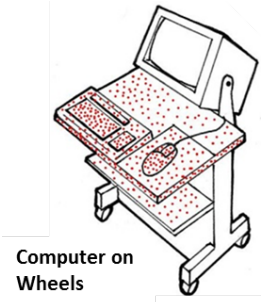


Light Switch

Call Bell

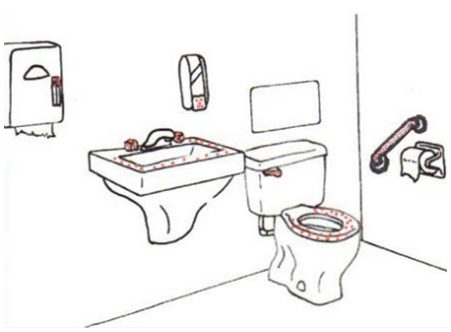


Door Handle

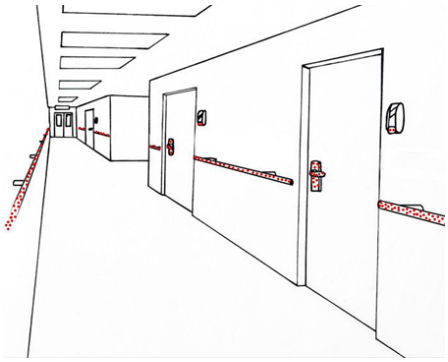


Computer on Wheels

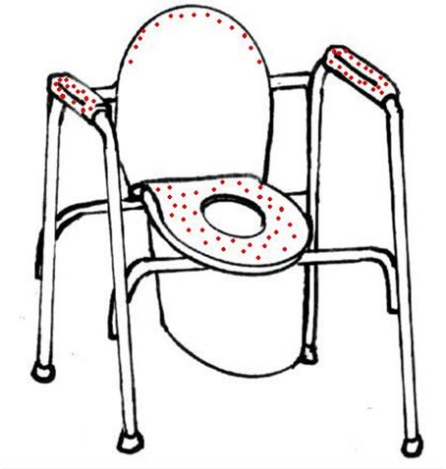
Figure 3a: Examples of High-Touch Items and Surfaces in the Health Care Environment
(Note: Dots indicate areas of highest contamination and touch)



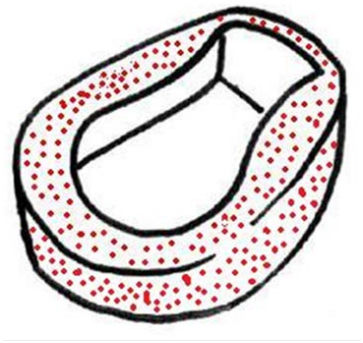
Patient Bathroom



Hallway on Patient/Resident Floor



Commode



Bedpan

Transport Items

Wheelchair

Figure 3b: Examples of High-Touch Items and Surfaces in the Health Care Environment
(Note: Dots indicate areas of highest contamination and touch)

4. Education

All aspects of environmental cleaning must be supervised and performed by knowledgeable, trained staff. Regular education and support must be provided by health care organizations and contract agencies to help staff consistently implement safe and effective cleaning, infection prevention and control, and occupational health and safety practices.[15-17,158,159,253,254,291-293] Education on the topics of infection prevention and control and of occupational health and safety should be provided at the initiation of employment as part of the orientation process and as ongoing continuing education.[8,79,219,220,229,242,294,295] Ergonomic considerations and safe management of chemical agents should be emphasized.

Environmental services must provide a training program that includes:

- a standardized curriculum
- a mechanism for assessing proficiency
- documentation of training and proficiency verification
- orientation and continuing education when new cleaning products or equipment are introduced

Education provided by environmental services should include:

- handling of mops, cloths, cleaning equipment
- cleaning and disinfection of blood and body fluids[296]
- handling and application of cleaning agents and disinfectants[8]
- waste handling (general, biomedical, sharps)[219,296]
- techniques for cleaning and/or disinfection of surfaces and items in the health care environment
- techniques for cleaning and disinfection of rooms under Additional Precautions
- proper use and care of personal protective equipment[219,220]
- WHMIS training relating to the use of cleaning agents and disinfectants[8,294]

Infection prevention and control and occupational health education provided to environmental service workers should be given in collaboration with the infection prevention and control department and the occupational health and safety department, and must include:[31]

- The correct and consistent use of Routine Practices as a fundamental aspect of infection prevention and control in health care settings.
- Hand hygiene, including the use of alcohol-based hand rubs and hand washing.
- Respiratory etiquette.
- Signage used to designate Additional Precautions in the health care setting.
- The appropriate use of personal protective equipment including selection, safe application, removal and disposal.
- Prevention of blood and body fluid exposure, including sharps safety.

Management and supervisory staff in environmental service departments should receive training and education that also includes:

- chain of transmission
- pest control
- outbreak response

It is recommended that managers and supervisors in environmental service departments attend, as a minimum, a recognized course directly related to environmental cleaning in health care and obtain certification within a recognized association:

- For courses available in Ontario, see the websites of the Ontario Health-Care Housekeepers' Association (OHHA) and the Centennial College.
- For national certification courses, see the Canadian Association of Environmental Management (CAEM) website.
- For certification courses offered in French, see the Association Hygiène et Salubrité en Santé (AHSS) website.

Recommendations:

44. **All aspects of environmental cleaning must be performed by knowledgeable, trained staff. [A III]** [modified 2018]

45. **Environmental services training programs:**
    a. **Must use a standardized curriculum. [A III]** [modified 2018]
    b. **Should have a mechanism for assessing proficiency. [B III]** [modified 2018]
    c. **Must document training and proficiency. [A III]** [modified 2018]

46. **Infection prevention and control and occupational health education provided to environmental service workers must be developed in collaboration with infection prevention and control and occupational health and safety. [A III]** [modified 2018]

47. **The education provided to environmental service workers:**
    a. **Shall include: [Legislation]** [modified 2018]
    - **The correct and consistent use of Routine Practices.**
    - **Hand hygiene and basic personal hygiene.**
    - **Signage used to designate Additional Precautions in the health care setting.**
    - **The appropriate use of personal protective equipment for infection prevention and for the safe handling of chemical agents.**
    - **Prevention of blood and body fluid exposure, including sharps safety; and**

    b. **Should include ergonomic cleaning principles. [B III]** [new 2018]

48. **Environmental service managers and supervisors must receive training. [AIII]** [reviewed and not changed 2018]

49. **Environmental service supervisors should be certified. [B III]** [modified 2018]

5. Occupational Health and Safety Issues Related to Environmental Services

Environmental service workers are exposed to occupational risks including exposure to infectious microorganisms from clients/patients/residents and the health care environment, exposure to the chemical agents used for cleaning, and ergonomic stressors related to the mechanics of cleaning that may involve repeated pushing, pulling, lifting or twisting.[147,222,297-303] Health care facilities shall ensure that these risks are minimized to protect their environmental service workers and allow them to perform their work in an optimal and safe environment.[229]

To minimize the risk of infection in both environmental service workers and clients/patients/residents, environmental service workers shall be:

- Provided with infection prevention and control education and training.[79,219,220,229,304]
- Trained in the use of, and have access to, appropriate personal protective equipment.[219,220]
- Included in staff immunization programs.[31,219]
- Educated on how to reduce exposure to blood and body fluids and on what to do if exposure to blood or body fluids occurs.[296]

In addition, environmental service workers should be aware of:

- Work restrictions including the need to avoid working in client/patient/resident areas when ill with a known or suspected communicable infection.[31,243,305]
- The risks associated with the chemical products and equipment used, and the appropriate strategies that must be used to mitigate against these risks (e.g., appropriate use of personal protective equipment when handling chemicals, ergonomic considerations in the selection and use of equipment, etc.)
- The need to report illnesses and injuries to occupational health and safety.[218,295]

Non-infectious occupational risks shall also be minimized and environmental service workers shall have access to and training in the use of the personal protective equipment required when preparing, handling or using chemical cleaning agents.[8,219,220] Strategies should also be in place to reduce the risk of injury due to ergonomic or other workplace hazards.[219,220,229,296,304]

5.1 Immunization

Appropriate immunization protects staff and clients/patients/residents. Environmental service workers shall be included in facility policies of staff immunization,[219] and must be offered appropriate immunizations based on the Ontario Hospital Association/Ontario Medical Association's *Communicable Diseases Surveillance Protocols* and the National Advisory Committee on Immunization recommendations for health care providers.[219,229,306-309]

Currently, immunizations appropriate for environmental service workers and other staff working in health care settings include:

- annual influenza vaccine[310]
- measles,[311] mumps,[312] rubella[313] (MMR) vaccine
- varicella vaccine[314]
- up-to-date tetanus vaccine[306]
- hepatitis B vaccine (due to risk of sharps injury)[315]
- acellular pertussis vaccine.[316]

Contracts with supplying agencies should include the above immunizations for contracted staff.

5.2 Personal Protective Equipment

➢ See 2.1.2 Personal Protective Equipment for more information.

5.3 Staff Exposures

There shall be written policies and procedures for the evaluation of staff (employees or contract workers), including environmental service workers, who may be exposed to blood or body fluids and other infectious hazards.[295] Examples of these policies and procedures include:

- A sharps injury prevention program.[31,218,219]
- A program or mechanism for timely post-exposure follow-up and prophylaxis. [31,295,296,315]
- A respiratory protection program if staff will be entering airborne infection isolation rooms and a mechanism for following up with personnel who have been exposed to tuberculosis.[218,221]
- A policy to ensure reporting of exposures and occupationally acquired infections to both infection prevention and control and occupational health and safety.[295]

➢ For more information about programs for managing staff exposures, refer to PIDAC's *Routine Practices and Additional Precautions in All Health Care Settings*.[7]

5.4 Work Restrictions

All health care settings must establish a clear expectation that staff members do not come into work when acutely ill with a probable infection (e.g., fever, diarrhea, vomiting, rash, conjunctivitis, severe cough) and support this expectation with appropriate attendance management policies.[31,218,304,305] Staff members carrying on activities in a health care setting who develop a communicable disease may be subject to work restrictions.[243]

5.5 Other Considerations

5.5.1 CHEMICAL SAFETY

Environmental service workers have potential exposures to chemicals and, in some circumstances, may develop symptoms related to these exposures.[297,298,317-319] Exposures occur most commonly via inhalation (respiratory) or direct skin contact.[145] Chemicals can function as irritants [e.g., products containing sodium

hypochlorite (bleach), ammonia (can be found in glass cleaners), improved hydrogen peroxide, quaternary ammonium compounds, ethanolamine (can be found in floor care products, glass and bathroom cleaners), glycol ethers (can be found in general purpose cleaners and floor care product), phenols] or sensitizers [(e.g., quaternary ammonium compounds, ethanolamine (can be found in floor care products, glass and bathroom cleaners)] and can result in respiratory symptoms or dermatitis.[144,145,222]

Cleaning agents acting as irritants may exacerbate symptoms of underlying asthma.[320] Over time, without adequate controls, a sensitizer may cause asthma or chronic bronchitis.[151,317,321] Respiratory symptoms increase in direct proportion to increased exposure time and higher concentrations of certain chemicals, such as bleach and ammonia.[317] Certain tasks, such as cleaning of toilet bowls, mirrors, sinks, and counter, as well as floor finishing tasks, regularly expose individuals to high concentrations of volatile organic compounds.[145]

Irritants in health care settings associated with skin symptoms (irritant contact dermatitis) include water, soaps and detergents, most frequently in those who have underlying atopic dermatitis (allergy, eczema). Symptoms (dryness, cracking, eczema) are usually worsened during winter months. A smaller number of people will develop allergic contact dermatitis where a particular allergen can cause an inflammatory response, usually hours to days later, which clinically may appear similar to irritant contact dermatitis.

It is important that any health care provider who has a significant allergic, asthmatic, or dermatitis history, or who develops symptoms that may be related to work exposures, be assessed by occupational health and safety.[322]

Exposure to workplace chemicals may be reduced through the use of engineering controls (e.g., good ventilation, improved design of containers and delivery systems[320]), administrative controls (e.g., development and maintenance of policies for the safe use of disinfectants, education and training), and the use of personal protective equipment (e.g., proper glove choice when handling chemicals, use of facial protection to prevent inhalation of vapours and splashes of chemicals to the eyes). Caution should be taken when cleaning and disinfection is performed in small and/or poorly ventilated spaces to reduce the risk of irritation to exposed skin and respiratory tract, and to ensure that exposure limits are not exceeded. Facilities should periodically conduct an occupational hazards assessment with respect to cleaning and disinfection of surfaces and equipment. The assessment should evaluate risks, and ensure that the safest cleaning agents, equipment and processes are selected; that appropriate training and access to personal protective equipment are in place; and that staff are aware of protocols to be followed in the event of accidents, exposures or injuries.[318]

The use of automated dispensing systems or ready-to-use products is preferred over manual dilution and mixing, as automated systems reduce direct personal contact with concentrated products and reduce inhalation of volatile organic compounds from concentrated products. Automated systems also ensure that correct dilution ratios are obtained and eliminate the need for decanting.

Applications of cleaning chemicals by aerosol or trigger sprays may cause eye injuries or induce or compound respiratory problems or illness and must not be used.[141,144,222,317,323-331]

Do not apply cleaning chemicals by aerosol or trigger sprays.

Chemicals must be stored and handled appropriately.[229] Health care settings shall have in place written policies and procedures in accordance with the Workplace Hazardous Materials Information System (WHMIS). All cleaning staff shall receive WHMIS training[8,294] and know the location of the safety data sheet for each of the cleaning and disinfecting agents they use. Safety data sheet documentation shall be available as required by *Workplace Hazardous Materials Information System (WHMIS). R.R.O. 1990, Reg. 860.*. Where appropriate, eyewash stations shall be available and accessible.[80,220]

- More information on WHMIS is available from Health Canada.

5.5.2 ERGONOMIC CONSIDERATIONS

Environmental service workers are at risk of injury due to ergonomic hazards. Repetitive movements, awkward work postures, heavy lifting, and application of high forces (e.g., when scrubbing) can lead to injury and are exacerbated by poorly designed or inappropriately sized cleaning equipment, lack of training in appropriate cleaning techniques, prolonged tasks and/or insufficient rest periods.[299,332-336] Selection of cleaning equipment must follow ergonomic principles.[337-339] Products that are lighter in weight, easily emptied and having proper handle length help reduce the risk of injury. Additionally, a variety of handle lengths should be available to ensure that differently sized cleaning staff have access to appropriate ergonomically designed equipment.[222] For more information about ergonomic design related to environmental cleaning, visit the Public Services Health & Safety Association website.

Recommendations:

50. **Environmental service workers must be offered appropriate immunizations. [A II]** [reviewed and not changed 2018]

51. **There shall be policies and procedures in place that include a sharps injury prevention program, post-exposure prophylaxis and follow-up, and a respiratory protection program for staff who may be required to enter an airborne infection isolation room accommodating a patient with tuberculosis. [Legislation]** [reviewed and not changed 2018]

52. **There must be appropriate attendance management policies in place that establish a clear expectation that staff members do not come into work when acutely ill with a probable infection or symptoms of an infection. [A III]** [reviewed and not changed 2018]

53. **There must be procedures for the evaluation of staff members who experience sensitivity or irritancy to chemicals. [A III]** [reviewed and not changed 2018]

54. **Aerosol or trigger sprays for cleaning chemicals must not be used. [A II]** [modified 2018]

55. **Selection of environmental cleaning equipment must follow ergonomic principles. [A II]** [reviewed and not changed 2018]

6. Environmental Cleaning for Specialized Areas

In this section, guidance is provided regarding cleaning and upkeep of specific facility areas including the cleaning of clean and soiled utility rooms, the upkeep of environmental cleaning equipment and supply rooms (i.e., housekeeping closets), and the cleaning of food preparation areas. Cleaning in construction areas and in response to floods is also addressed.

6.1 Soiled (Dirty) and Clean Utility/Supply Rooms

It is an essential environmental cleaning principle that clean and soiled (i.e., dirty, used) supplies and equipment should be clearly separated.[80] Each client/patient/resident care area should be equipped with a room dedicated as a soiled utility room that may be used to clean soiled patient/resident equipment that is not sent for central reprocessing (e.g., IV poles, commode chairs).[340] A separate room shall be dedicated to the storage of clean supplies and equipment.[80]

A soiled utility room is used for temporary storage of supplies and equipment that will be removed for cleaning, reprocessing or destruction,[80] for the disposal of small amounts of liquid human waste,[341] and for rinsing and gross cleaning of medical instruments.[81] Soiled utility rooms should:

- Be physically separate from other areas, including clean supply/storage areas.[80,81]
- Should have a hands-free door, as long as this is not a risk to clients/patients/residents.
- Have a work counter and flushing-rim clinical sink (i.e., hopper) with a hot and cold mixing faucet.[81] Sprayers attached to the hopper shall NOT be used.[80]
- Have a dedicated hand washing sink with both hot and cold running water.[80,81,219]
- A separate utility sink is also required if the soiled utility room will be used for rinsing or removal of gross soiling of medical instruments or equipment.[341]
- Have adequate space to permit the use of equipment required for the disposal of waste.[80]
- Have personal protective equipment available to protect staff during cleaning and disinfecting procedures.[80,341]
- Be adequately sized within the unit and located near the point-of-care.[80,81,341]

If a soiled utility room is used only for temporary holding of soiled materials, the work counter and clinical sink is not required; however, facilities for cleaning bedpans must be provided elsewhere.[81] Soiled utility rooms/workrooms should not be used to store unused equipment.[80]

A clean utility/supply room for storing sterile supplies and equipment should:

- Be separate from and have no direct connection with soiled workrooms or soiled holding areas.[80,81]
- Be able to keep supplies free from dust and moisture, and stored off the floor.[80]
- Be adjacent to usage areas and easily available to staff.[80]
- Be equipped with a work counter and dedicated hand washing sink if used for preparing patient care items.[81,341]

6.2 Care and Storage of Supplies and Equipment for Environmental Cleaning

6.2.1 CLEANING EQUIPMENT

Cleaning equipment itself requires careful and regular cleaning and disinfection to avoid inadvertent cross-transmission of microorganisms during subsequent use.

- Tools and equipment used for cleaning and disinfection must be cleaned and dried between uses (e.g., mops, buckets, rags).
- Cleaning tools and equipment used in a room or bed space on Additional Precautions must be cleaned and disinfected after use before being used in another room or bed space.
- Mop heads should be laundered daily. All washed mop heads must be dried thoroughly before storage.
- Cleaning equipment shall be well maintained, clean and in good repair.

6.2.2 STORAGE OF CLEANING SUPPLIES

All chemical cleaning agents and disinfectants should be appropriately labelled and stored in a manner that eliminates exposure, inhalation, skin contact or personal injury. Chemicals shall be clearly labelled in accordance with *Workplace Hazardous Materials Information System (WHMIS).* R.R.O. 1990, Reg. 860, and a safety data sheet shall be readily available for each item in case of accidents.[8,80]

Equipment used to clean toilets (e.g., toilet brushes, toilet swabs) should not be carried from room-to-room. If feasible, the toilet brush may remain in the patient's bathroom for the duration of the patient's stay; if not, consideration should be given to using disposable toilet swabs. Toilet cleaning and disinfecting equipment should be discarded when the patient/resident leaves or sooner if required. In multi-bed rooms, a system should be developed for replacement of toilet brushes on a regular basis or as required. When choosing a tool for cleaning toilets, consideration should be given to equipment that will minimize splashing.

6.2.2.1 Housekeeping Closet

It is essential that equipment and supplies for environmental cleaning be appropriately and safely used, transported, maintained, and cleaned. To facilitate this, facilities shall have a sufficient number of rooms that are dedicated to the storage of cleaning equipment and supplies required for daily cleaning (housekeeping closets) and are located conveniently throughout the facility.[80,340,341] These rooms are used for the storage, preparation and disposal of cleaning supplies and equipment,[80,341] and are distinct from the clean utility/supply rooms described in 6.1 Soiled (Dirty) and Clean Utility/Supply Rooms. Facilities may also have centralized housekeeping rooms for storing bulky cleaning equipment and large volume of supplies for distribution to local areas.[80,341] At a minimum, there shall be at least one housekeeping closet in all major care areas.[80,340] In addition, housekeeping closets:

- Must be dedicated for use as a cleaning supply room where cleaning solution is prepared, and dirty cleaning solution is disposed; and must not be used for other purposes.[80,341]
- Shall be maintained in accordance with good hygiene practices.[219]
- Shall have a dedicated hand washing sink with hot and cold running water.[80]
- Shall have access to an eyewash station.[80,220]
- Shall have appropriate personal protective equipment available, including safety eyewear.[217,219]

- Shall have a hot and cold water supply and a floor sink.[80,340]
- Shall be well ventilated[80] and illuminated.
- Shall be designed to be at negative pressure in relation to surrounding areas.[342]
- Shall be easily accessible in relation to the area it serves.[80,81,340]
- Shall be secure with access restricted to clinical and support staff.[80,340]
- Shall be appropriately sized to the amount of materials, equipment, machinery and chemicals stored in the room/closet[80,81,340] and allow for proper ergonomic movement within the room/closet.
- Shall not contain personal belonging, food or beverages.[219]
- Shall have chemical storage that ensures chemicals are not damaged and may be safely accessed.
- Should be free from clutter to facilitate cleaning.[343]
- Should be ergonomically designed so that, whenever possible, buckets can be emptied without lifting them.[80]

6.2.2.2 Cleaning Carts

Cleaning carts:

- Should have a separation between clean and soiled items.
- Should never contain personal clothing or grooming supplies, food or beverages.[219]
- Should be thoroughly cleaned at the end of the day.
- Shall be equipped with a locked compartment for storage of hazardous substances and each cart shall be locked at all times when not attended, and stored, when not in use, within a locked housekeeping closet.[80,270,340]

6.3 Cleaning Food Preparation Areas

This best practices document does not address environmental cleaning required for facility kitchens, cafeterias, commercial food premises or any area where food is prepared or stored (e.g., unit kitchens).

- Facilities should have policies and procedures that address the cleaning of food preparation areas that follow the requirements of the *Health Protection and Promotion Act,* R.S.O. 1990, c. H.7 and *Food Premises.* R.R.O. 1990, Reg. 562.

6.4 Cleaning in Areas of Active Construction

Construction activities generate dust and contaminants that may pose a risk to clients/patients/residents, staff or visitors in all health care settings. Infection prevention and control must assess construction and maintenance projects during planning, work, and after completion to verify that infection prevention and control recommendations are followed throughout the process.[31,86] Where required, work must be performed under appropriately controlled conditions. Infection prevention and control and occupational health and safety have the authority to halt projects if there is a safety risk.[31]

Cleaning is of particular importance both during construction and after completion of the construction project. What is considered to be clean may be interpreted differently by contractors and hospital/health care staff:

- "Construction clean" is the level of cleaning performed by construction workers to remove gross soil, dust and dirt, construction materials and workplace hazards within the construction zone (Components of Construction Clean).[5] This should be done as frequently as is necessary to avoid accumulation of dust and dispersion of dust to other areas of the facility, and at least daily.
- "Hotel clean"(Components of Hotel Clean in Areas of Active Construction) and "health care clean" (Components of Health Care Clean in Areas of Active Construction) begin where the construction site ends, i.e., outside the hoarding (see Glossary), and are generally done by the staff of the health care setting (see 3.1.2 Health Care Cleaning Practices for more information about hotel clean and health care clean).

It is important that there is good liaison between the contractor, environmental services, infection prevention and control, and occupational health and safety. The level of cleaning that is expected during construction and at commissioning must be stated in the contract and the responsibility for cleaning both the job site and adjacent areas shall be clearly defined.[86] Where there is transport of construction materials (both clean and used materials) through the health care setting, a clear plan for traffic flow that bypasses care areas as much as possible shall be established and adhered to.[86]

Responsibility for construction clean and hotel/health care clean must be clearly defined within the health care setting:

Components of Construction Clean

Performed by construction workers inside the construction zone/hoarding:

- Floors are swept to remove debris.
- Walk-off mats are vacuumed.
- "Sticky" mats are replaced regularly and as required.
- Construction debris (e.g., Large pieces of drywall, wiring) are removed.
- Work surfaces may be wiped clean.

Components of Hotel Clean in Areas of Active Construction

Performed by facility cleaning staff in areas outside the construction zone/hoarding:

- Floors and baseboards are free of stains, visible dusts, spills and streaks.
- Walls, ceilings and doors are free of visible dust, gross soil, streaks, spider webs and handprints.
- All horizontal surfaces are free of visible dust or streaks (includes furniture, window ledges, overhead lights, phones, picture frames, carpets, etc.)
- Bathroom fixtures including toilets, sinks, tubs and showers are free of streaks, soil, stains and soap scum.
- Mirrors and windows are free of dust and streaks.
- Dispensers are free of dust, soiling and residue and replaced when empty.
- Appliances are free of dust, soiling and stains.
- Waste is disposed of appropriately.
- Identification of items that are broken, torn, cracked or malfunctioning for replacement.

Components of Health Care Clean in Areas of Active Construction

Performed by facility cleaning staff and/or professional staff in patient care areas outside the construction zone/hoarding

HOTEL CLEAN
+
High-touch surfaces in client/patient/resident care areas are disinfected after cleaning with hospital disinfectant

Noncritical medical equipment is cleaned and disinfected between clients/patients/residents
+
CLEANING PRACTICES ARE PERIODICALLY MONITORED AND AUDITED

For more information, refer to the following guidelines regarding infection prevention and control related to facility design in health care facilities:

- The Facility Guidelines Institute: *Guidelines for Design and Construction of Hospitals and Outpatient Facilities* (2014).[81]
- Public Health Agency of Canada: *Construction-related Nosocomial Infections in Patients in Health Care Facilities*.[344]
- CSA Group: *CAN/CSA-Z317.13-12 Infection Control During Construction, Renovation and Maintenance of Health Care Facilities*.[86]

6.5 Environmental Cleaning Following Flooding

In the event of a flood or other significant water leakage within a health care facility, regardless of the presumed source of the water, the area must be immediately assessed by infection prevention and control to determine the risk of contamination. Until confirmed as a clean water source, all staff should assume that the water is contaminated. Immediate contamination may occur if the source of water harbours pathogenic bacteria (e.g., sewer or toilet overflow). Regardless of the water source, the area will need to be cordoned off until cleaning and disinfection are completed.

Persistent moisture following floods can lead to mould growth on plaster, drywall, carpeting and furnishings.[124] Drywall that remains wet after 48 hours shall be removed and replaced.[86] Wet carpets, if present, must be dried completely within 48 hours as the risk of mould growth increases substantially after that point.[86] If moisture persists beyond 48 hours, carpeting in a care area must be removed and should not be replaced with carpeting (see 1.2.1.4 Carpeting).[86]

If the flooding involves a food preparation area, all food products that have come into contact with water must be discarded and the public health unit notified. Public health units must also be notified if vaccine refrigerators are involved in a flood or if flooding leads to a prolonged power outage that compromises food or vaccine refrigeration. Food service areas cannot re-open until the flood is controlled, the area has been cleaned, disinfected, and approval for food preparation has been obtained from public health units.

See Table 3 for designation of types of flood or leaked water and recommended action for infection prevention and control purposes.

Table 3: Types of Flood Water and Recommended Action for Infection Prevention and Control [345]

Category	Examples	Action
I. Clean water	Broken pipes, tub overflows, sink overflows, many appliance malfunctions, falling rainwater, broken toilet tanks.	Allow materials to dry completely before use. Remove all porous materials (e.g., drywall, cloth furnishings, carpets) that have been wet for more than 48 hours.
II. Gray water ***Some degree of contamination present***	Overflow from a dishwater, washing machine or a clean toilet bowl.	Allow materials to dry completely before use. Remove all porous materials (e.g., drywall, cloth furnishings, carpets) that have been wet for more than 48 hours.
III. Black water ***Heavily and grossly unsanitary***	Water containing raw sewage. Includes overflow from a toilet bowl containing faeces, broken sewer line, backed up sewage, all forms of ground surface water rising from rivers or streams.	Remove and discard wet carpet, drywall, furniture and other porous materials.

A sample procedure for dealing with a flood in a health care setting may be found in Appendix 25.

Recommendations:

56. **Soiled utility rooms/workrooms:**
    a. **Shall be physically separate from other areas, including clean supply/storage areas. [A III]** [modified 2018]
    b. **Should have a hands-free door where this does not pose a risk to clients/patients/residents. [B III]** [new 2018]
    c. **Shall contain a work counter and flushing-rim clinical sink.[A III]** [modified 2018]
    d. **Shall not use sprayers attached to the hopper. [A III]** [new 2018]
    e. **Shall contain a dedicated hand washing sink with hot and cold running water. [Legislation]** [modified 2018]
    f. **Must contain a utility sink if rinsing or gross cleaning of medical instruments or equipment is performed within the room. [A III]** [new 2018]
    g. **Shall have adequate space to permit the use of equipment required for the disposal of waste. [A III]** [modified 2018]
    h. **Shall contain personal protective equipment for staff protection during cleaning and disinfection procedures. [A III]** [modified 2018]
    i. **Shall be adequately sized within the unit and located near the point-of-care. [A III]** [modified 2018]

57. **Clean supply rooms/areas shall:**
    a. **Be separate from and have no direct connection with soiled areas. [A III]** [modified 2018]
    b. **Protect supplies from dust and moisture, and ensure storage off the floor. [A III]** [modified 2018]
    c. **Be adjacent to usage areas and easily available to staff. [A III]** [modified 2018]

58. **Housekeeping closets shall be provided in all major care areas with a minimum of one closet per 650 square metres. [A III]** [new 2018]

59. **Housekeeping closets:**
    a. **Shall be dedicated for storage of cleaning supplies and the preparation and disposal of cleaning solution; and shall not be used for other purposes. [A III]** [modified 2018]
    b. **Shall be maintained in accordance with good hygiene practices. [Legislation]** [reviewed and not changed 2018]
    c. **Shall have a dedicated hand washing sink with hot and cold running water. [A III]** [new 2018]
    d. **Shall have access to an eyewash station. [Legislation]** [new 2018]
    e. **Shall have appropriate personal protective equipment available, including safety eyewear. [Legislation]** [modified 2018]
    f. **Shall have a hot and cold water supply and a floor sink. [A III]** [modified 2018]
    g. **Shall be well ventilated and illuminated. [A III]** [modified 2018]
    h. **Shall be designed to be at negative pressure in relation to surrounding areas. [A III]** [new 2018]
    i. **Shall be easily accessible in relation to the area it serves. [A III]** [modified 2018]
    j. **Shall be secure with access restricted to clinical and support staff. [A III]** [modified 2018]
    k. **Shall be appropriately sized to the amount of materials, equipment, machinery and chemicals stored in the room/closet, and allow for proper ergonomic movement within the room/closet. [A III]** [modified 2018]
    l. **Shall not contain personal belonging, food or beverages. [Legislation]** [modified 2018]
    m. **Shall have chemical storage that ensures chemicals are not damaged and may be safely accessed. [Legislation]** [modified 2018]
    n. **Shall be ergonomically designed so that, whenever possible, buckets can be emptied without lifting them. [A III]** [modified 2018]

60. **Cleaning agents and disinfectants shall be labelled with WHMIS information. [Legislation]** [reviewed and not changed 2018]

61. **Cleaning agents and disinfectants shall be stored in a safe manner in storage rooms or closets. [A III]** [reviewed and not changed 2018]

62. **Cleaning carts must have a clear separation between clean and soiled items. [A III]** [modified 2018]

63. **Cleaning carts must never contain personal belonging, food or beverages. [A III]** [modified 2018]

64. **Health care settings must have a plan in place to deal with the containment and transport of construction materials, as well as clearly defined roles and expectations of environmental service and construction staff related to cleaning of the construction site and areas adjacent to the site. [A III]** [reviewed and not changed 2018]

65. **All health care settings must have a plan in place to deal with floods and water leaks. [A III]** [modified 2018]

7. Facility Laundry and Waste Management

7.1 Management of Laundry and Bedding

Although rare, serious outbreaks have been associated with the transmission of microorganisms associated with inappropriate management of hospital linens. Environmental microorganisms are the most frequently implicated, including *Bacillus cereus* and environmental fungi (e.g., *Aspergillus*, Zygomycetes) and recently reported fungal outbreaks have resulted in severe infection and death in immune-compromised patients.[346-349] An outbreak of *C. difficile* was also linked to inappropriate cleaning of mop heads.[350] Such outbreaks have been caused by errors in the washing process, contamination during post-cleaning transportation and inappropriate storage conditions.[347]

In addition to outbreaks affecting patients, exposure of staff to harmful microorganisms can occur if soiled linens are not handled appropriately. In most staff exposures, failure to use appropriate personal protective equipment and/or inappropriate sorting of linens resulting in aerosolization contributed to the transmission of microorganisms.[351-353]

Policies and procedures should address the collection, transport, handling, washing and drying of soiled linen, including protection of staff.[304] Published laundry regulations must be followed if the facility does its own laundry.

- See the *Occupational Health and Safety Act*, R.S.O. 1990, c. O.1. including *Health Care and Residential Facilities*, O. Reg. 67/93 for legal requirements relating to laundry.
- See *General*, O. Reg. 79/10 for legal requirements related to laundry services in long-term care homes.
- See CSA Group's Z314.10.2-15 *Laundering, maintenance, and preparation of multiple-use gowns, drapes, and wrappers for health care settings and laundries*.

7.1.1 LAUNDRY AREA

Laundry facilities (including health care settings that do their own laundry) must have policies that will ensure that:[3,92]

- The laundry area is in a dedicated space.[304]
- Staff members do not consume food or beverages in laundry areas.[219]
- Floors and walls are made of durable materials that can withstand the rigors of the laundry area (i.e., water/steam resistant).[304]
- The soiled linen area shall be separate from other areas and be at negative pressure relative to surrounding areas.[92,304,342]
- Hand hygiene facilities shall be located in all laundry work areas.[3,80,92,304]
- Laundry equipment is used and maintained according to manufacturers' instructions.[92,304,322]
- There is an established procedure to determine when laundry should be sorted in the laundry facility (i.e., before or after washing).[92]

7.1.2 SOILED LINEN

All linen that is soiled with blood, body fluids, secretions or excretions should be handled using the same precautions, regardless of source or health care setting:[3,92,218,304,354]

- Remove gross soil (e.g., faeces) with a gloved hand and dispose into toilet or hopper. Excrement shall not be removed by spraying with water.[3,80]
- Bag or otherwise contain soiled laundry at the point-of-care.[3,92]
- Do not sort or pre-rinse soiled laundry in care areas.[3,92,347]
- Bag personal laundry/ items (e.g., in long-term care) separately at the point of collection, or have it laundered by family members.
- Handle soiled laundry with minimum agitation to avoid contamination of the air, surfaces and persons (e.g., roll up).[3,92,218,304,355]
- Contain wet laundry before placing it in a laundry bag (e.g., wrap in a dry sheet or towel). Water-soluble bags and double-bagging are not necessary and are not recommended.[3,356,357]
- Laundry carts or hampers used to collect or transport soiled linen need not be covered unless otherwise required by regulation.[3,92,304]
- Containers (including carts, bags, and plastic bins) for collecting, storing, or transporting soiled linen shall be waterproof, leak-proof, nonporous, and in good repair, and shall be decontaminated after use.[304] In addition, carts shall be cleaned and disinfected before being used to transport clean or sterile linen.[304]
- Linen bags shall be tied securely and not be over-filled.[3] Reusable linen bags shall be laundered before re-use.[304]
- Laundry chutes should not be used. [304] If their use is unavoidable, ensure that they are properly designed, maintained, cleaned, disinfected,[304] and used in a manner that minimizes dispersion of aerosols from contaminated laundry:[92,218]
  - Ensure that laundry bags are securely bagged and tightly closed before placing the filled bag into the chute.[3,92]
  - Do not place loose items in the chute.[92]
  - Laundry chutes should be maintained under negative pressure and discharge into the soiled linen collection area.[92]
  - Laundry chutes should be cleaned on a regular basis.[3,304]
- Routine practices for handling and laundering are sufficient, regardless of the source of the linen. Special handling of linen for clients/patients/residents on Additional Precautions is not routinely required.[92,218,358]
- Change personal protective equipment when it becomes wet or soiled; remove personal protective equipment upon leaving the soiled sorting area.[304]
- Do not hold laundry bag close to the body to avoid potential risk of injuries due to sharps.

7.1.3 WASHING AND DRYING LAUNDRY

Patient/resident laundry should be done as a separate cycle from environmental cleaning items such as cloths and mop heads. Cloth linen bags should washed after each use[3,304] and can be washed in the same cycle as the linen contained in them.[3] Laundered items should be taken out of the washer as soon as feasible to reduce the risk of contaminating the washer and formation of biofilm.[92,347] There should be posted instructions on washing and drying patient/resident laundry.[3,92]

The effectiveness of the laundering process in rendering the laundered items hygienically clean* depends on the following factors and their interactions:[304]

- time and temperature
- mechanical action
- chemicals used
- water quality, including pH level, hardness
- rinsing requirements
- volume of the load
- nature and extent of soiling in the items to be laundered
- model of washers and dryers

Health care facilities shall take into consideration the recommendations of the manufacturers of the washer and dryer, materials to be laundered, and the detergent used when setting their laundry formula.[304,359] Using a disinfectant (such as bleach) may not offer additional advantage when soiling is at low levels.[347] However, a disinfectant can be used to enhance the overall disinfection of the laundry process when there is heavy soiling of the items to be laundered, or when resettling of microorganisms in the wash or rinse water onto the laundered items is a concern.[347]

* Hygienically clean is defined by the American National standards Institute (ANSI)/Association for the Advancement of Medical Instrumentation (AAMI) as being "free of pathogens in sufficient numbers to cause human illness".[360]

7.1.4 CLEAN LINEN

Clean laundry should be sorted, packaged, transported and stored in a manner that prevents inadvertent handling, contamination by dust or debris, and contact with soiled linens or other soiled or contaminated items during sorting, packaging, transport and storage. [3,218,304,347]

Each client/patient/resident floor should have a designated area (e.g., dedicated closet, clean supply room) for sorting and storing clean linen. If a closed cart system is used, storage of clean linen carts in an alcove is permitted if it is out of the path of normal traffic and under staff control.[80,81]

7.1.5 LAUNDRY STAFF PROTECTION

Protection of staff in laundry areas includes:[3]

- Training for all health care providers and laundry staff in the procedures for handling of soiled linen that includes infection prevention and control and WHMIS training.
- Dedicated hand washing sink and alcohol-based hand rub that is readily available in laundry areas.[3,80,92,304]
- Provision of appropriate personal protective equipment, e.g., gloves, gowns or aprons, face protection, to provide protection from potential cross-infection and sharps injury when handling soiled linen.[3,92,217] Disposable gloves are recommended and these should be sufficiently long to cover the forearm and be tear-resistant.[304,322] If reusable personal protective equipment is used, it shall be cleaned daily at a minimum and designated to the individual.[304,322]
- Replacement of personal protective equipment when the integrity is compromised.[304]

- Disposal of sharps at point-of-use to ensure that there are no residual sharps in linen. Any sharps found in linen shall be reported to management and documented to prevent future incidents from happening.[304]
- Immunization of laundry staff against hepatitis B and tetanus due to the high risk of sharps injury.[304]
- Hand hygiene whenever gloves are changed or removed.[304,322]

Recommendations:

66. **The laundry facility must follow published laundry regulations. [A III]** [modified 2018]
67. **There must be policies and procedures to ensure that clean laundry is transported and stored in a manner that will ensure that cleanliness is maintained. [A III]** [modified 2018]
68. **There shall be clear separation between clean and dirty laundry through all steps of the laundering process, including transportation and storage. [A III]** [modified 2018]
69. **There should be appropriate designated areas for storing clean linen. [B III]** [modified 2018]
70. **Health care facilities should use the same laundering practices for all patients, including those requiring Additional Precautions. [B III]** [modified 2018]

7.2 Management of Biomedical Waste and Disposal of Sharps

In order to allow for proper treatment and disposal of waste and to optimize waste diversion, waste shall be segregated at the point of generation into the following categories and should not be mixed:[296]

- biomedical
- pharmaceutical
- chemical
- radioactive
- general, and
- recyclable

Biomedical waste is contaminated, infectious waste from a health care setting that requires treatment prior to disposal in landfill sites, sanitary sewer systems, or incineration. It is estimated that about 60% of the waste generated by a health care facility is general (nonhazardous) waste, about one-third of the waste is recyclable (including compost), and biomedical waste constitutes only about 7% of all waste.[361] Biomedical waste includes:[2]

- Human anatomical waste.
- Human and animal cultures or specimens (excluding urine and faeces).
- Human liquid blood and blood products
- Items contaminated with blood or blood products that would release liquid or semi-liquid blood if compressed.
- Body fluids visibly contaminated with blood.
- Body fluids removed in the course of surgery, treatment or for diagnosis (excluding urine and faeces).
- Sharps that have come into contact with blood or body fluids.
- Broken glass which has come into contact with blood or body fluid.
- Cytotoxic waste.
- Live or attenuated vaccines.

Written policies and procedures for the management of waste from health care settings should be developed based on provincial and municipal legislations[2,8] and relevant standards,[296] and should address issues such as the collection, storage, transport, handling and disposal of waste. Responsibility for waste management shall be clearly defined,[296] with a commitment to sustainability by reducing the amount of waste generated through waste segregation and diversion (reusing and recycling).[296,361,362] This will reduce the amount of waste categorized as biomedical and subsequently going for incineration or land disposal.

7.2.1 COLLECTION OF BIOMEDICAL WASTE

Waste shall be collected in containers that can withstand the weight of the waste within without tearing, cracking or breaking. In addition, they should be appropriate for the nature of the waste being collected (e.g., leak-proof for wet wastes), and be of appropriate size to allow for safe transport within the facility.[296] To prevent spillage and to protect the safety of waste handlers, waste containers should not be overfilled.[296]

Legislation dictates that biomedical waste be handled and disposed of in a manner that avoids transmission of potential infections:[2,3,92,219,229,363]

- Biomedical waste (excluding sharps waste) destined for incineration shall be placed in leak proof single use biomedical waste containers, which may be rigid plastic containers or cardboard containers that are sealed and lined with a leak proof plastic bag that can be securely tied.[2] Re-usable containers are not appropriate for biomedical waste destined for incineration.[2]
- Biomedical waste destined to landfill sites may be placed into leak proof single-use or reusable biomedical waste containers. Reusable containers shall be puncture resistant, cleanable, and disinfected after use.[2]
- Sharps waste (including cytotoxic sharps waste) may be put in single-use or re-usable containers that are resistant to puncture and leakage.[2] Single-use containers should have a lid that cannot be removed after the container is sealed; re-usable containers should have a lid that is locked when the container is full.[2]

Biomedical waste should be segregated according to the categories listed in Table 4: Disposal Streams for Biomedical and General Waste.[2,3,296] Placing regular waste that does not require special handling into containers designated for biomedical waste will result in increased costs and may incur penalties from collection agencies.

Table 4: Disposal Streams for Biomedical and General Waste[2,3,296]

Waste Category	Colour Code	Examples	Disposal
Anatomical waste	Red	▪ Tissues, organs, body parts other than teeth, hair, or nails	▪ Incineration
Microbiologic waste	Yellow	▪ Diagnostic specimens other than urine and feces, cultures, live or attenuated vaccines, or disposable laboratory material that has come into contact with the afore-mentioned	▪ Incineration not required ▪ Treatment capable of inactivating spores (e.g., autoclave), then disposal in landfill[364] ▪ Return publicly funded vaccines

Waste Category	Colour Code	Examples	Disposal
			to the Ontario Government Pharmacy
Fluid waste	Yellow	▪ Drainage collection units and suction container contents, blood, blood products, bloody body fluids and other materials that will release liquid or semi-liquid blood if compressed	▪ Sanitary sewer if permitted by municipal bylaws ▪ Incineration not required ▪ Treatment capable of inactivating spores (e.g., autoclave), then disposal in landfill ▪ Do NOT dispose fluid waste into hand washing basins, as that has been implicated in outbreaks traced to contaminated sinks[365-369]
Sharps	Yellow, *or* Red for cytotoxic sharps waste	▪ Needles including safety engineered needles, syringes, lancets, blades, or clinical glass that have come into contact with blood or body fluids	▪ Incineration for cytotoxic sharps waste ▪ For noncytotoxic sharps, treatment capable of inactivating spores, then disposal in landfill
General waste	Green, black or clear	▪ Dressings, sponges, diapers, incontinent pads, personal protective equipment, disposable drapes, dialysis tubing and filters, empty IV bags and tubing, catheters, empty specimen containers, lab coats and aprons and pads that will not release liquid or semi-liquid blood if compressed ▪ Isolation waste from Contact, Droplet and Airborne Precautions rooms ▪ Waste from offices, kitchens, washrooms, public areas	▪ Landfill

For cytotoxic waste handling, see:

- *Environmental Protection Act*, R.S.O 1990, c. E. 19, Part V and *Guideline C-4: The Management of Biomedical Waste in Ontario*.
- Cancer Care Ontario's *Safe Handling of Cytotoxic Drugs*.
- CSA Group's *Z317.10-15 Handling of Health Care Waste Materials*.

For pharmaceutical waste handling, see:

- CSA Group's *Z317.10-15 Handling of Health Care Waste Materials*.

For chemical waste handling, see:

- *General—Waste Management,* R.R.O. 1990, Reg. 347
- *Ozone Depleting Substances and Other Halocarbons,* O. Reg. 463/10 (deals with sterilants)
- CSA Group's *Z317.10-15 Handling of Health Care Waste Materials*.

For waste from patients of viral hemorrhagic fevers, see:

- Ontario Agency for Health Protection and Promotion (Public Health Ontario). *Infection Prevention and Control Guidance for Patients with Suspect or Confirmed Viral Hemorrhagic Fevers (VHF) in Acute Care Settings*.
- Public Health Agency of Canada's *Infection Prevention and Control Expert Working Group: Advice on the Management of Ebola Virus Disease-associated Waste in Canadian Healthcare Settings*.

For waste from patients of human transmissible spongiform encephalopathies (TSE), including Creutzfeldt-Jakob disease (CJD), see:

- CSA Group's *Z317.10-15 Handling of Health Care Waste Materials*.

For waste diversion (including reuse and recycling), see:

- Ontario Hospital Association's *Greening Health Care Sector Report: Waste Management*.

For waste management by home health care providers, see:

- CSA Group's *Z317.10-15 Handling of Health Care Waste Materials*.

7.2.2 HANDLING OF SHARPS

Sharps are devices that are capable of causing a cut or puncture wound. Examples include needles, sutures, lancets, blades and clinical glass.

In Ontario, all health care settings are required to use safety-engineered needles, according to the *Needle Safety Regulation,* O. Reg. 474/07.

Incorrectly disposed needles cause needle-stick injuries in environmental service workers.[370-372] Over-filling sharps containers can cause sharps injuries.[296,371] Sharp instruments can end up in bedding or other linen after being used. Laundry staff can sustain injuries when needles or other instruments are accidentally left in bedding, linen or other laundry.

Prevention of sharps injuries may be achieved by:[92,219]

- Using safety-engineered needles.[296,370,371,373]
- NEVER re-capping a used needle.[296,371]
- Providing rigid, puncture-resistant sharps containers at or near the point-of-use to permit safe one-handed disposal.[370,371]
- Ensuring that staff ALWAYS place sharps into the sharps container, immediately after use and educating staff about sharps safety, including the correct disposal of used sharps and sharps found in the environment (e.g., sharps in laundry, waste, or on the floor). [370,371]

- NEVER reaching into waste or sharps containers.[371]
- Replacing sharps containers when they are three-quarters full or the sharps have reached the fill line and securely closing the lid.[296]
- Handling laundry and waste with care.[371]

Facilities shall have policies and procedures for managing sharps injuries (see 5. Occupational Health and Safety Issues Related to Environmental Services)[31,218,219] Environmental service workers must be provided with education about the facility procedure to be followed in the event of a sharps injury, including immediate follow-up if a sharps injury occurs.[296]

A procedure for safely disposing of a contaminated sharp that has not been correctly disposed of may be found in Appendix 26.

7.3 Management of Waste (General and Biomedical)

7.3.1 STORAGE OF WASTE

Waste must be placed in appropriate containers at the point-of-care/use and stored in a designated enclosed room with access limited to authorized staff.[296] Refrigerated space at or below 4°C shall be provided for storage of anatomical waste and for biomedical waste if stored for more than four days.[2,296] Biomedical waste storage areas shall be locked, except where authorized staff are on hand.[3,296]

Segregated waste should be removed to central holding areas at frequent intervals[219] and be stored in rigid, secondary leak-proof bins that are cleaned and disinfected prior to re-use.[296] Waste bags for general waste should never be stored directly on the floor. Provincial regulations for specific storage requirements shall be followed.[2,219]

Health care facilities shall have a contingency plan for dealing with the storage of refrigerated waste in the event of:[296]

- excess waste production
- the on-site cold storage unit or treatment equipment becoming inoperative
- other disruption of disposal services

7.3.2 TRANSPORT OF WASTE

All waste should be transported within the health care setting incorporating the following procedures:

- There are clearly defined transport routes for waste.
- Manual handling of waste is minimized.[296]
- Waste transport routes avoid crossing through clean zones, public areas or client/patient/resident care units.[296]
- A dedicated elevator is assigned for the transport of waste. If a dedicated elevator is not available, waste should not be transported at the same time as clients/patients/residents, food serving carts or clean/sterile instruments/supplies/linen.
- Waste is transported in leak-proof carts which are cleaned on a regular basis.[296]

All external transportation of infectious waste must comply with Transport Canada's *Transportation of Dangerous Goods Act, 1992* (S.C. 1992, c. 34) *and* Transportation of Dangerous Goods Regulation (SOR/2001-286),[267] and the *Environmental Protection Act*, R.S.O. 1990, c. E. 19, Part V.[2] Waste must be transported by a certified waste hauler who provides a certificate of approval.[2] In general, where the primary biomedical waste container is a sharps container or a rigid container with a nonremovable lid, additional packaging or containment of the waste is not necessary for off-site transportation. Where the primary container is a plastic bag, the bag shall be placed into a rigid, leak-proof outer container for transportation off-site.[374] For details on the classification, packaging, documentation and training requirements for shipping infectious substances, see

- Transport Canada's *Transportation of Dangerous Goods Bulletin: Shipping Infectious Substances*.

7.3.3 PROTECTION OF STAFF HANDLING WASTE

A dedicated hand washing sink must be available to waste handlers.[80,296] It is strongly recommended that non-immunized waste handlers be offered immunization against hepatitis B[3,296] and tetanus.[296]

Health care facilities shall provide, and waste handlers shall wear, personal protective equipment appropriate for the risk of the tasks when handling waste.[3,217,296] Environmental service workers who clean reusable waste containers, carts, final storage areas, or biomedical waste treatment equipment also shall wear personal protective equipment appropriate for the tasks. Depending on the task and type of waste, examples of protective equipment may include:

- Gloves to protect from exposure (e.g., nitrile for exposure to blood, body fluids, chemicals; and puncture-resistant gloves for exposure to sharps).[375]
- Coveralls or aprons.[375]
- Facial protection, e.g., face shield.[375]
- Protective footwear to protect against sharps.[296,375]

Recommendations:

71. **There shall be written policies and procedures for the collection, handling, storage, transport and disposal of biomedical waste, including sharps, based on provincial and municipal regulations and legislation. [A III]** [reviewed and not changed 2018]

72. **Waste handlers shall wear personal protective equipment appropriate to their risk. [Legislation]** [modified 2018]

73. **Waste that is transported within a health care setting:**
    a. **Should be transported following clearly defined transport routes. [B III]** [reviewed and not changed 2018]
    b. **Shall not be transported through clean zones, public areas, or patient/resident care units. [A III]** [modified 2018]
    c. **Should not be transported on the same elevator as clients/patients/residents or clean/sterile instruments/supplies/linen. [B III]** [modified 2018]
    d. **Shall be transported in leak-proof and covered carts which are cleaned on a regular basis. [A III]** [modified 2018]

74. **There shall be a system in place for the prevention of sharps injuries and the management of sharps injuries when they occur. [Legislation]** [reviewed and not changed 2018]

8. New and Evolving Technologies for Environmental Cleaning

8.1 Background

The technology used to perform environmental cleaning continues to evolve. In this chapter, the use of antimicrobial surfaces within the health care setting and the use of "no-touch" disinfection systems are discussed.

8.2 New and Evolving Technologies

8.2.1 ANTIMICROBIAL SURFACES

Contamination of environmental surfaces with infectious microorganisms is common in health care settings.[14,376] Microorganisms have also been shown to persist on surfaces even after routine cleaning and to re-accumulate rapidly following cleaning.[14,16] Replacing materials traditionally used in the health care setting (e.g., plastic, stainless steel) with materials with antimicrobial properties or treating surfaces with coatings that have persistent antimicrobial activity is a potential solution to this problem.[377,378] Candidate antimicrobial surfaces and coatings supported by data from nonclinical settings include copper,[379-385] silver,[386-388] stainless steel coated with titanium dioxide,[389] glass coated with xerogel,[390] and surfaces sprayed with surfacine[391] or organosilane.[392,393]

With the exception of copper, there is very limited evidence that any of these approaches persistently reduce microbial contamination in clinical settings and no evidence that they reduce the incidence of health care-associated infection. There is now evidence from multiple studies demonstrating that copper surfaces used in acute and long-term care settings reduce overall bacterial burden (e.g., total colony forming units per item or area).[379,381-385,394,395] In a systematic review conducted by PHO,[24] these studies demonstrated a modest but consistent (~1 $\log_{10}$) reduction in bacterial load on copper surfaces as compared to standard surfaces.[381-385] Additionally, one study using copper oxide impregnated linens demonstrated a 24% reduction in health care-associated infection in a chronic care ward,[385] and another study demonstrated a 44% reduction in health care-associated infection in the acute care setting among patients admitted to a room containing six copper items as compare to patients admitted to a room with noncopper items.[380] Although these studies show promise, both were at high risk of bias.[24]

There is, therefore, insufficient evidence to recommend for or against the use of copper surfaces or copper impregnated linens in the health care setting, and facilities should weigh the cost, functionality, the limitation of copper (See Table 6) against its known antimicrobial properties, and low quality evidence suggesting it may impact infection rates when considering the use of copper surfaces or linens.

- See CSA Group's *EXP06-2015 Evaluating Emerging Materials and Technologies for Infection Prevention and Control* for more information on assessing antimicrobial surfaces.[396]

There is insufficient evidence to recommend for or against the installation of copper surfaces.

8.2.2 NO-TOUCH DISINFECTION SYSTEMS

Environmental surfaces in the health care setting are frequently contaminated with clinically relevant pathogens and these pathogens often persist despite routine cleaning and disinfection.[397] No-touch disinfection systems are systems that use chemical disinfectants or physical agents to disinfect surfaces and which do not require that the active agent is directly applied to and removed from the surface manually.

The most studied no-touch disinfection systems include the use of hydrogen peroxide mist or vapour[76,85,398-415] or the use of ultraviolet light[77,254,406,416-421] to disinfect surfaces. A variety of other no-touch technologies have also been described (e.g., high-intensity, narrow-spectrum light,[422-424] quaternary ammonium fogging,[425,426] alcohol-mist,[427] ozone gas,[428-431] superoxide water,[432] and steam vapour[433,434]). In all cases, these technologies were designed as a supplement to, and not as a replacement for, routine cleaning and disinfection by environmental service workers.[16,397,435] These technologies, the evidence for their use, are considered individually below.

8.2.2.1 Disinfection Using Hydrogen Peroxide Vapour or Mist

Systems that produce hydrogen peroxide for surface disinfection include: (a) hydrogen peroxide vapour at 30% to 35% generated by heat, and (b) aerosolized hydrogen peroxide at 5% to 6% generated by pressure or ultrasonic nebulization.[435] Hydrogen peroxide systems are effective against a wide range of microorganisms, including bacteria, viruses and spores, particularly those of *C. difficile*.[376,397]

Hydrogen peroxide decomposes to water and oxygen. The vapour or mist is typically delivered by a computer-controlled distribution system that ensures even distribution throughout the room while monitoring gas concentration, temperature and relative humidity. Once decontamination is complete, an aeration unit in the room converts the hydrogen peroxide into water and oxygen. The complete decontamination process takes an average of three to five hours.

Hydrogen peroxide vapour systems have several limitations, including health and safety risk to patients and staff present when the system is operating,[16] erosion of some plastic and polymer surfaces after repeated exposure,[16] and reduced efficacy where organic materials are not removed prior to using the system.[16] In addition, different materials (e.g., linen, soft furnishings) may also affect the efficacy of these systems.[436] To achieve optimal disinfection effect, these systems also need to be positioned properly,[16] and the heating, ventilation and air conditioning system must be shut off during while these systems are operating.[397] The time required to complete a cycle of disinfection using some hydrogen peroxide vapour systems may take more than four times longer than the time required for manual environmental cleaning.[437] (See Table 5 for a summary of the advantages and disadvantages of hydrogen peroxide vapour systems.)

There is evidence from multiple studies that hydrogen peroxide vapour reduces the level of bacterial contamination on surfaces following routine cleaning and disinfection.[76,85,398,399,401,402,404,406-415] It is difficult to estimate the magnitude of this effect, as sampling methodology and microbiological outcomes measured varied widely between studies. However, the majority of studies demonstrate that routine cleaning and disinfection, followed by hydrogen peroxide vapour disinfection, reduces levels of bacterial contamination when compared to routine cleaning and disinfection alone. Additionally, there are a number of studies evaluating the impact of hydrogen peroxide vapour on health care-associated infections and/or antibiotic-resistant organism transmission, most commonly in the context of outbreak

management.[76,400,402-405,409-411] In the five studies evaluating hydrogen peroxide vapour in the outbreak setting, three used hydrogen peroxide vapour as a one-time treatment of an entire ward,[405,409,410] two additional studies did the same thing but then continued using hydrogen peroxide vapour for discharge cleaning of rooms occupied by patients with antibiotic-resistant organisms on an ongoing basis.[402,411] All studies showed a reduction in their specific antibiotic-resistant organism; however interpretation of these studies is difficult as the reduced antibiotic-resistant organism infection rate could be attributed to regression to the mean (i.e., rates were unusually high before the use of hydrogen peroxide vapour systems started, so it was likely that rates would have fallen even without using hydrogen peroxide vapour), or to the use of co-interventions in most of these studies. Four studies evaluated hydrogen peroxide vapour in the non-outbreak setting using before-after study designs.[76,400,403,404] In these studies, hydrogen peroxide vapour was used for discharge cleaning for patients with one or more antibiotic-resistant organisms (or *C. difficile*). All studies demonstrated a reduction in antibiotic-resistant organism transmission rate either overall (3 studies) or in patients admitted to a room previously occupied by a patient colonized with the antibiotic-resistant organism of interest.

In one study comparing the microbicidal efficacy of hydrogen peroxide vapour with ultraviolet light disinfection, hydrogen peroxide vapour was found to be significantly more effective in reducing bacterial contamination on surfaces in patient rooms, and was significantly more effective against spores.[406] In a study by French et al,[415] isolation rooms contaminated with MRSA were decontaminated more effectively with hydrogen peroxide vapour than with routine cleaning measures. The vapour was particularly effective for decontaminating complex furniture and equipment that was difficult to clean manually.

Similar to the studies of antimicrobial surfaces, studies of hydrogen peroxide vapour disinfection show the potential for this technology to prevent antibiotic-resistant organism transmission, but all were at high risk of bias.

There is, therefore, not sufficient evidence to recommend for or against the routine use of hydrogen peroxide vapour in the health care setting as a supplement to routine cleaning. Facilities should weight the cost and limitations of hydrogen peroxide vapour (see Table 5) against its established ability to reduce bacterial contamination on surfaces as well as some low quality evidence that it may be effective in terminating outbreaks, limiting antibiotic-resistant organism transmission, and preventing *C. difficile* infection. Hydrogen peroxide vapour may be most useful for facilities with a high incidence of and/or frequent outbreaks secondary to antibiotic-resistant organisms or *C. difficile*. However, such facilities should ensure that they have sufficient, trained environmental service workers, have assessed the feasibility of using this technology in their practice setting, and have implemented appropriate infection control measures before deploying these technologies.

8.2.2.2 Disinfection Using Ultraviolet Light

Ultraviolet light at wavelengths of 200 to 320 nm can kill microorganisms by destroying bonds in genetic materials.[16] The wavelength of ultraviolet-C light lies between 200 to 270 nm,[436] and has been used in the health care setting to destroy airborne organisms or inactivate microorganisms on surfaces.[154] Bacteria and viruses are more easily killed by ultraviolet light than are bacterial spores.

The germicidal effectiveness of ultraviolet light is influenced by:[154,438]

- amount and type of organic matter present
- wavelength of ultraviolet light
- air mixing and air velocity
- temperature and relative humidity
- exposure time
- type of microorganisms present
- ultraviolet light intensity, which is affected by distance, angle of incidence, and cleanliness of lamp tubes

If ultraviolet light is used in a health care setting, warning signs should be posted in the affected area to alert staff, clients/patients/residents and visitors of the hazard. A schedule for replacing ultraviolet lamps should be developed according to the manufacturer's recommendations. Ultraviolet light intensity should be regularly monitored.[439] (See Table 5 for a summary of the advantages and disadvantages of ultraviolet light disinfection systems.)

Pre-cleaning of visibly soiled surfaces is necessary before ultraviolet light disinfection, as ultraviolet light is absorbed by organic materials and its ability to penetrate is low.[421]

There is evidence from multiple studies that ultraviolet light disinfection reduces the level of bacterial contamination on surfaces following routine cleaning and disinfection.[254,406,417-421,440,441] As with the studies of hydrogen peroxide vapour, it is difficult to estimate the magnitude of this effect due to variations in how the intervention was implemented (type of ultraviolet device, number of devices, amount of ultraviolet light, room size and shape), sampling methodology and microbiological outcomes. However, the majority of studies demonstrate that routine cleaning and disinfection, followed by ultraviolet disinfection, reduces levels of bacterial contamination when compared to routine cleaning and disinfection alone.

There are also seven studies that evaluated the impact of ultraviolet light on antibiotic-resistant organisms or health care-associated infection outcomes.[77,416,441-445] All are uncontrolled before-after studies. A strength of these studies is that they were not conducted during outbreaks. Six of the seven studies reported a reduction in antibiotic-resistant organism or health care-associated infection incidence, ranging from 20% to 57%.[77,416,441,442,444,445] These studies show the potential for this technology to prevent antibiotic-resistant organism transmission under non-outbreak conditions, but all were at high risk of bias related to their study design.

There is, therefore, not sufficient evidence to recommend for or against the use of ultraviolet light disinfection in health care setting as a supplement to routine cleaning. Facilities should weight the cost and limitations of ultraviolet light disinfection systems (see Table 6) against its established ability to reduce bacterial contamination on surfaces and some evidence that it may be effective in limiting antibiotic-resistant organism transmission or preventing health care-associated infections. Ultraviolet light may be most useful for facilities with moderate to high incidence of antibiotic-resistant organisms or *C. difficile* infection that already have an appropriately resourced environmental service department.

- See CSA Group's *EXP06-2015 Evaluating Emerging Materials and Technologies for Infection Prevention and Control* for more information on assessing no-touch disinfection systems.[396]

There is insufficient evidence to recommend for or against the use of hydrogen peroxide vapour or ultraviolet disinfection technologies for room or ward disinfection following manual cleaning and disinfection.

Table 5: Advantages and Disadvantages of Hydrogen Peroxide Vapour and Ultraviolet Disinfection Systems Compared to Manual Cleaning and Disinfection Alone

Technology	Advantages	Disadvantages
Hydrogen peroxide vapour [16,396,397,415]	▪ Reduces bacterial burden when added to manual cleaning ▪ Broad-spectrum microbicidal activity and sporicidal ▪ Environmentally safe residues ▪ Simultaneous disinfection of room surfaces, furniture, and complex equipment ▪ Uniform distribution in the room via an automated dispersal system ▪ No need to move furniture and equipment away from the walls ▪ May be used to decontaminate entire units or wards during outbreaks	▪ Adds to the time required for room cleaning ▪ Discharge/transfer cleaning only, as patients and staff must be removed from the room before decontamination ▪ Efficacy affected by surface nature, hydrogen peroxide concentration, presence of organic soiling ▪ Pre-cleaning required to remove dust and stains ▪ Sealing of air ducts from the room and gaps under doors required prior to decontamination ▪ Optimal methodology (including exposure time) is still under investigation ▪ Expensive ▪ Potential damage of some plastic and polymer surfaces ▪ Staff must not enter during the disinfection cycle ▪ Trained system operators required ▪ Transport of system to rooms where disinfection occurs requires time and labour
Ultraviolet light [16,396,397]	▪ Reduces bacterial burden when added to manual cleaning ▪ Broad spectrum microbicidal activity ▪ Sporicidal at higher dose and/or longer cycle time ▪ Relatively short cycle time (15 to 50 minutes) ▪ No residue after use ▪ Prior-to-use sealing of heating, ventilation and air conditioning system not required ▪ Simultaneous disinfection of room surfaces, furniture, and equipment ▪ Low operating costs	▪ Adds to the time required for room cleaning ▪ Discharge/transfer cleaning only, as patients and staff must be removed from the room before decontamination ▪ Destructive effect over time on plastics and vinyls and fading of paints and fabrics ▪ Low penetrating effect ▪ Efficacy affected by wavelength, dose, cycle time, airflow, distance from target, organic soiling ▪ Pre-cleaning required to remove dust and stains ▪ Equipment and furniture must be moved into line of vision for disinfection to occur ▪ Expensive for initial outlay of equipment ▪ Staff must not enter during the disinfection cycle ▪ Trained system operators required ▪ Transport of system to rooms where disinfection occurs requires time and labour

8.2.2.3 Other Methods of No-Touch Disinfection

A number of other no-touch disinfection technologies are currently in development or have been evaluated in the past. Examples include fogging with formaldehyde,[92] ethylene oxide, superoxidized water,[432] ozone,[428-431,446,447] or quaternary ammonium compounds;[425,426] use of alcohol mist;[427] steam disinfection; and high-intensity narrow spectrum light.[422-424] There are few studies evaluating these technologies but no studies use antibiotic-resistant organisms or health care-associated infections as outcomes. For some of these technologies, there are significant concerns about toxicity and safety (e.g., ozone,[448] fogging with formaldehyde[3] or ethylene oxide[3]).

While interest remains in developing new technologies for disinfection within the health care environment, the use of any of these technologies for environmental disinfection is not recommended until evidence confirming their effectiveness and safety in clinical environments is available.

Table 6: Advantages and Disadvantages of Copper Surfaces, Ultraviolet Light, and Hydrogen Peroxide Vapour in Addition to Manual Cleaning and Disinfection

Method	Can be Used for Routine Daily Cleaning / Disinfection	Can be Used at Discharge or Transfer	Removes Dirt and Debris	Turnaround Time	Susceptible to Missing Surfaces	Achieves Hotel Clean in Addition to Disinfection
Manual cleaning	Yes	Yes	Yes	Variable	Yes, due to time constraint, unclear responsibility, cluttering, room layout	Yes
Copper surfaces	N/A	N/A	No	N/A	Only a limited number of surfaces can be targeted	No
Ultraviolet light	No	Partial*	No	Adds additional time to manual cleaning	Objects not in line of sight may be missed	No
Hydrogen peroxide vapour	No	Partial*	No	Adds additional time to manual cleaning	Uniform distribution by an automated dispersal system	No

* Depends on frequency of discharges/transfers and number of available machines (and staff).

> **The use of no-touch disinfection systems does not replace the need for routine manual cleaning of environmental surfaces.**

Recommendations:

75. **Infection prevention and control, environmental services, and occupational health and safety must be consulted before making any changes to cleaning and disinfection procedures and technologies in the health care setting. [A III]** [reviewed and not changed 2018]

9. Assessment of Cleanliness and Quality Control

9.1 Overview of Approaches used to Monitor Cleaning and Cleanliness

The responsibility for ensuring that cleaning of the environment in a health care facility is performed according to best practices and facility policy belongs to all staff involved in environmental cleaning, from the front-line environmental service workers, to supervisors, managers and directors. Facility administration is also responsible for ensuring that a safe and sanitary health care environment is maintained.[16]

To ensure that this goal is met, a quality control program that includes regular assessments of cleaning and cleanliness is required.[158,253-257,293,449,450] In addition, health care facilities should develop and maintain appropriate environmental cleaning policies and procedures, as well as hire and maintain sufficient numbers of trained and educated environmental service workers.[15-17,158,159,253,254,291]

Measures of cleaning and cleanliness can facilitate the following:

- training environmental service workers (see 4. Education)
- standardizing cleaning procedures
- ensuring that cleaning is performed consistently
- assessing the adequacy of resource dedicated for environmental cleaning (see 3.1.1 Organization and Required Resources for Effective Environmental Cleaning)
- improving the efficacy of cleaning

There are currently a wide variety of approaches that can be used to monitor cleanliness in the health care environment. Each approach addresses different aspects of cleaning and each has strengths and weaknesses. To obtain the maximum benefit from any of the approaches described in this chapter, tools used to monitor cleanliness must be standardized, applied on a regular basis, and implemented cooperatively as a partnership between the environmental service department and infection prevention and control.[35,256] Results should be used for education and training and to provide both positive and constructive feedback to front-line environmental service workers.[141,451] Additionally, aggregate results should be presented regularly to environmental service leadership, infection prevention and control, and the facilities administrative leadership.[141] An overview of approaches to monitoring cleaning and cleanliness is provided in Table 7 and Table 8**.**

In general, facilities should incorporate several of these methods as they have different advantages and disadvantages.

9.2 Assessing Cleaning and Cleanliness using Observational Methods

Table 7: Observational Methods Used to Monitor Cleaning and Cleanliness in Health Care Facilities

Method	Description	Advantages	Disadvantages
Visual assessment [376,452]	Trained observer (e.g., environmental service supervisor) assesses cleanliness of an area following cleaning	▪ Easy to implement[376] ▪ Useful to assess whether a "hotel clean" has been obtained ▪ Allows feedback to individual environmental service staff	▪ Results do not correlate with levels of microbial contamination[376] ▪ Does not assure that a "health care clean" has been achieved[452] ▪ Results may vary across different observers[376]
Performance observation [230,376]	Environmental service supervisor observes environmental service workers perform cleaning	▪ Easy to implement[376] ▪ Useful to assess that facility procedures for cleaning are performed correctly[376] ▪ Allows feedback to environmental service staff	▪ Time consuming ▪ Labour intensive[230] ▪ Performance while observed may not be the same as performance when not observed[376]
Satisfaction surveys [453]	Patients/residents/clients complete surveys and provide feedback on the facilities' cleanliness	▪ Useful to ensure needs of client/patient/resident are met	▪ Results may not correlate with levels of microbial contamination[453]

9.2.1 VISUAL ASSESSMENT OF CLEANLINESS

In the past, visual assessment has been the primary approach to measure cleanliness and it remains an important approach to ensure that an adequate "hotel clean" is achieved.[141,454-456] Ensuring that the physical environment is uncluttered and appears clean is valued by patients/residents/clients and staff and is an important goal. However, although visibly clean surfaces are free of obvious visual soil they may remain contaminated with microorganisms, organic materials or chemical residues.[6,454,457-459]

When conducting visual assessments, a standardized approach and checklist is important to ensure consistency. Results can be reported as the proportion of items or surfaces inspected that were "clean", out of the total number of items/surfaces assessed. If the same group of items or surfaces are tested repeatedly, the results of visual assessments can be used as a quality indicator for environmental cleaning, as long as the limitations of this approach are understood.

9.2.2 PERFORMANCE OBSERVATION

Performance observation involves trained observers, often environmental service supervisors, watching environmental service workers perform routine cleaning tasks. Performance observation is important to

ensure that environmental service workers are appropriately educated and trained, and are able to follow the correct cleaning procedure. It promotes staff engagement, and is an opportunity for direct feedback from supervisors and for front-line staff to ask questions or clarify procedures and protocols.

Disadvantages of performance observation are that it is labour intensive, it may be difficult to standardize or measure, and the observed environmental service worker may perform differently when observed than they do during routine unobserved cleaning.

Performance observation is an important tool for quality assurance in environmental services. To maximize the benefit of performance observation, the observer should be trained, observation should be conducted on a regular basis to ensure consistency of performance over time,[230] and feedback or required re-training should be provided to the observed environmental service worker in a constructive and timely manner.[15,460]

9.2.3 CLIENT/PATIENT/RESIDENT SATISFACTION SURVEYS

The results of satisfaction surveys provide information on how patients/residents/clients perceive the cleanliness of the environment of the health care facility. As with visual assessment, these perceptions may not correlate with the level of microbial or chemical contamination, and may not provide an adequate measure of the efficacy of environmental cleaning.[453] However, as providing the best possible care for patients/residents/clients is the primary goal of health care, it is important to respond to problems identified on these surveys, particularly if the same problem is noted on multiple surveys. Satisfaction surveys are not sufficient to ensure that an effective "health care clean" has been obtained.[461]

If surveys are used, it is important to ask questions that are clear, understandable and relevant to patients/residents/clients. The response to questions should be measured in a standardized manner (e.g., use of "yes" or "no" questions is preferred to free text answers in most cases). The survey should be delivered in a standardized manner (e.g., survey all patients/residents/clients from the same unit during the same two-week period each year) and there should be a benchmark for comparison–most often based on the results of previous surveys.

9.3 Post Cleaning Testing of Surfaces

Currently there are several approaches that can be used to assess the efficacy of cleaning through testing of surfaces after cleaning is completed. Different approaches assess different aspects of cleaning including cleaning thoroughness (i.e., environmental marking), removal of organic materials (i.e., adenosine triphosphate bioluminescence) or removal of microorganisms (i.e., environmental culturing). An overview of these approaches is provided in Table 8.

Table 8: Assessment of Cleaning Through Testing of Surfaces Following Cleaning

Method	Description	Advantages	Disadvantages
Environmental marking [462]	Prior to cleaning, environmental surfaces are marked with an invisible tracing agent that can only be seen using a revealing agent.	▪ Allows direct assessment of cleaning thoroughness (i.e., proportion of surfaces actually cleaned) ▪ Allows assessment of which high- and low-	▪ Does not directly measure microbial contamination ▪ Does not measure quality or intensity of cleaning (i.e., a single wipe will

Method	Description	Advantages	Disadvantages
	After cleaning, a trained observer can check to determine if the tracing agent was removed from the surfaces during cleaning. Failure to remove the tracing agent from a smooth surface suggests that the surface was not cleaned.	touch surfaces are cleaned consistently and which are omitted ▪ Associated with rapid improvement when constructive feedback is provided ▪ Easy to implement ▪ Results easily understood[462]	remove marker) ▪ Does not assess adequacy of cleaning of unmarked surfaces ▪ Surface texture may affect removal of the tracing agent
Adenosine triphosphate (ATP) bioluminescence [3,376,463-468]	ATP is a substance found in all living cells. Surfaces can be tested after cleaning to determine the quantitative level of ATP present.	▪ Allows assessment of residual organic material present after cleaning ▪ Provides quantitative result ▪ Easy to implement[376] ▪ Provides quick and direct feedback[376]	▪ Not a direct measure of microbial contamination[376] ▪ Some cleaning products and materials may interfere with the test (e.g., microfibre,[468] bleach,[463,466,467] hydrogen peroxide,[463,466] quaternary ammonium compounds,[463] etc.) ▪ Does not assess adequacy of cleaning of unmarked surfaces ▪ Results not comparable across systems due to lack of standardization[465]
Environmental culture[376]	Cultures can be taken from surfaces after cleaning to determine if bacteria are present.	▪ provides the only direct measure of contamination of viable microorganisms[376] (level of bacterial contamination, type of bacteria present)	▪ expensive[376] ▪ slow turnaround time[376] ▪ not standardized[376] ▪ does not assess bacterial contamination beyond the small areas tested[376]

9.3.1 ENVIRONMENTAL MARKING

Environmental marking measures the thoroughness of cleaning by using a tracing agent (e.g., fluorescent material, chemical tracer) to mark items and environmental surfaces prior to cleaning. Following cleaning, a trained observer can assess the marked surfaces using a detecting agent (e.g.,

ultraviolet light, enzymatic detector) that allows visualization of the tracing agent to determine whether they were cleaned.

When environmental marking programs are initially implemented, it is immediately recognized that many high-touch surfaces within the patient environment are missed during cleaning.[55,254,255,469-471] Identification of surfaces omitted during cleaning provides an important learning and feedback opportunity. Importantly, feedback of the results of environmental marking audit to environmental service staff, supervisors and managers typically leads to rapid improvement[472-475] and may reduce infection rates.[71,255,451] Additionally, in many cases specific reasons that surfaces were missed can be identified through discussion with environmental services—for example in some cases environmental service workers were not aware that they were responsible for cleaning a specific surface or item, were not aware that a specific surface or item required cleaning, or were afraid of damaging the surface or item.[475,476] Clarification of the cleaning requirements for missed items therefore can lead to prompt improvements that would not occur without environmental marking.

If environmental marking is performed, it should be done in a standardized manner. The specific surfaces or items to be marked should be determined, assessments should be made on a regular basis by a trained observer,[477] environmental service staff should be unaware which rooms or areas are being marked, and regular positive and constructive feedback should be provided.

Development of a quality indicator can be done as follows:

- Identify 15 specific surfaces or items to be marked each time cleaning is assessed.
- After cleaning is completed, determine the number of surfaces where the marker was removed ("cleaned") and the number of surfaces where the marker is still present ("missed"). (See Figure 4)

Item	Audit Dates												No. of "clean" audit results	No. of audits conducted	Overall cleanliness for the item
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec			
Bedrail	clean	clean	missed	clean	clean	clean	clean	clean	clean	clean			9	10	90%
Bedside table	missed	clean	clean	clean	missed	clean	missed	clean	clean	clean			7	10	70%
Call bell	clean	missed	clean	missed	clean	missed	clean	missed	clean	missed			5	10	50%
Chair arm	clean	clean	clean	clean	clean	clean	clean	clean	clean	clean			10	10	100%
Curtain edge	missed	missed	clean	missed	missed	clean	clean	missed	missed	clean			4	10	40%
Door knob	clean	clean	clean	missed	clean	clean	missed	clean	clean	clean			8	10	80%
Drip stand	missed	missed	clean	clean	missed	missed	clean	clean	clean	missed			5	10	50%
ECG machine	missed	clean	clean	clean	clean	clean	missed	clean	clean	clean			8	10	80%
Keyboard	missed	clean	clean	clean	missed	clean	clean	clean	clean	missed			7	10	70%
Light switch	missed	clean	missed	clean	clean	missed	missed	clean	missed	missed			4	10	40%
Sink	missed	missed	missed	clean	missed	missed	missed	missed	clean	missed			2	10	20%
Tab	missed	clean	missed	clean	clean	missed	clean	clean	clean	missed			6	10	60%
Telephone	clean	clean	clean	clean	missed	clean	clean	clean	clean	clean			9	10	90%
Toilet handle	missed	missed	clean	missed	clean	missed	clean	clean	missed	clean			5	10	50%
Toilet seat	missed	clean	missed	clean	missed	missed	clean	missed	missed	clean			4	10	40%
No. of "clean" items	5	10	10	11	8	8	10	11	11	9			93	150	62%
No. of "missed" items	10	5	5	4	7	7	5	4	4	6			57		
Monthly cleaning rate	33%	67%	67%	73%	53%	53%	67%	73%	73%	60%					

Figure 4: Sample Audit Results

- Calculate the overall proportion of surfaces cleaned as a percentage (see Example 1):

$$= \frac{\text{number of surfaces cleaned}}{\text{total number of surfaces tested}} \times 100\%$$

$$= \frac{\text{number of "cleaned" surfaces}}{\text{number of "clean" surfaces} + \text{number of "missed" surfaces}} \times 100\%$$

Example 1: Calculating Monthly Cleaning Rates

Using the data for the month of January in Figure 4:

- Number of "clean" surfaces = 5
- Number of "missed" surfaces = 10
- Cleaning rate for the month of January = $\frac{5}{5+10} \times 100\% = 33\%$

In addition to using the results of repeated environmental marking as an overall quality indicator for environmental cleaning, further information can be gained for education and feedback by looking at the percentage of time a specific surface is cleaned or missed, which can be calculated as follows (see also Example 2):

$$\frac{\text{number of audits with "clean" result for the item}}{\text{total number of audits conducted for the item}} \times 100\%$$

Environmental marking audits should generally be introduced collaboratively with environmental service departments and used for training, education and for the provision of both positive and constructive feedback. If used in a negative or punitive manner, or implemented secretively, this could lead to misleading results as there are several ways that environmental service staff could manipulate the results—for example the marking is not completely invisible and/or ultraviolet lights are easy to obtain and environmental service workers could achieve high scores not by improving the thoroughness of routine cleaning, but by deliberate cleaning of the marked surfaces only. At the same time as it is important to make environmental service programs aware of the audit program in advance, it is also important that environmental service workers are not aware of when individual rooms will be marked to minimize the risk that they focus inappropriately on removal of the marks only in these circumstances. Finally, although it is not possible to mark all relevant surfaces, it may be useful to add or remove specific marked targets over time to ensure that staff are truly cleaning all room surfaces every time.

Example 2: Calculating Overall Cleaning Rates for Specific Items or Surfaces

Using the data in Figure 4:

The overall cleaning rate for toilet seat in the last 10 months is calculated as follow:

- Number of audits with "clean" result = 4
- Number of audits conducted = 10
- Overall cleaning rate = $\frac{4}{10} \times 100\% = 40\%$

The overall cleaning rate for bedrail in the last 10 months is calculated as follow:

- Number of audits with "clean" result = 9
- Number of audits conducted = 10
- Overall cleaning rate = $\frac{9}{10} \times 100\% = 90\%$

- See Public Health Ontario's Sample Audit Tool for Routine Cleaning of Patient Rooms

9.3.2 ADENOSINE TRIPHOSPHATE BIOLUMINESCENCE

Adenosine triphosphate (ATP) is a substance present in all living cells and some organic materials, including food, body fluids.[465] The presence of ATP on a surface indicates that organic material remains on the surface—thus while the absence of ATP suggests that there is little microbial contamination of a surface, the presence of ATP could represent either microbial (viable and dead) contamination or other organic material.[15,465,478] ATP bioluminescence is a system for swabbing surfaces to measure the level of ATP present, which is a surrogate for microbial contamination. ATP testing can, therefore, provide rapid feedback on the level of organic contamination of surfaces as a measure of cleaning thoroughness and intensity.[479] Similar to environmental marking, ATP bioluminescence can be used systematically and regularly for training and education, to provide immediate feedback to environmental service workers, or as a quality indicator for cleaning.[478,480-483] Also, similar to environmental marking, an audit and feedback program based on ATP bioluminescence should be developed in a collaborative manner with environmental services.

There are limitations to ATP bioluminescence, however. Some products and surfaces can interfere with the test results by quenching the ATP readings (anionic detergents,[484] ethanol,[463] isopropanol, [463] phenol,[463] sodium phenate,[463] triclosan,[466] citric acid,[463] hydrogen peroxide,[463,466] quaternary ammonium compounds,[463] bleach[463,466,467], stainless steel[485], roughness of surface texture[485]); or enhancing the ATP readings (microfibre,[468] laundry additives,[468] some plastics,[468] cationic and non-ionic detergents,[484] bleach,[463,467] quaternary ammonium compounds,[466,467] citric acid,[463] hydrogen peroxide[463]). In some studies, ATP levels do not correlate closely to measures of microbial contamination[193,198,459,486] and there are few studies demonstrating a reduction in infection rates with implementation of ATP bioluminescence monitoring.[256] Furthermore, appropriate benchmarks for "safe" post-cleaning ATP levels from different surfaces or environments are not fully established[16,481,487,488] although some have recommended or proposed benchmarks ranging from 100 to 500 relative light units, depending on the clinical setting.[16,457,478,479] In addition, performance of different ATP bioluminescence systems varies in their reliability and accuracy. When selecting a system for auditing environmental cleanliness, health care facilities should consider the following aspects:[489]

- Sensitivity—the system is able to detect the smallest amount of contamination.
- Linearity—the amount of contamination is proportional to the level of relative light units reported by the system.
- Repeatability—the system gives the same result when the same surface is tested multiple times by the same person.
- Accuracy—the system is able to detect all available ATP on a surface.
- Precision—the results are consistent and as close to the true value as possible.
- Shelf life—the test kit is stable at room temperature for a practical period of time.

9.3.3 ENVIRONMENTAL CULTURE

Routine environmental cultures of environmental surfaces in health care facilities may be performed by swabbing or using contact agar plates.[460] Culturing is the only direct measurement of levels of microbial contamination after cleaning. Culturing by swabbing is commonly used to indicate the presence of specific

bacteria on a surface. On the other hand, contact agar plates are often used to quantify the level of bacterial contamination on an area of a large, flat surface.[460] However, such cultures are costly, the turnaround time for results is slow, and they may not be a cost-effective form of monitoring.[376] Additionally, there is no accepted standard of how such cultures should be performed or interpreted.[488,490] Some methods attempt to quantitate total bacterial burden in terms of colony-forming units per area[478,491] while others use qualitative or quantitative methods to identify the presence of, or levels of, a specific pathogen [e.g., methicillin-resistant *Staphylococcus aureus*, *C. difficile*, vancomycin-resistant enterococci, carbapenemase-producing *Enterobacteriaceae*, *Acinetobacter* species].[66,230,254,256,479]

In general, environmental cultures should not be used as a routinely performed quality assessment method for environmental cleaning due to their cost and delay in obtaining results, although they may be important for establishing the relationship between other interventions (e.g., ATP bioluminescence, environmental marking) and environmental culture results in the research setting. However, environmental cultures may be useful for investigating transmission events or outbreaks.[141,492]

9.4 Monitoring Cleaning and Cleanliness in the Health Care Setting—Putting It All Together

There are now an increasing number of tools that can be used to assess cleaning and cleanliness in the health care setting, as discussed above. These approaches will only be useful when adopted in a standardized manner and with the cooperation of the environmental service department and environmental service workers.[141]

As different tools measure different aspects of environmental cleaning, it is appropriate and recommended to use several of these tools.[471,478,486,493-495] Health care facilities should use most or all of the observational tools (i.e., visual assessment of cleanliness, performance observation and feedback, satisfaction surveys) combined with at least one measure of surface cleaning (e.g., environmental marking or ATP bioluminescence) on a routine basis. Although this approach may not be feasible in outpatient settings and office practices, the same quality control principles apply. For clinical office settings that are part of a larger health care organization, observational methods to assess cleaning and cleanliness should be strongly considered for use, and the periodic use of a measure of surfaces cleaning may also be beneficial, particularly in areas that are higher risk due to their patient population or because of the types of interventions and procedures that are performed. Free-standing clinical office practices should use observational methods to assess the efficacy of cleaning (see 9.2 Assessing Cleaning and Cleanliness using Observational Methods).

Recommendations:

76. **There must be a process in place to measure the quality of cleaning in the health care setting. [A III]** [modified 2018]
77. **Health care facilities should use at least one measure that directly assesses cleaning (i.e., environmental marking, ATP bioluminescence), in addition to observational assessments (e.g., performance observation, visual assessment). [B III]** [modified 2018]
78. **Results of cleaning audits should be used for the purposes of training and to provide positive and constructive feedback to frontline environmental service workers. [B III]** [modified 2018]

79. **Aggregate results must be presented to relevant stakeholders, e.g., environmental service leadership, infection prevention and control, and administration. [A III]** [new 2018]

Section Two:

Cleaning and Disinfection Practices for All Health Care Settings

10. Health Care Cleaning and Disinfection Practices

This chapter, and the remaining chapters in Section Two, provides detailed practical guidance on cleaning and disinfection in the health care setting. This chapter focuses on the cleaning of client/patient/ resident rooms (including rooms used for patients in isolation), health care surfaces, and noncritical equipment. Subsequent chapters address cleaning and disinfection of rooms used for patients on Additional Precautions (Cleaning and Disinfection When Patients/Residents Are on Additional Precautions), and cleaning of blood or chemical spills (12. Cleaning Spills of Blood and Body Substances).

The goal of cleaning is to provide a safe, functional and aesthetic environment for the client/patient/resident. The key objectives of cleaning efforts are to keep surfaces visibly clean and uncluttered,[256] to prevent infection transmission by removing or inactivating microorganisms from surfaces and items within the care environment, and to clean up spills promptly.

Cleaning procedures must be applied regularly, consistently and correctly to prevent the accumulation of soil, dust and debris that can harbour and support the growth of microorganisms and to avoid transmitting microorganisms from one item or surface to another.[15,156,245,455,496] Effective cleaning strategies must, therefore, incorporate the principles of infection prevention and control into the development and determination of cleaning methodology and cleaning frequency.

10.1 General Cleaning Practices

As described in 3.1.2.1 Approach to Cleaning for Care and Noncare Areas Within the Health Care Setting, health care settings are comprised of noncare areas requiring a hotel clean and care areas where a health care clean is required. This section focuses on the appropriate approach to health care cleaning for client/patient/resident rooms and other care areas.

It is a fundamental principle that microorganisms can only be successfully removed and/or inactivated if dirt and debris are completely removed. To achieve the removal of dirt and debris, the application of friction (i.e., elbow grease) is critical. Surfaces must be cleaned of visible soil before being disinfected, as organic material may inactivate a disinfectant. General practices to be followed in all health care settings for all cleaning are listed in Appendix 1. More specific sample protocols for cleaning and disinfection for different environments or indications are provided in Section Four.

10.2 Cleaning Methods

10.2.1 PATIENT/RESIDENT ENVIRONMENT CLEANING

10.2.1.1 Daily Routine Cleaning of Patient/Resident Room or Bed Space

The health care clean of patient/resident rooms should follow a standard, methodical format that includes each of the following elements:

- assessment
  - Determine if the health status of the patient/resident may pose a challenge to safe cleaning (e.g., patient agitated or acutely deteriorating); notify the clinical team and defer cleaning if concerns are identified.
  - Determine if the patient/resident is/was on Additional Precautions and whether additional personal protective equipment and/or special cleaning/disinfection procedures are required.
  - Walk through the room to determine what needs to be replaced (e.g., toilet paper, paper towel, soap, alcohol-based hand rub, gloves, sharps container) and whether any special materials or equipment are required for cleaning—this may be done before or during the cleaning process.
- preparation
  - Gather all supplies and equipment required for room cleaning before starting.
- Routine Practices and Additional Precautions
  - Perform hand hygiene before entering the room or bed space (for multi-bed rooms).*
  - Put on additional personal protective equipment if required to avoid exposure to blood or body fluids or if indicated by Additional Precautions signage.
  - Remove gloves and other personal protective equipment and then perform hand hygiene upon room exit.*
- cleaning and disinfection
  - As much as is possible, work from clean to dirty (to avoid moving dirt and microorganisms from dirty areas to cleaner areas) and from high to low (to avoid having dirt or microorganisms drip down and re-contaminate areas already cleaned).
- waste disposal
  - Collect and remove waste from the room.
- resupply room
  - Replace required clean supplies; avoid overstocking.

* Hand hygiene is required every time the room or bed space is re-entered and every time upon leaving the room or bed space. If gloves or other personal protective equipment are worn, they must also be removed every time you leave the room or bed space, and new personal protective equipment must be put on when re-entering the room or bed space.

See Appendix 4 for a sample procedure for routine daily cleaning of a patient/resident room and Appendix 5 for cleaning of the patient/resident bathroom. In-room bathrooms should be cleaned last, after completing room cleaning, based on the principle of cleaning from clean to dirty.

10.2.1.2 Discharge/Transfer Patient/Resident Room Cleaning

When a patient/resident is discharged, transferred or dies, the room or bed space must be cleaned and disinfected thoroughly before the next patient/resident occupies the space to prevent the transfer of microorganisms to the new client/patient/resident. Cleaning and disinfection upon discharge includes several steps not required during routine daily cleaning (see 10.2.1.1 Daily Routine Cleaning of Patient/Resident Room or Bed Space) and requires the close cooperation of clinical staff and cleaners.

In general, clinical staff are responsible for:

- Removing or discarding medical supplies.
- Removing or discarding medical equipment, including oxygen therapy equipment.
- Emptying items containing blood or body fluids and removing items or equipment potentially contaminated with blood or body fluids (e.g., discarding IV bags and tubing and urinary catheter collection bag, emptying bedpans/commodes/urinals/washbasins, emptying suction bottles).
- Disposal of personal articles left by the patient/resident including toiletries (e.g., soap, creams, razors, toothbrushes, comb, books, magazines, toys). These items can transmit microorganisms to other clients/patients/residents and must be taken with the client/resident/patient on discharge/transfer or discarded.

Once these tasks are completed, cleaners can then conduct a discharge/transfer clean of the room, following the steps outlined in Appendix 6.

10.2.1.3 Scheduled Patient/Resident Room Cleaning

In addition to the daily and discharge/transfer cleanings of patient/resident rooms, there are other cleaning tasks that should be scheduled to occur on a regular basis within the patient/resident room, including:

- high dusting (see below) in room
- clean baseboard and corners
- removal and laundering privacy curtains
- clean window curtains/ coverings
- dust window blinds

All of these activities should be scheduled on a regular basis. In all cases, cleaning should be performed immediately if contamination or gross soil is identified and sufficiently frequently to maintain a clean, dirt and dust free environment. The appropriate frequency for changing privacy curtains (or other solutions that minimize the need for laundering privacy curtains) is discussed in 1.2.1.3 Cloth and Soft Furnishings in Health Care Settings. For the other tasks listed, facilities should determine the minimum frequency required to maintain a clean, dirt and dust free environment. As a minimum, high dusting and baseboard cleaning should occur weekly; window blinds should be dusted monthly; and window curtains and coverings should be cleaned at least annually. These are minimum frequencies and more frequent cleaning may be required to maintain appropriate levels of cleanliness.

➢ Refer to Appendix 8 for more information.

High dusting involves dusting all horizontal surfaces and fixtures above shoulder height, including vents. When performing high dusting:

- Dust when the patient/resident is out of the room to minimize exposure to spores.
- Minimize dissemination of dust by using HEPA-filtered vacuums and/or damp mop/dusters.
- Proceed in an organized direction, to avoid missing any areas (e.g., clockwise).
- Note and report stained or misplaced ceiling tiles, fixtures or walls, so that they can be replaced or repaired.

10.2.2 BATHROOM CLEANING

Bathrooms within the patient/resident room should be cleaned last, after completing room cleaning, following the principle of cleaning from clean to dirty. Shower walls should be thoroughly scrubbed at least weekly. Shower curtains should be changed at least monthly and as required.

Bathrooms for patients in a private room should be cleaned daily, at the time of routine daily room cleaning. For shared bathrooms in semi-private or ward rooms, daily cleaning of the bathroom is a minimum and consideration should be given to twice daily cleaning, particularly for ward rooms housing more than two patients/residents. Additional, immediate cleaning is required when there are spills or gross contamination of room surfaces is identified.

➢ See Appendix 5 for a sample procedure for cleaning patient/resident bathrooms.

Emergency room/urgent care centre bathrooms are located in high traffic areas and are used frequently by ill patients who may contaminate the environment with microorganisms including enteric viruses such as norovirus, and *C. difficile*.[497-500] Emergency room bathrooms:

- Should be cleaned and disinfected every four hours. For bathrooms with infrequent usage, cleaning may take place less frequently.
- Must be disinfected with a sporicidal agent.[154,498,501]
- Must be frequently inspected, and re-cleaned whenever necessary (e.g., during high usage times, outbreaks, or when visibly soiled).
- Must be cleaned more frequently based on identified need.

Bathrooms may be located outside of care areas (e.g., public washroom). However, because bathrooms are at high risk of microbial contamination, they still require a health care clean.

Bathrooms require a health care clean regimen.

10.2.3 FLOOR CLEANING

Floors in health care settings may be comprised of a number of materials, depending on the location of the flooring and the client/patient/resident population in the vicinity. It is important to review the manufacturer's recommendations for cleaning a particular type of flooring before developing cleaning protocols.

➢ See 1.2.1 Selection of Surfaces, Finishes, Furnishings and Equipment for Areas Where Client/Patient/Resident Care is Delivered for information about floor finishes and carpeting in health care.

10.2.3.1 Floor Care

Floor cleaning consists of dry dust mopping to remove dust and debris, followed by wet mopping with a detergent to clean. Floors are low-touch surfaces that rarely come in contact with the hands of patients/residents or health care providers; under normal circumstances, the use of a disinfectant is not required.[152,502-505]

Dry mopping is done to collect dust and debris from the floor to prepare it for wet mopping. Dry mopping may be done with microfibre mops or pads to reduce dispersal of dust and debris. A fresh mop pad should be used for each room. Wet mopping can be done using a bucket and loop mop, or with a microfibre mop.

- For sample procedures for mopping, see;
  - Appendix 9: Sample Procedure for Mopping Floors Using Dry Dust Mop
  - Appendix 10: Sample Procedure for Mopping Floors Using Wet Loop Mop and Bucket
  - Appendix 11: Sample Procedure for Mopping Floors Using a Microfibre Mop

10.2.3.2 Carpet Care

Carpeting should not be used within the care areas of health care facilities. For facilities that have not yet removed all carpeting from care areas, there should be a plan for permanent removal of carpeting. In the meantime, a rigorous program of carpet care is required and that should include:

- daily vacuuming with a HEPA-filtered vacuum cleaner
- scheduled extraction/shampooing
- rapid response for dealing with spills of blood, body fluids or other liquid

- See 1.2.1.4 Carpeting for general information about carpeting in health care settings.

10.2.4 EQUIPMENT AND SPECIALIZED ITEM CLEANING

10.2.4.1 Noncritical Medical Equipment

Noncritical medical equipment in health care settings should be cleaned with a detergent or a low-level one-step cleaner/disinfectant, depending on the type of equipment. The manufacturer's recommended contact time for the product being used must be closely followed.[16,85,158,159]

- Refer to Appendix 8 for more information.

10.2.4.2 Electronic Equipment

Electronic equipment in the health care setting includes infusion pumps, ventilators, patient-controlled analgesia pumps, telemetry receivers and transmitters, infusion fluid warmers, infant sensors, monitoring equipment, and keyboards. Increasingly, electronic equipment used in health care settings also includes mobile phones, tablets, laptops and a variety of items that may be purchased by the facility or may be owned by staff. Inappropriate use of liquids on electronic medical equipment may result in fires and other damage, equipment malfunctions and health care provider burns. Equipment malfunctions could result in life-threatening events to patients such as over-infusion of medications and loss of life-supporting interventions.[506]

When selecting electronic equipment, it is important that it be compatible with the cleaning and disinfecting agents used in the health care setting and that manufacturer's recommendations for cleaning are followed (See 1.2.2.3 Electronic Equipment for details).

To avoid hazards:

- Obtain the manufacturer's labelling which may include instructions for cleaning and disinfection; information may be available on the manufacturer's website.
- Review labelling for any cautions, precautions, or warnings about wetting, immersing, or soaking the equipment.
- Review the manufacturer's cleaning and maintenance instructions and ensure all staff who will be cleaning the item are trained.
- Protect equipment from contamination whenever possible:
  - Position equipment to avoid contact with anticipated spatter.
  - Avoid laying contaminated items on unprotected equipment surfaces.
  - Use barriers on equipment surfaces that you expect to touch with contaminated hands or when contact with spatter cannot be avoided (e.g., keyboard skins).
- If equipment is contaminated with blood or other potentially infectious material, follow the equipment manufacturer's directions for cleaning to remove as much soil as possible; it may be necessary to remove the equipment from service for thorough cleaning and disinfection.

Electronic equipment that cannot be adequately cleaned, disinfected or covered should not enter the immediate care environment. Plastic coverings may be an effective means to protect keyboards and other devices from contamination, but must be cleaned and maintained appropriately (see 1.2.2.2 Plastic Coverings). In addition, no-touch disinfection systems may offer a means for disinfecting electronic devices but efficacy of this approach has not yet been widely validated.[507-510]

Electronic equipment should be cleaned on a regular basis, depending upon its use and the risk for patient-to-patient transmission of microorganisms, as follows:

- Electronic equipment that goes from client/resident/patient to client/resident/patient within the care environment must be cleaned and disinfected between patients (e.g., tablet used by ICU patients for communication).
- Electronic equipment used within the client/patient/resident's environment by staff (e.g., work station on wheels) should be cleaned and disinfected by the user before entry into the client/patient/resident's environment and after removal from the client/patient/resident's environment.
- Electronic equipment that is handled by staff in the care areas outside of the client/patient/resident environment (e.g., keyboard at the nursing station) should be cleaned and disinfected on a routine basis (e.g., daily, twice daily).
- Electronic equipment used within the client/patient/resident's environment that is difficult to clean and disinfect should be covered with a clean plastic covering before entry into the client/patient/resident's environment and the cover should be cleaned and disinfected, or discarded, upon removal from the client/patient/resident's environment.

If you cannot clean or cover an electronic item, do not bring it into the care environment.

These recommendations apply not only to products purchased by the health care facility (e.g., ICU monitors, workstations on wheels), but to electronic equipment owned by health care providers (e.g., mobile phones, laptop computers) if these devices will be handled by clients/patients/residents or used by the health care provider when in the immediate care environment.

10.2.4.3 Ice Machines

Bacteria have been isolated from ice, ice-storage chests and ice-making machines.[366,511-515] Microorganisms in ice can contaminate clinical specimens and medical solutions that require ice for transport or holding.[366] Ice may become contaminated if the water source for the ice is contaminated and from contaminated hands touching the ice.[511,512]

To minimize contamination, ice machines that dispense ice directly into a container are recommended.[366] Ice machines requiring scoops are not recommended and should be replaced.

If older machines have not yet been replaced:

- Provide a scoop for dispensing the ice.[366]
- Do not store the ice scoop loose in the ice machine.
- Provide a holder for the ice scoop.
- Ice scoop should be cleaned and disinfected at least once a day and more often if necessary.

Ice machines and ice chests should be cleaned at least quarterly, including cleaning, de-scaling and disinfection. Clean ice machines following the manufacturer's instructions.

➢ See Appendix 12 for more information.

10.2.4.4 Playrooms/Toys

Toys can be a reservoir for microorganisms that can be present in saliva, respiratory secretions, faeces or other body substances.[516-520] Outbreaks associated with toys have been described.[44,521,522] Transmission of influenza and other respiratory pathogens may occur in pediatric waiting rooms and contamination of toys with insufficient cleaning and disinfection may contribute to this problem.[523]

Playrooms or play areas that are used by more than one child should have an area for segregation of used toys (e.g., a bin into which children/parents/staff can place used toys). Clean toys should be stored in a manner that prevents contamination (e.g., dust and water splatter) and should be clearly marked as clean. Toy storage boxes/cupboards should be emptied and cleaned weekly or when visibly soiled.[524]

Toys must:[524]

- be smooth, nonporous and able to withstand rigorous mechanical cleaning
- not retain water (e.g., bath toys)
- have parts that can be cleaned
- not be cleaned with phenolics

All toys should be cleaned and disinfected between users. Rinsing after disinfection may be required for some disinfectants. If a toy cannot be cleaned (e.g., plush toys), it should be dedicated to an individual patient and be sent home or discarded when the patient is discharged. Toys, books, magazines and puzzles should be dedicated to children on Additional Precautions and discarded afterwards or sent home with the child if the article cannot be cleaned. Responsibility for cleaning toys should be assigned and written procedures regarding frequency and methods of cleaning are required. Toys should be removed from general waiting rooms if an adequate process cannot be established to ensure their daily inspection, cleaning and disinfection. Staff assigned to clean toys must be trained in effective cleaning procedures.

The procedure for cleaning toys must include:[524]

- Inspection for damage, cracked or broken parts.
- Cleaning according to the manufacturer's instructions or local practices (e.g., in hot, soapy water).
- Options for disinfection:
  - A commercial dishwasher/cart washer cycle (must reach 82°C).
  - Approved, hospital disinfectant, following the manufacturer's recommendations regarding dilution and contact times.
  - 70% alcohol solution for 10 minutes.
  - 500 ppm sodium hypochlorite (1:100 dilution of 5.25% sodium hypochlorite)
- Thorough rinsing following disinfection.
- Air-drying prior to storage.

During outbreaks it may be prudent to remove, and not replace, the toys until the outbreak is over.

➢ See Appendix 13 for more information.

10.2.4.5 Adult Activity Rooms

When activity rooms are used by adults:

- Encourage hand hygiene before and after activity.
- Clean items on a scheduled basis.
- Regularly assess items that cannot be easily cleaned and discard if soiled.

10.2.4.6 Cloth Furnishings

Cloth furnishings are discouraged in patient care areas. Refer to the manufacturer's recommendations for cleaning upholstered furnishings. There should be a plan in place to replace cloth furnishings with cleanable furnishings. Replace cloth furnishings that are torn or damaged. If cloth furnishings are present, these should be vacuumed regularly and steam cleaned as necessary when stained or visibly soiled.[3]

10.2.4.7 Hydrotherapy Equipment

Whirlpools, spas, bathtubs and physiotherapy pools have been associated with the acquisition of infection.[525-531] Skin and wound infections may result from direct contact of intact skin or wounds to contaminated water. Inhalation of microorganisms in aerosolized water has resulted in respiratory infections (e.g., whirlpools).[92]

Cleaning of hydrotherapy equipment must at a minimum follow the manufacturer's instructions with regard to frequency, and must use a hospital disinfectant. Cleaning and disinfection should be scheduled and the schedule strictly adhered to regardless of whether tub liners are used.[92] When replacing or purchasing hydrotherapy equipment, health care facilities should consider designs with improved cleanability and that are meant for use in the health care setting.[532]

10.2.4.8 Transport Equipment

Equipment used to transport patients with limited mobility (e.g., stretchers, wheelchairs, walkers) that is used for more than one client/patient/resident should be disinfected with a hospital disinfectant immediately after use, before use for another client/patient/resident, and when visibly soiled,[533-540] paying particular attention to high-touch areas (e.g., rails, push handles, chair arms).[541] Transport equipment such as wheelchairs that may have padded areas should be carefully inspected for damage prior to cleaning. Damaged parts that cannot be adequately cleaned should be removed and replaced.

In addition, all transport equipment should be cleaned according to a written schedule. Responsibility for cleaning transport equipment must be clearly designated (e.g., transport staff, environmental service workers). Transport equipment that is clean should be stored in an appropriate clean area and/or covered to prevent recontamination between uses.

Equipment used to transport a single resident within a facility (e.g., personal walkers, wheelchairs) must be immediately cleaned when soiled or visibly contaminated with blood or body fluids, as well as routinely following a written schedule.

Ambulances (vehicles that transport patients on stretchers) should be cleaned, disinfected and restocked after each patient transport; a thorough cleaning should also be completed when required for heavy contamination and on a regular, scheduled basis.[542]

➢ See Appendix 14 for more information.

10.2.4.9 Hand Washing Sinks

If used improperly or not regularly cleaned and disinfected, hand hygiene sinks can become contaminated. Contaminated hand hygiene sinks, and other sinks within the health care environment, have been associated with outbreaks, including outbreaks of antibiotic resistant organisms. Outbreaks occurred due to poor sink design,[368,543-548] use of a hand hygiene sink for purposes other than hand hygiene,[366-369,549] or suboptimal sink cleaning practices.[368]

If sinks drains become contaminated, decontamination of the sink can be difficult, likely due to the presence of biofilm.[368,369,550-554] Some facilities have reported success in terminating their outbreaks by disinfecting the sinks with acetic acid,[546] chlorine-based disinfectants,[545,554,555] heat,[556] or some self-decontaminating drain systems.[557-559] In many cases, facilities have reported that their outbreaks were not controlled until the implicated sinks (and parts) were replaced.[369,543,544,550,552,553,559-562]

Given these concerns it is important that hand hygiene sinks, and other sinks located within the health care environment, are cleaned and disinfected regularly. When cleaning sinks, it is important to clean from the least contaminated to the most contaminated area with taps cleaned prior to the rest of the

sink.[563] The water outlet should not be touched during cleaning.[365] After cleaning a sink, the cloths used should not be used to clean another sink.[563] Consideration may also be given to using three different cloths to clean the tap, the sink and the area around the tap and sink.[365]

It is also critically important that hand hygiene sinks not be used for disposing body fluids and other waste (e.g., IV solutions).[80,366,369,544,545,551,552,556,561,563] Prolonged contamination of sink drains with microorganism can result from this practice.

10.2.5 SURGICAL/STERILE SETTINGS

10.2.5.1 Operating Rooms

Environmental cleaning in surgical settings minimizes patients' and health care providers' exposure to microorganisms. The Operating Room Nurses Association of Canada (ORNAC) has published standards for environmental cleaning in surgical settings that include:[564]

- The ultimate responsibility for ensuring a clean surgical environment rests with the perioperative Registered Nurse.
- Environmental cleaning must be performed by trained staff according to the protocol of the health care setting.
- A regular cleaning schedule must be established, posted and documented.

Responsibility for cleaning anesthetic machines and carts should be clearly defined. The sample protocols for routine cleaning in Appendix 15 and Appendix 16 are based on ORNAC standards. Additional cleaning should be performed on a scheduled basis.

➢ See *The ORNAC Standards, Guidelines, and Position Statements for Perioperative Registered Nurses*, 13th edition for more information on environmental cleaning/sanitation in operating room suites.[564]

10.2.5.2 Medical Device Reprocessing Departments

Sterile processing areas in medical device reprocessing departments and other areas that store sterile supplies require a health care clean and a schedule that ensures that counters, shelves and floors are cleaned at least daily. Appendix 17 is based on the CSA Group's standard *Z314.0-13 Medical Device Reprocessing—General Requirements*.[322]

10.2.6 LABORATORIES

Clinical laboratories in Ontario should follow the Public Health Agency of Canada's *Canadian Biosafety Standard (CBS)* (2015) recommendations regarding environmental cleanliness in the laboratory.

➢ See Appendix 18 for more information.

10.2.7 HEMODIALYSIS CENTRES

The patient's hemodialysis station is comprised of individual care areas like bed spaces, the bed or dialysis chair, table and dialysis machine with its components. Any item taken into a hemodialysis station could become contaminated with blood and other body fluids and serve as a vehicle of transmission to other patients either directly or by contamination via the hands of staff.[565,566] Outbreaks and transmission of bloodborne pathogens including hepatitis C and hepatitis B secondary to re-use of items and medical equipment that moved from one dialysis station to another has been documented.[565,567-572] Each hemodialysis station should be treated as an individual entity and hand hygiene must be performed on entry to the station and at exit from the station, before doing other tasks in the unit.

> **Each hemodialysis station should be treated as an individual entity and hand hygiene must be performed on entry to the station and at exit from the station, before doing other tasks in the unit.**

Disposable items taken to a patient's hemodialysis station, including those placed on top of dialysis machines, should disposed of;[573] and reusable items should be cleaned and disinfected before being returned to a common clean area or used for other patients.[565,573] Items that cannot be adequately cleaned and disinfected should not be taken into a hemodialysis station. Unused medications or supplies taken to the patient's station should not be returned to a common clean area or used on other patients.[573]

The external surfaces of the hemodialysis machine and its components are the most likely sources for contamination with bloodborne viruses and pathogenic bacteria. This includes not only frequently touched surfaces such as the control panel, but also attached waste containers, blood tubing and items placed on top of machines (e.g., patient chart).[574] Contamination can occur even where blood or soiling is not visible.[575] To thoroughly clean and disinfect environmental surfaces at a hemodialysis station and to reduce the risk of cross-contamination, cleaning should take place when the station is not occupied by a patient and dialysis centres should allow sufficient time between patient shifts to allow thorough cleaning. Facilities may also consider regularly setting aside a period of time for a more thorough cleaning and disinfection environmental surfaces when there are no patients in the unit (e.g., weekly if the dialysis unit is closed 1 day per week).[573] This approach does not replace the need for sufficient time between all dialysis shifts for thorough cleaning between patients.

> **Items that cannot be adequately cleaned and disinfected should not be taken into a hemodialysis station.**

Blood contaminated waste generated by the hemodialysis facility should be handled as biomedical waste (see 7. Laundry and Waste Management). All disposable items should be placed in bags thick enough to prevent leakage.

- See Appendix 19 for more information.

10.2.8 NURSERIES AND NEONATAL INTENSIVE CARE UNITS

Routine daily cleaning in nurseries and neonatal intensive care units should be performed following the same procedures as for adult patient rooms. The isolette/incubator/bassinet and equipment in the

immediate vicinity associated with the infant are considered to be the patient's environment. Products used for cleaning and disinfecting in nurseries and neonatal intensive care units must not be toxic to infants (e.g., phenolics must not be used[3]).

Milk preparation areas may become contaminated and must be cleaned by environmental services daily and cleaned by milk preparation staff between mothers. Refrigerators and freezers should have a regular cleaning schedule and not be used for preparing or storing other items such as food, specimens or medications.

- See Appendix 20 for more information.

10.3 Cleaning Frequencies and Levels of Cleaning and Disinfection

The frequency of cleaning and the level of cleaning are dependent upon the risk classification of the area to be cleaned. See 3.2 Frequency of Routine Cleaning for information about risk stratification.

- Refer to Appendix 21 for recommendations regarding cleaning frequency.

Recommendations:

80. **At a minimum, emergency room/urgent care patients' and public bathrooms:**
    a. **Should be cleaned every four hours. [B III]** [modified 2018]
    b. **Must be disinfected with a sporicidal agent. [A II]** [modified 2018]
    c. **Must be cleaned more frequently based on need. [A III]** [modified 2018]

81. **Electronic equipment used in care areas must be cleaned and disinfected with the same frequency as non-electronic equipment. [A III]** [new 2018]

82. **Areas that have toys must have policies and procedures for cleaning the toys. [A II]** [reviewed and not changed 2018]

83. **All equipment must be cleaned and disinfected between patients/residents, including transport equipment. [A II]** [reviewed and not changed 2018]

84. **Health care settings must have policies and procedures for cleaning specialized areas, such as hemodialysis units, operating room suites and laboratories. [A III]** [reviewed and not changed 2018]

11. Cleaning and Disinfection When Patients/Residents Are on Additional Precautions

For patients/residents cared for in Additional Precautions, environmental service workers must be aware of the correct protocols for personal protective equipment use to minimize their risk of acquiring and/or transmitting infection:

- For rooms or bed spaces on Contact Precautions: put on a gown and gloves immediately before entry;[7,218] remove gown and gloves at the time of exit.[7,218]
- For rooms or bed spaces on Droplet Precautions: put on facial protection (i.e., mask and eye protection) when working within two metres of the client/patient/resident (or upon room entry).[7,218] Droplet Precautions are often combined with Contact Precautions, in which case gowns and gloves are required in addition to facial protection and all required personal protective equipment should be donned upon room entry.[7] Remove facial protection after gloves and gowns have been removed and hand hygiene has been performed at the time of exit. Ensure that hands are clean before contact with face.
- For rooms on Airborne Precautions: put on a fit-tested and seal-checked N95 respirator* if indicated and follow any other Additional Precautions (e.g., Contact/Droplet) indicated. The door must be kept closed to maintain negative pressure even if the client/patient/resident is not in the room.[7,576] Remove respirator (and other personal protective equipment) after exiting the room.
  * Only immune staff may enter a room where Airborne Precautions are in place for measles or varicella (chickenpox); an N95 respirator is not required.

For most indications for Additional Precautions, routine cleaning practices as described in 10. Health Care Cleaning and Disinfection Practices and routine discharge cleaning practices as described in 10.2.1.2 Discharge/Transfer Patient/Resident Room Cleaning are adequate for the cleaning of rooms, and no special handling or precautions are required for linen. (See also Appendix 4 and Appendix 6.) However, additional cleaning practices are required for rooms or bed spaces that house patients/residents with VRE,[16,293,577,578] *C. difficile*,[15-17,75,158,159,256,257,579] norovirus,[16,282,580-582] and carbapenemase-producing *Enterobacteriaceae* (CPE). (See 11.1 Cleaning Rooms/Cubicles/Bed Space on Contact Precautions.) At facilities that do not routinely change privacy curtains for all discharges and transfers, privacy curtains must be changed when cleaning rooms of all patients that were on Additional Precautions.[103,105,108,109,534]

Before entering a room in Additional Precautions, the required cleaning equipment and supplies should be gathered before putting on personal protective equipment. Do not bring cleaning carts into the room. After performing hand hygiene and putting on the required personal protective equipment, the room can be entered. Personal protective equipment should be removed, discarded in the designated receptacles, and hand hygiene repeated, at the time of room exit. Personal protective equipment should never be worn outside the client/patient/resident room or bed space.[7] All cleaning tools and equipment (e.g., cloths, mop heads/pads) used to clean a room or bed space on Contact Precautions or Droplet Precautions must be cleaned and disinfected after use before being used in another room or bed space to avoid cross-contamination.

Because supplies stored within the room under Additional Precautions may need to be discarded when the patient/resident is discharged or transferred, these rooms should be stocked with the minimum required supplies. There should not be more than one day's supplies available within the room.

When cleaning rooms on Additional Precautions, it is also important to have protocols, and to clean the portable isolation carts and/or built-in holders used to store the personal protective equipment.

Cleaning of Additional Precautions rooms requires extra time[583] due to the requirements for personal protective equipment and/or additional cleaning procedures that are required in some instances. Sufficient time must be allocated for cleaning and disinfection of the rooms for patients/residents on Additional Precautions, particularly for patients with *C. difficile.*[85,159,583]

> **Additional time must be allowed for cleaning rooms of patients/residents on Additional Precautions.**

For additional information on the control of antibiotic-resistant organisms and *C. difficile* infection please see:

- PIDAC's *Annex A: Screening, Testing and Surveillance for Antibiotic-Resistant Organisms (AROs) in All Health Care Settings* for methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE).[534]

- PIDAC's *Annex C: Testing, Surveillance and Management of Clostridium difficile in All Health Care Settings* for *C. difficile*.[533]

11.1 Cleaning Rooms/Cubicles/Bed Space on Contact Precautions

There must be a process to ensure that there has been adequate cleaning and disinfection of rooms or bed space and shared equipment following client/patient/resident discharge or transfer.[258,534,584-586] This may be accomplished through the use of a task checklist to ensure that all areas and surfaces are cleaned and disinfected, and that post-cleaning inspection of the room or bed space has taken place (see Appendix 4, Appendix 6, and Appendix 22 for sample cleaning protocols and checklists.)

For rooms or bed space housing patients with vomiting or diarrhea, vomit and faeces must be cleaned promptly, including items in the immediate vicinity, followed by disinfection with a virucide against norovirus, or sporicidal disinfectant for *C. difficile*.[587]

11.1.1 VANCOMYCIN-RESISTANT ENTEROCOCCI

VRE can persist for prolonged periods of time in the health care environment and routine cleaning and disinfection often fails to remove VRE from surfaces[265,534,588,589]. In addition to careful, meticulous room cleaning and disinfection as described for patients on Contact Precautions above, facilities may consider increasing the frequency of cleaning VRE room (e.g., twice a day) during VRE outbreaks or at facilities with ongoing, uncontrolled VRE transmission.[66,265,577,578]

11.1.2 METHICILLIN-RESISTANT STAPHYLOCOCCUS AUREUS

MRSA is not as persistent on dry surfaces as VRE or *C. difficile*.[590] No special approach is required to clean and disinfect rooms that housed patients colonized or infected with MRSA beyond what is recommended for the rooms of all patients in contact precautions.

11.1.3 CLOSTRIDIUM DIFFICILE

Specialized cleaning and disinfection practices are required for *C. difficile*. *C. difficile* is a spore-forming bacterium. The vegetative (nonspore) form of the bacteria is readily killed with hospital disinfectants, but the spores are resistant to many disinfectants, and can persist in the environment for months.[60,591] The spores can be spread by contact and transform back to an infectious vegetative form once ingested.[189,190,592] Control of environmental *C. difficile* requires both thorough cleaning (to remove spores) and the use of a sporicidal disinfectant (to inactivate spores).[593,594]

The following chemical agents have shown activity against *C. difficile* spores when used at the concentration and for the contact time recommended by the manufacturer:

- sodium hypochlorite (1000-5000 parts per million)[73,75,595,596]
- improved hydrogen peroxide (4.5%)[597]
- peracetic acid (0.26%)[598]

➢ See also, Public Health Ontario's online chlorine dilution calculator for dilution of household bleach to achieve desired chlorine level.

For adequate control of *C. difficile*, a sporicidal agent should be used:

- For twice daily cleaning of bathrooms of patients/residents with *C. difficile* infection.
- For disinfection after the room has been cleaned for each *C. difficile* infection patient discharged or transferred to another room. This includes the situation when a patient/resident is first identified as having *C. difficile* infection and is transferred to an isolation room. In this case the initial room must be cleaned using this protocol.
- Prior to discontinuing Contact Precautions for patients/residents with resolved *C. difficile* infection.[73]

Environmental contamination with *C. difficile* is most concentrated in patients'/residents' rooms,[599-601] making these areas the focus of stringent cleaning methods. Specific recommendations include:[602]

- Twice daily cleaning and disinfection of patient/resident room using a hospital disinfectant or sporicidal agent.[73,593,603-605]
- Twice daily cleaning and disinfection of patient/resident bathroom using a sporicidal agent.

If there are multiple cases of *C. difficile* infections on a unit/ward or attributable to a unit/ward:

- When each patient/resident is discharged or transferred, consider disinfecting their bed/bed space with a sporicide, regardless of the patient/resident's *C. difficile* infection status.[72,579]
- Disinfect all high-touch surfaces on the unit with a sporicide.[75,158,257]
- Disinfect all equipment on the unit with a sporicide.

➢ See Appendix 4 and Appendix 6 for more information.

11.1.4 NOROVIRUS

Noroviruses are non-enveloped viruses that cause acute gastroenteritis in humans and are highly contagious.[606-608] Environmental contamination plays a significant role in disease transmission. Norovirus can persist on surfaces for at least 12 days[609,610] and is resistant to some disinfectants.[611,612] Disinfectants used for patients with norovirus, or during norovirus outbreaks, should have an appropriate virucidal claim. Most quaternary ammonium compounds do not have significant activity against norovirus.[587] In some jurisdictions, sodium hypochlorite at 1000 to 5000 ppm is recommended, although other broad-spectrum virucides also have activity against norovirus.[581,608,613-615] Norovirus is inactivated by heat at 70°C.[616] Vacuum cleaning carpets and buffing floors during an outbreak have the potential to re-circulate norovirus and are not recommended.[609,613] Carpet and soft furnishings (if present) should be removed and not replaced. If this is not feasible, they should be steam cleaned following regular cleaning, provided they are heat tolerant and at least 60°C is achieved by the unit.[587] (See also 1.2.1.3 Cloth and Soft Furnishings in Health Care Settings and 1.2.1.4 Carpeting.) Health care settings may also consider increasing the frequency of cleaning and disinfecting the bathrooms and toilets on affected units. [587]

11.1.5 CARBAPENEMASE-PRODUCING ENTEROBACTERIACEAE

CPE are primarily transmitted by direct and indirect contact in health care settings.[534] Despite the fact that the health care environment can often be contaminated by these bacteria from colonized or infected patients/residents, careful application of routine cleaning practices should be sufficient to remove this pathogen.[130,275,617]

Although CPE can be effectively removed from most surfaces and equipment in CPE rooms using routine environmental cleaning practices, sinks and shower drains may act as a reservoir for CPE and persistent colonization of sinks can result in CPE transmission to subsequent room occupants. Sinks (including the drain pipes) have been documented as source of several CPE and ESBL outbreaks.[367-369,555,561,562] As these bacteria form biofilms in moist environments such as the sink drainage system, their eradication has been challenging[368,585] and may require replacement of the implicated sinks[367] and/or the horizontal drainage system. [562] See also 10.2.4.9 Hand Washing Sinks.

Facilities may want to consider enhanced sink and shower cleaning on a regular basis, (e.g., twice weekly), and at the time of discharge/transfer cleaning for CPE rooms (see Appendix 7) and may consider testing sink drains for CPE at the time of patient discharge/transfer. If sinks remain colonized despite repeated attempts at cleaning, replacement of sinks and/or the related horizontal drainage system may be required. [367,562]

11.2 Cleaning Rooms on Airborne Precautions

The discharge/transfer cleaning practices specified in Appendix 6 may be used for rooms on Airborne Precautions. The following additional measures must be taken:

- After patient/resident transfer or discharge, the door must be kept closed and the Airborne Precautions sign must remain on the door until sufficient time has elapsed to allow removal of airborne microorganisms (dependent on air changes per hour). For more information, see PIDAC's *Routine Practices and Additional Precautions for All Health Care Settings*.[7]

- It is preferable to wait for sufficient air changes to clear the air before cleaning the room.
- If the room is urgently needed before the air has been sufficiently cleared of tubercle bacilli, an N95 respirator must be worn during cleaning.
- Remove N95 respirator only after leaving room and door has been closed.

Recommendation:

85. Health care facilities must have policies and procedures for the routine and discharge/transfer cleaning of rooms on Contact and Contact/Droplet Precautions, with specification of required cleaning and disinfection procedures for *C. difficile,* norovirus, VRE and CPE. [A III] [modified 2018]

12. Cleaning Spills of Blood and Body Substances

Spills of blood and other body substances, such as urine, faeces and emesis, must be contained, cleaned and the area disinfected immediately. A mycobactericidal disinfectant or a hypochlorite solution (diluted to 500-5000 ppm, equivalent to a 1:10-1:100 dilution of 5.25% sodium hypochlorite) should be used for blood spills.[3,154]

- See also, Public Health Ontario's online chlorine dilution calculator for dilution of household bleach to achieve desired chlorine level.

The health care setting shall have written policies and procedures for dealing with blood and body fluid spills that include:[296]

- Clearly defined assignment of responsibility for cleaning the spill in each area of the health care setting during all hours when a spill might occur.
- Provision for timely response.
- A method for the containment and isolation of the spill.
- Training of staff who will clean the spill.
- Access to personal protective equipment, equipment, supplies, waste and linen disposal for staff who will clean the spill.
- Proper disposal of waste.
- Procedure to be followed if there is a staff exposure to blood or body fluid material.
- Documentation of the spill incident.

12.1 Procedure for Cleaning a Spill of Blood

The protocol described in Appendix 23 could be used when cleaning and disinfecting a spill of blood or other body substance.[3,363] The protocol described in Appendix 24 should be used when cleaning and disinfecting a spill of blood or other body substance on carpet.[141]

Recommendation:

86. Health care settings shall have written policies and procedures dealing with spills of blood and other body fluids. [A III] [reviewed and not changed 2018]

Section Three:

Summary of Recommendations for Best Practices for Environmental Cleaning for Infection Prevention and Control in All Health Care Settings

The following summary tables are intended to assist with self-assessment internal to the health care setting for quality improvement purposes. See complete text for rationale. See Table 1: Assessment of the Quality of Evidence Supporting a Recommendation and Table 2: Determination of the Strength of a Recommendation for the ranking systems for the recommendations.

Table 9: Summary of Recommendations

Recommendation and Relevant Section(s) in Text	Compliant	Partial Compliance	Noncompliant	Action Plan	Accountability
Principles of Cleaning and Disinfecting Environmental Surfaces in a Health Care Environment: Health Care Design and Product Selection. (See subsection 1.2 Health Care Design and Product Selection)					
1. Health care settings shall only purchase, install, or use surfaces, finishes, furnishings and equipment that can be effectively cleaned and disinfected. [A III]					
2. Health care settings should have policies that specify the criteria to be used when choosing surfaces, finishes, furnishings, and equipment for the health care setting. [A III]					
3. Environmental services, infection prevention and control, and occupational health and safety must be involved in the selection of surfaces, finishes, furnishings and equipment in health care settings. [A III]					
4. Surfaces, finishes, furnishings, and equipment in health care setting shall be cleanable with hospital cleaners, detergents and disinfectants (except in those long-term care homes where the furniture is supplied by the resident; [A III]and must be smooth, nonporous, and seamless. [A III]					
5. Surfaces that support or promote microbial growth must not be used in the health care setting. [A III]					
6. Cracked or torn furnishings must be removed from care areas until either repaired so that they can be effectively cleaned, or replaced. [A III]					
7. Cloth furnishings and upholstered furniture shall not be used in care areas housing immunocompromised patients and must not be used in other care areas. [A III]					
8. Privacy curtains must be removed, and replaced or cleaned and disinfected immediately if they become contaminated with blood or body fluids, or are visibly					

Recommendation and Relevant Section(s) in Text	Compliant	Partial Compliance	Noncompliant	Action Plan	Accountability
soiled. [A III]					
9. Privacy curtains used for patients/residents requiring Additional Precautions must be removed, and replaced or cleaned and disinfected following discharge or transfer of the patient/resident and before a new patient/resident is admitted to that room or bed space. [A III]					
10. Privacy curtains should be changed after all discharges. [A III]					
11. Carpeting shall not be used in areas that house or serve immunocompromised patients and must not be used where there is a high likelihood of contamination with blood or body fluids. [A III]					
12. Carpeting must not be used in any care area within health care facilities. [A III]					
13. Noncritical medical equipment used in the health care setting, including purchased, borrowed or donated equipment and equipment used for research purposes, shall be able to be cleaned and disinfected with a hospital disinfectant. [A III]					
14. Facilities must have item-specific instructions from manufacturers for cleaning and disinfecting all noncritical medical equipment, including purchased, borrowed or donated equipment and equipment used for research purposes. [A III]					
15. Reusable equipment used for cleaning must itself be cleaned and disinfected with a hospital disinfectant. [A III]					
16. Plastic coverings used to cover equipment must be: a. Cleaned and disinfected (or discarded) between client/patient/resident (for patient care equipment) or on a regular basis (for nonpatient care equipment within the care environment.) [A III] b. Replaced if damaged. [A III]					
17. Electronic equipment that cannot be cleaned and disinfected must not be purchased, installed or used in health care settings. [A III]					
Principles of Cleaning and Disinfecting Environmental Surfaces in a Health Care Environment: Cleaning Agents and					

Recommendation and Relevant Section(s) in Text	Compliant	Partial Compliance	Noncompliant	Action Plan	Accountability
Disinfectants. (See subsection 1.3 Cleaning Agents, Disinfectants, and Cleaning Equipment)					
18. Cleaning and disinfecting products: a. Must be approved by environmental services, infection prevention and control, and occupational health and safety. [A III] b. Disinfectants must have a DIN from Health Canada. [A III] c. Should be compatible with surfaces, finishes, furnishings, items and equipment to be cleaned and disinfected. [B III] d. Must be used according to the manufacturer's recommendations. [A III]					
19. Disinfectants chosen for use in health care: a. Must be active against the microorganisms encountered in the health care setting. [B III] b. Should require little or no mixing or diluting, i.e., be dispensed through an appropriate effective proportioner. [B III] c. Should be active at room temperature with a short contact time. [B III] d. Should have low irritancy and allergenic characteristics. [B III] e. Should be safe for the environment. [B III]					
20. Health care facilities should select a limited number of hospital disinfectants to minimize training requirements and the risk of error. [B III]					
21. Hospital disinfectants used on noncritical equipment and surfaces: a. Must only be applied after visible soil and other impediments to disinfection have been removed. [A III] b. Must follow the manufacturer's instructions for dilution and contact time. [A III]					
22. Cloths must not be repeatedly immersed into disinfectant (i.e., no "double-dipping" of cloths.) [A III]					
23. Where personal protective equipment is recommended for use to prevent exposure to a specific disinfectant, such personal protective equipment shall be worn.					

Recommendation and Relevant Section(s) in Text	Compliant	Partial Compliance	Noncompliant	Action Plan	Accountability
[Legislation]					
Principles of Infection Prevention and Control for Environmental Service Workers: Routine Practices. (See subsection 2.1 Routine Practices)					
24. Environmental service workers must follow best practices for hand hygiene. [A II]					
25. Gloves must be removed and hand hygiene performed on moving from one patient environment to another, or between the patient and the health care environment. [A III]					
26. Gloves must not be worn when walking from room to room, from bed space to bed space, or in other areas of the health care facility. [A III]					
Principles of Infection Prevention and Control for Environmental Service Workers: Additional Precautions. (See subsection 2.2 Additional Precautions)					
27. Environmental service workers must adhere to Routine Practices and Additional Precautions when cleaning. [A III]					
28. Personal protective equipment: a. Shall be sufficient and accessible for all environmental service workers. [Legislation] b. Shall be worn as required by Routine Practices, Additional Precautions, and by safety data sheets when handling chemicals. [Legislation] c. Must be removed immediately after the task for which it is worn. [A III]					
Cleaning Best Practices for Client/Patient/Resident Care Areas. (See chapter 3. Cleaning Best Practices for Client/Patient/Resident Care Areas)					
29. Environmental cleaning in the health care setting must be performed on a routine and consistent basis to provide for a safe and sanitary environment. [A III]					
Cleaning Best Practices for Client/Patient/Resident Care Areas: General Principles. (See subsection 3.1 General Principles)					
30. Sufficient resources must be devoted to environmental services to ensure effective cleaning at all times,					

Recommendation and Relevant Section(s) in Text	Compliant	Partial Compliance	Noncompliant	Action Plan	Accountability
including surge capacity for high-demand periods, e.g., outbreaks; high occupancy; or high turnover. [A III]					
31. Health care settings should design their environmental service organizational structure to ensure accountability at all levels and should have: a. A single individual with assigned responsibility for the cleaning of the physical facility. [B III] b. Supervisors with responsibility for ensuring adherence to occupational health and infection prevention and control policies and protocols, including the correct use of personal protective equipment, maintaining a safe work environment, and ensuring adherence to cleaning schedules and protocols. [B III]					
32. Audit and feedback results must be presented to the environmental service leadership of the health care facility and to the appropriate infection control and/or quality and safety committee (or equivalent). [A III]					
33. Health care facilities must have written procedures for cleaning and disinfection of care areas and equipment that include: • defined responsibility for specific items and areas • routine and discharge/transfer cleaning • cleaning in construction/renovation areas • cleaning and disinfecting areas under Additional Precautions • outbreak management, and • cleaning standards and frequency [A III]					
34. Health care facilities must review policies and procedures for environmental cleaning on a regular basis. [A III]					
35. Health care facilities must provide initial and continuing education for environmental service workers. [A III]					
36. If environmental services are contracted out, the occupational health and safety policies of the contracting services must be consistent with the facility's occupational health and safety policies. [A III]					
37. Environmental service staffing levels must reflect the physical nature and the acuity of the facility as well as					

Recommendation and Relevant Section(s) in Text	Compliant	Partial Compliance	Noncompliant	Action Plan	Accountability
other factors that will impact environmental service workload. [A III]					
38. Dedicated environmental service workers are preferred. [B III]					
39. If other task is assigned to environmental service workers, facilities need to recalculate staffing level, and environmental service tasks must be made a priority. [A III]					
40. Levels of supervisory staff must be appropriate to the number of staff involved in cleaning and sufficient to ensure that a. All staff are appropriately trained. [A III] b. A safe workplace is maintained at all times, and occupational health and infection prevention and control procedures are routinely followed, including the correct use of personal protective equipment. [A III]					
Cleaning Best Practices for Client/Patient/Resident Care Areas: Frequency of Routine Cleaning. (See subsection 3.2 Frequency of Routine Cleaning)					
41. Cleaning schedules must be developed based on an assessment of the risk of contaminated surfaces resulting in infection in patients/residents/clients and staff. [A II]					
Cleaning Best Practices for Client/Patient/Resident: Equipment. (See subsection 3.3 Equipment)					
42. Noncritical medical equipment requires cleaning and disinfection after each use. [A II]					
43. Each health care setting should have written policies and procedures for the appropriate cleaning of noncritical medical equipment that clearly defines the frequency and level of cleaning, and which assigns responsibility for the cleaning. [A III]					
Education (See chapter 4. Education)					
44. All aspects of environmental cleaning must be performed by knowledgeable, trained staff. [A III]					

Recommendation and Relevant Section(s) in Text	Compliant	Partial Compliance	Noncompliant	Action Plan	Accountability
45. Environmental services training programs: a. Must use a standardized curriculum [A III] b. Should have a mechanism for assessing proficiency [B III] c. Must document training and proficiency [A III]					
46. Infection prevention and control and occupational health education provided to environmental service workers must be developed in collaboration with infection prevention and control and occupational health and safety. [A III]					
47. The education provided to environmental service workers: a. Shall include: [Legislation] ▪ The correct and consistent use of Routine Practices. ▪ Hand hygiene and basic personal hygiene. ▪ Signage used to designate Additional Precautions in the health care setting. ▪ The appropriate use of personal protective equipment for infection prevention and for the safe handling of chemical agents. ▪ Prevention of blood and body fluid exposure, including sharps safety. And b. Should include ergonomic cleaning principles. [B III]					
48. Environmental service managers and supervisors must receive training. [A III]					
49. Environmental service supervisors should be certified. [B III]					
Occupational Health and Safety Issues Related to Environmental Services. (See chapter 5. Occupational Health and Safety Issues Related to Environmental Services)					
50. Environmental service workers must be offered appropriate immunizations. [A II]					
51. There shall be policies and procedures in place that include a sharps injury prevention program, post-exposure prophylaxis and follow-up, and a respiratory protection program for staff who may be required to enter an airborne infection isolation room accommodating a patient with tuberculosis. [Legislation]					

Recommendation and Relevant Section(s) in Text	Compliant	Partial Compliance	Noncompliant	Action Plan	Accountability
52. There must be appropriate attendance management policies in place that establish a clear expectation that staff members do not come into work when acutely ill with a probable infection or symptoms of an infection. [A III]					
53. There must be procedures for the evaluation of staff members who experience sensitivity or irritancy to chemicals. [A III]					
54. Aerosol or trigger sprays for cleaning chemicals must not be used. [A II]					
55. Selection of environmental cleaning equipment must follow ergonomic principles. [A II]					
Environmental Cleaning for Specialized Areas. (See chapter 6. Environmental Cleaning for Specialized Areas)					
56. Soiled utility rooms/workrooms: a. Shall be physically separate from other areas, including clean supply/storage areas. [A III] b. Should have a hands-free door where this does not pose a risk to clients/patients/residents. [B III] c. Shall contain a work counter and flushing-rim clinical sink. [A III] d. Shall not use sprayers attached to the hopper. [A III] e. Shall contain a dedicated hand washing sink with hot and cold running water. [Legislation] f. Must contain a utility sink if rinsing or gross cleaning of medical instruments or equipment is performed within the room. [A III] g. Shall have adequate space to permit the use of equipment required for the disposal of waste. [A III] h. Shall contain personal protective equipment for staff protection during cleaning and disinfection procedures. [A III] i. Shall be adequately sized within the unit and located near the point-of-care. [A III]					
57. Clean supply rooms/areas shall: a. Be separate from and have no direct connection with soiled areas. [A III]					

Recommendation and Relevant Section(s) in Text	Compliant	Partial Compliance	Noncompliant	Action Plan	Accountability
b. Protect supplies from dust and moisture, and ensure storage off the floor. [A III] c. Be adjacent to usage areas and easily available to staff. [A III]					
58. Housekeeping closets shall be provided in all major care areas with a minimum of one closet per 650 square metres. [A III]					
59. Housekeeping closets: a. Shall be dedicated for storage of cleaning supplies and the preparation and disposal of cleaning solution; and shall not be used for other purposes. [A III] b. Shall be maintained in accordance with good hygiene practices. [Legislation] c. Shall have a dedicated hand washing sink with hot and cold running water. [A III] d. Shall have access to an eyewash station. [Legislation] e. Shall have appropriate personal protective equipment available, including safety eyewear. [Legislation] f. Shall have a hot and cold water supply and a floor sink. [A III] g. Shall be well ventilated and illuminated. [A III] h. Shall be designed to be at negative pressure in relation to surrounding areas. [A III] i. Shall be easily accessible in relation to the area it serves. [A III] j. Shall be secure with access restricted to clinical and support staff. [A III] k. Shall be appropriately sized to the amount of materials, equipment, machinery and chemicals stored in the room/closet, and allow for proper ergonomic movement within the room/closet. [A III] l. Shall not contain personal belonging, food or beverages. [Legislation] m. Shall have chemical storage that ensures chemicals are not damaged and may be safely accessed. [Legislation] n. Shall be ergonomically designed so that, whenever possible, buckets can be emptied without lifting them. [A III]					

Recommendation and Relevant Section(s) in Text	Compliant	Partial Compliance	Noncompliant	Action Plan	Accountability
60. Cleaning agents and disinfectants shall be labelled with WHMIS information. [Legislation]					
61. Cleaning agents and disinfectants shall be stored in a safe manner in storage rooms or closets. [A III]					
62. Cleaning carts must have a clear separation between clean and soiled items. [A III]					
63. Cleaning carts must never contain personal belonging, food or beverages. [A III]					
64. Health care settings must have a plan in place to deal with the containment and transport of construction materials, as well as clearly defined roles and expectations of environmental services and construction staff related to cleaning of the construction site and areas adjacent to the site. [A III]					
65. All health care settings must have a plan in place to deal with floods and water leaks. [A III]					
Laundry and Waste Management: Management of Laundry and Bedding. (See subsection 7.1 Management of Laundry and Bedding)					
66. The laundry facility must follow published laundry regulations. [A III]					
67. There must be policies and procedures to ensure that clean laundry is transported and stored in a manner that will ensure that cleanliness is maintained. [A III]					
68. There shall be clear separation between clean and dirty laundry through all steps of the laundering process, including transportation and storage. [A III]					
69. There should be designated areas for storing clean linen. [B III]					
70. Health care facilities should use the same laundering practices for all patients, including those requiring Additional Precautions. [B III]					
Laundry and Waste Management: Management of Waste (General and Biomedical). (See subsection 7.3 Management					

Recommendation and Relevant Section(s) in Text	Compliant	Partial Compliance	Noncompliant	Action Plan	Accountability
of Waste (General and Biomedical))					
71. There shall be written policies and procedures for the collection, handling, storage, transport and disposal of biomedical waste, including sharps, based on provincial and municipal regulations and legislation. [A III]					
72. Waste handlers shall wear personal protective equipment appropriate to their risk. [Legislation]					
73. Waste that is transported within a health care setting: a. Should be transported following clearly defined transport routes. [B III] b. Shall not be transported through clean zones, public areas, or patient/resident care units. [A III] c. Should not be transported on the same elevator as clients/patients/residents or clean/sterile instruments/supplies/linen. [B III] d. Shall be transported in leak-proof and covered carts which are cleaned on a regular basis. [A III]					
74. There shall be a system in place for the prevention of sharps injuries and the management of sharps injuries when they occur. [Legislation]					
New and Evolving Technologies for Environmental Cleaning. (See chapter 8. New and Evolving Technologies for Environmental Cleaning)					
75. Infection prevention and control, environmental services, and occupational health and safety must be consulted before making any changes to cleaning and disinfection procedures and technologies in the health care setting. [A III]					
Assessment of Cleanliness and Quality Control. (See chapter 9. Assessment of Cleanliness and Quality Control)					
76. There must be a process in place to measure the quality of cleaning in the health care setting. [A III]					
77. Health care facilities should use at least one measure that directly assesses cleaning (i.e., environmental marking, ATP bioluminescence), in addition to observational assessments (e.g., performance					

Recommendation and Relevant Section(s) in Text	Compliant	Partial Compliance	Noncompliant	Action Plan	Accountability
observation, visual assessment). [B III]					
78. Results of cleaning audits should be used for the purposes of training and to provide positive and constructive feedback to frontline environmental service workers. [B III]					
79. Aggregate results must be presented to relevant stakeholders, e.g., environmental service leadership, infection prevention and control, and administration. [A III]					
Health Care Cleaning and Disinfection Practices. (See chapter 10. Health Care Cleaning and Disinfection Practices)					
80. At a minimum, emergency room/urgent care patients' and public bathrooms: a. Should be cleaned every four hours. [B III] b. Must be disinfected with a sporicidal agent. [A II] c. Must be cleaned more frequently based on need. [A III]					
81. Electronic equipment used in care areas must be cleaned and disinfected with the same frequency as non-electronic equipment. [A III]					
82. Areas that have toys must have policies and procedures for cleaning the toys. [A II]					
83. All equipment must be cleaned and disinfected between patients/residents, including transport equipment. [A II]					
84. Health care settings must have policies and procedures for cleaning specialized areas, such as hemodialysis units, operating room suites and laboratories. [A III]					
Cleaning and Disinfection When Patients/Residents Are on Additional Precautions. (See chapter Cleaning and Disinfection When Patients/Residents Are on Additional Precautions)					
85. Health care settings must have policies and procedures for the routine and discharge/transfer cleaning of rooms on Contact and Contact/Droplet Precautions, with specification of required cleaning and disinfection procedures for *C. difficile*, norovirus, VRE and CPE. [A III]					
Cleaning Spills of Blood and Body Substances. (See chapter 12. Cleaning Spills of Blood and Body Substances)					

Recommendation and Relevant Section(s) in Text	Compliant	Partial Compliance	Noncompliant	Action Plan	Accountability
86. Health care settings shall have written policies and procedures dealing with spills of blood and other body fluids. [A III]					

Section Four:

Implementation Resources

Appendix 1: Advantages and Disadvantages of Common Hospital Disinfectants and Sporicides for Environmental Cleaning

Alcohol (60%-80%)

The advantages of alcohols include its broad spectrum of activity (bactericidal, fungicidal, virucidal, and mycobactericidal),[198] and being nontoxic,[198] low cost, rapid action,[3,198] nonstaining,[3,198] leaving no residue,[3] noncorrosive,[3,198] and being effective on clean equipment or devices that can be immersed.

The disadvantages of alcohol include the following:

- evaporation may diminish concentration, not suitable for use on large surface[3,198]
- flammable—store in a cool, well-ventilated area; refer to Fire Code restrictions for storage of large volume of alcohol[198]
- coagulates protein; a poor cleaner
- may dissolve shellac lens mountings[92]
- hardens and swells plastic tubing[92]
- harmful to silicone; causes brittleness
- may harden rubber or cause deterioration of glues[3,198]
- inactivated by organic material[3,198]
- contraindicated in the operation room[3]
- slow acting against non-enveloped viruses[198,463]

Sodium hypochlorite (bleach)

The advantages of sodium hypochlorite include its broad-spectrum of activity (bactericidal, fungicidal, virucidal, mycobactericidal), sporicidal at higher concentrations (e.g., 5000 ppm for 10 minutes),[3,198,376,597] reduction of biofilm at high concentrations,[198] low cost, rapid action, readily available in nonhospital settings, nonflammable, and unaffected by water hardness.[198]

The disadvantages of sodium hypochlorite include the following:

- Corrosive to metals at high concentration (e.g., > 500 ppm).[3,198,376]
- Inactivated by organic materials;[3,198,376] blood must be removed prior to disinfection of blood spills.
- Irritate skin and mucous membranes.[3,198] Use in well-ventilated area required due to possible burns to oropharyngeal, oesophageal, and gastric tissues. [376]
- Storage in closed containers away from ultraviolet light and heat to prevent deterioration. Immediate use after dilution preferred.[3,198]
- Discolouration of clothing and carpets.[198,376]
- Salt residue left behind.[198]
- Release of toxic chlorine when mixed with acids or ammonia.[198,463,466,467]

Improved Hydrogen Peroxide 0.5% (7% solution diluted 1:16)

The advantages of this disinfecting agent include its broad spectrum of activity (fungicidal, virucidal and mycobactericidal),[154,198,376] and being nontoxic,[198,376] safe for the environment,[198] rapid action,[198,376] nonstaining and nonflammable,[198] active in the presence of organic materials, [376] noncorrosive,[376] and having excellent cleaning ability due to detergent properties. However, it is contraindicated for use on copper, brass, and other nonferrous metals.[463,618]

Improved Hydrogen Peroxide 4%-5%

The advantages of this disinfecting agent include being sporicidal,[376] nontoxic, safe for the environment, and available in a gel format to ensure vertical surface adhesion during required contact time. However, its disadvantages include the following:

- expensive[198,376]
- contraindicated for use on copper, brass, and other nonferrous metals, rubber, plastics
- do not use on monitors

Hydrogen Peroxide 3% (Non-antiseptic Formulations)

The advantages of this disinfecting agent include its being nontoxic and safe for the environment.[3] However, it requires a prolonged contact time and is contraindicated for use on copper, zinc, brass, aluminum.[3] In addition, it requires storage in a cool place protected from light. Hydrogen peroxide has also been reported to quench the results of ATP bioluminescence.[466]

Iodophors (Non-antiseptic Formulations)

Iodophors have a broad spectrum of microbicidal activity but are not fungicidal or sporicidal.[198] They are nonflammable[198] and rapid in action[3] and nontoxic. However, their disadvantages include:

- corrosive to metal unless combined with inhibitors[3]
- inactivated by organic materials[3]
- slow in action against fungi[198]
- degrading silicone catheters[154,198]
- may stain fabrics and synthetic materials[3,198]

Phenolics

Phenolics have a broad spectrum of activity but are not sporicidal.[198,376] They are nonstaining and nonflammable,[198] and they are commercially available with added detergents to provide one-step cleaning and disinfecting.[3] However, their disadvantages include the following:

- NOT for use in nurseries or equipment contacting infants (e.g., baby scales) due to an association with neonatal jaundice or hyperbilirubinemia[3,92,154]
- not recommended for use on food contact surfaces[3]
- leave a residual film on environmental surfaces[3]
- possible absorption through skin[3]
- absorption by porous materials[198,376]
- possible depigmentation of skin[198,376]
- irritating tissue[198,376]
- leaving some synthetic flooring sticky after repeated use[3]
- damaging rubber and react with some plastics and aluminum[619]

Quaternary Ammonium Compounds

Quaternary ammonium compounds are noncorrosive[3] compatible with various surface materials, and have persistent microbicidal effect on surfaces.[198] They have good cleaning ability and usually have detergent properties.[3,198] They may also be used on food contact surfaces. However, their disadvantages include the following:

- do not use to disinfect instruments[3]
- limited use as disinfectant because of narrow microbicidal spectrum (limited activity against non-enveloped viruses, not mycobactericidal or sporicidal)[3,198,376]
- diluted solutions may support the growth of microorganisms[161,620]
- activity reduced by various materials (e.g., cotton , water hardness, microfibre)[160,198,376]
- have been reported to cause or worsen respiratory and skin irritation and allergic reactions[318,324,376]

Adapted from Ontario Agency for Health Protection and Promotion (Public Health Ontario). Provincial Infectious Diseases Advisory Committee. Best practices for cleaning, disinfection and sterilization of medical equipment/devices. 3rd ed. Toronto, ON: Queen's Printer for Ontario; May 2013.

Appendix 2: Cleaning and Disinfection Decision Chart for Noncritical Equipment

The following table relates to noncritical patient care equipment only, i.e., equipment that comes into contact with intact skin. For semi-critical and critical equipment that require high-level disinfection or sterilization, see PIDAC's *Best Practices for Cleaning, Disinfection and Sterilization in All Health Care Settings*.[19]

Table 10: Decision Chart for Cleaning and Disinfection of Noncritical Equipment

Level of Cleaning and Disinfection	Classification of Equipment and Devices	Effective Products**
Cleaning Physical removal of soil, dust or foreign material. Chemical, thermal or mechanical aids may be used. Cleaning usually involves soap and water, detergents or enzymatic cleaners. Thorough cleaning is required before disinfection or sterilization may take place.	All reusable equipment and devices	Concentration and contact time are dependent on manufacturers' instructions ▪ Quaternary ammonium compounds ▪ Enzymatic cleaners ▪ Soap and water ▪ Detergents ▪ 0.5% improved hydrogen peroxide
Low-Level Disinfection Level of disinfection required when processing noncritical equipment/devices or some environmental surfaces. Low-level disinfectants kill most vegetative bacteria and some fungi as well as enveloped (lipid) viruses. Low-level disinfectants do not kill mycobacteria or bacterial spores.	Noncritical equipment and devices	Concentration and contact time are dependent on manufacturers' instructions ▪ 3% hydrogen peroxide ▪ 60% to 80% alcohol ▪ Sodium hypochlorite (bleach) at 1000 ppm ▪ 0.5% improved hydrogen peroxide ▪ Quaternary ammonium compounds ▪ Iodophors ▪ Phenolics (should not be used in nurseries or equipment that comes into contact with infants such as scales)

Appendix 3: General Cleaning Practices for All Health Care Settings

Before cleaning:

- Gather materials required for cleaning before entering the room.
- Follow the manufacturer's instructions for proper dilution and contact time for cleaning and disinfecting solutions.
- Check for Additional Precautions signs. Follow precautions as indicated.
- Clean hands and put on appropriate personal protective equipment on entering the room.
- Remove clutter before cleaning.

During cleaning:

- Progress from the least soiled areas to the most soiled areas.
- Progress from high surfaces to low surfaces.
- Remove gross soil prior to cleaning and disinfection.
- Dry mop prior to wet/ damp mop.
- Minimize turbulence to prevent the dispersion of dust that may contain microorganisms (e.g., never shake mops).
- Do not double-dip cloths.
- Change cloths/ mop heads frequently.
- Change cleaning solutions as per manufacturer's instructions. Change more frequently in heavily contaminated areas, when visibly soiled and immediately after cleaning blood and body fluid spills.
- Containers for liquid soap, cleaners/disinfectants are disposable. The practice of topping up is not acceptable since it can result in contamination of the container and solution.
- Be alert for needles and other sharp objects. Pick up sharps using a mechanical device and place into sharps container. Report incident to supervisor.
- Collect waste, handling plastic bags from the top (do not compress bags with hands).
- Clean hands on leaving the room.

After cleaning:

- Do not overstock rooms.
- Tools used for cleaning and disinfecting must be cleaned and dried between uses.
- Launder mop heads daily. All washed mop heads must be dried thoroughly before re-use.
- Clean housekeeping cart and carts used to transport waste daily.

Appendix 4: Sample Procedure for Routine Daily Cleaning of Patient/Resident Room

For All Rooms, Including Those in Additional Precautions (Except for *C. difficile* and VRE)

1. **Assessment**

   - Check for Additional Precautions signs and follow the precautions indicated.
   - Walk through room to determine what needs to be replaced (e.g., toilet paper, paper towels, soap, alcohol-based hand rub, gloves, sharps container) and whether any special materials are required; this may be done before or during the cleaning process.
   - Remove clutter.

2. **Assemble supplies**

   - Ensure an adequate supply of clean cloths is available.
   - Prepare fresh disinfectant solution according to manufacturer's instructions.

3. **Clean hands using alcohol-based hand rub and put on gloves and any other required personal protective equipment.**

4. **Clean room, working from clean to dirty and high to low areas of the room:**

   - Use fresh cloth(s) for cleaning each patient/resident bed space:
     - If a bucket is used, do not double-dip cloth(s).
     - Do not shake out cloth(s).
     - Change the cleaning cloth when it is no longer saturated with disinfectant and after cleaning heavily soiled areas such as toilet and bedpan cleaner.
     - If there is more than one patient/resident bed space in the room, use fresh cloth(s) for each and complete the cleaning in each bed space before moving to the next.
   - Start by cleaning doors, door handles, push plate and touched areas of frame.
   - Check walls for visible soiling and clean if required.
   - Clean light switches and thermostats.
   - Clean wall mounted items such as alcohol-based hand rub dispenser and glove box holder.
   - Check and remove fingerprints and soil from low level interior glass partitions, glass door panels, mirrors and windows with glass cleaner.
   - Check privacy curtains for visible soiling and replace if required.
   - Clean all furnishings and horizontal surfaces in the room including chairs, window sill, television, telephone, computer keypads, night table and other tables or desks. Lift items to clean the tables. Pay particular attention to high-touch surfaces.
   - Wipe equipment on walls such as top of suction bottle, intercom and blood pressure manometer as well as IV pole.
   - Clean bedrails, bed controls and call bell.
   - Clean bathroom/shower (see Appendix 5).
   - Clean floors (see Appendix 9, Appendix 10, and Appendix 11 for floor cleaning procedures).

5. **Disposal**

   - Place soiled cloths in designated container for laundering.
   - Check sharps container and change when ¾ full (do not dust the top of a sharps container).
   - Remove soiled linen if bag is full.
   - Place obvious waste in receptacles.
   - Remove waste.

6. **Remove gloves and clean hands** with alcohol-based hand rub; if hands are visibly soiled, wash with soap and water. Do NOT leave room wearing gloves or other personal protective equipment.

7. **Replenish** supplies as required (e.g., gloves, alcohol-based hand rub, soap, paper towel).

8. **Clean hands with alcohol-based hand rub.**

For Rooms of Patients/Residents on Contact Precautions for *C. difficile* and VRE

In addition to the procedure above:

- Use a fresh bucket and mop head (dust mop and wet mop) for each room, and only for that room.
- After cleaning, apply a disinfectant to all surfaces in the room. Ensure sufficient contact time with the disinfectant.
  - For *C. difficile*, use a sporicidal agent (omit this step if the cleaning product is also a sporicidal disinfectant).
  - For VRE, use a low-level hard surface disinfectant (omit this step if the cleaning product is a one-step cleaner/disinfectant).

Appendix 5: Sample Procedure for Routine Bathroom Cleaning

NOTE: Bathrooms require Hospital Clean

Working from clean areas to dirty areas:

- Remove soiled linen from floor; wipe up any spills; remove waste.
- Clean door handle and frame, light switch.
- Clean chrome wall attachments.
- Clean inside and outside of sink, sink faucets and mirror; wipe plumbing under the sink; apply disinfectant to interior of sink; ensure sufficient contact time with disinfectant; rinse sink and dry fixtures.
- Clean all dispensers and frames.
- Clean call bell and cord.
- Clean support railings, ledges/shelves.
- Clean shower/tub faucets, walls and railing, scrubbing as required to remove soap scum; inspect grout for mould; apply disinfectant to interior surfaces of shower/tub, including soap dish, faucets and shower head; ensure sufficient contact time for disinfectant; rinse and wipe dry; inspect and replace shower curtains monthly and as required.
- Clean bedpan support, entire toilet including handle and underside of flush rim; ensure sufficient contact time with disinfectant.
- Remove gloves and wash hands.
- Replenish paper towel, toilet paper, waste bag, soap and alcohol-based hand rub as required.
- Report mould and cracked, leaking or damaged areas for repair.

Additionally for discharge/transfer cleaning:

- Change all waste bags, clean waste container if dirty.
- Scrub shower walls.
- Discard toilet brush/swab if single bathroom.

Appendix 6: Sample Procedure for Routine Discharge/Transfer Cleaning of a Patient/Resident Room

For All Rooms, Including Those on Additional Precautions (Except for *C. difficile* and VRE)

1. **Assessment.**

   - Check for Additional Precautions signs and follow the precautions indicated.
   - Walk through room to determine what needs to be replaced (e.g., toilet paper, paper towels, soap, alcohol-based hand rub, gloves, sharps container) and whether any special materials are required; this may be done before or during the cleaning process.
   - Remove clutter.

2. **Assemble supplies.**

   - Ensure an adequate supply of clean cloths is available.
   - Prepare fresh disinfectant solution according to manufacturer's instructions.

3. **Clean hands using alcohol-based hand rub and put on gloves and any other required personal protective equipment.**

4. **Remove dirty linen:**

   - Strip the bed, discarding linen into soiled linen bag; roll sheets carefully to prevent aerosols.
   - Inspect bedside curtains and window treatments; if visibly soiled, clean or change. In long-term care homes, change curtain. **For rooms on Additional Precautions, remove curtains for cleaning and disinfecting.**
   - Remove gloves and clean hands.

5. **Apply clean gloves and clean room, working from clean to dirty and from high to low areas of the room:**

   - Use fresh cloth(s) for cleaning each patient/resident bed space:
     - If a bucket is used, do not double-dip cloth(s).
     - Do not shake out cloth(s).
     - Change the cleaning cloth when it is no longer saturated with disinfectant and after cleaning heavily soiled areas such as toilet and bedpan cleaner.
     - If there is more than one patient/resident bed space in the room, use fresh cloth(s) for each and complete the cleaning in each bed space before moving to the next.
   - Start by cleaning doors, door handles, push plate and touched areas of frame.
   - Check walls for visible soiling and clean if required.
   - Clean light switches and thermostats.
   - Clean wall mounted items such as alcohol-based hand rub dispenser and glove box holder.
   - Check and remove fingerprints and soil from low level interior glass partitions, glass door panels, mirrors and windows with glass cleaner.

- Clean all furnishings and horizontal surfaces in the room including chairs, window sill, television, telephone, computer keypads, night table and other tables or desks. Lift items to clean the tables. Pay particular attention to high-touch surfaces.
- Wipe equipment on walls such as top of suction bottle, intercom and blood pressure manometer.
- Clean equipment (e.g., IV pole and pump, walkers, wheelchairs).
- Clean inside and outside of patient/resident cupboard or locker.

6. **Clean the bed.**

   - Clean top and sides of mattress, turn over and clean underside.
   - Clean exposed bed springs and frame.
   - Check for cracks or holes in mattress and have mattress replaced as required.
   - Inspect for pest infestation.
   - Clean headboard, foot board, bed rails, call bell and bed controls; pay particular attention to areas that are visibly soiled and surfaces frequently touched by staff.
   - Clean all lower parts of bed frame, including casters.
   - Allow mattress to dry.

7. **Clean bathroom/shower** (see Appendix 5).

8. **Clean floors** (see Appendix 9, Appendix 10, and Appendix 11 for floor cleaning procedure).

9. **Disposal.**

   - Place soiled cloths in designated container for laundering.
   - Check sharps container and change when ¾ full (do not dust the top of a sharps container).
   - Remove soiled linen bag and replace with fresh bag.
   - Place obvious waste in receptacles.
   - Close waste bags and remove; clean waste can/holder if soiled and add a clean bag.

10. **Remove gloves and clean hands** with alcohol-based hand rub; if hands are visibly soiled, wash with soap and water. **Do NOT leave room wearing gloves or other personal protective equipment.**

11. **Remake** bed and **Replenish** supplies as required (e.g., gloves, alcohol-based hand rub, soap, paper towel, toilet brush).

12. Return cleaned equipment (e.g., IV poles and pumps, walkers, commodes) to clean storage area.

For Rooms of Patients/Residents on Contact Precautions for *C. difficile* and VRE

In addition to the procedure above:

- Remove all dirty/used items (e.g., suction container, disposable items).
- Discard and replace the following:
  - soap
  - toilet paper
  - paper towels
  - glove box
  - toilet brush
- Use fresh cloths, mop, supplies and solutions to clean the room.
- Clean and disinfect all surfaces and allow for the appropriate contact time with the disinfectant.
  - For *C. difficile*, use a sporicidal agent (omit this step if the cleaning product is also a sporicidal disinfectant).
  - For VRE, use a low-level hard surface disinfectant (omit this step if the cleaning product is a one-step cleaner/disinfectant).

Appendix 7: Sample Procedure for Enhanced Shower and Sink Cleaning

These procedures may be used for enhanced sink cleaning if the grid over the plug hole is removable.

After cleaning the bathroom as described in Appendix 5:

- Put on personal protective equipment (e.g., tyvek suit, gloves, facial protection)
- Take out shower grate.
- Remove debris from shower grate, descale if necessary, rinse.
- Squall grout and pipe.
- Rinse with water for 10 minutes.
- Apply enzymatic cleaner to grout, pipe sides; fill P-trap with cleaner.
- Insert plumbers plug.
- Fill pipe with enzymatic cleaner and cover grout. Allow for sufficient contact time as per cleaner instruction.
- Remove plumbers plug.
- Brush drain.
- Rinse with water for 10 minutes.
- Apply sporicidal agent to grout, pipe sides; fill P-trap with sporicidal agent.
- Insert plumbers plug.
- Fill pipe with sporicidal agent and cover grout. Allow for sufficient contact time as per disinfectant instruction.
- Remove plumbers plug.
- Brush drain.
- Rinse with water for 5 minutes.
- Heat up steamer.
- Tape over drain pipe.
- Insert steamer tip and apply steam for 10 minutes.

This tool is modified from St. Joseph's Health Centre Toronto, Toronto, Ontario (shower drain disinfection protocol). Received 2017 Mar 7.

Appendix 8: Recommended Minimum Cleaning and Disinfection Level and Frequency for Noncritical Client/Patient/Resident Care Equipment and Environmental Items

The following chart relates to **noncritical patient care equipment** only, i.e., equipment that comes into contact with intact skin. For semi-critical and critical equipment that require high-level disinfection or sterilization, see PIDAC's *Best Practices for Cleaning, Disinfection and Sterilization in All Health Care Settings*. Refer to Appendix 2 for appropriate agents that may be used for cleaning and disinfection of noncritical patient care equipment.

This chart also includes **environmental surfaces and items** that do not come into contact with skin. Refer to Section III and Appendix E for guidance regarding cleaning and disinfection of environmental surfaces and items.

Table 11: Recommended Minimum Cleaning and Disinfection Level and Frequency for Noncritical Equipment and Environmental Items

Item	Minimum Cleaning and Disinfection Level	Minimum Frequency	Remarks
Airflow sensors (sleep labs)	clean + low-level disinfect	• between patients	• clean with detergent and water before disinfection
Apnoea monitor: monitor/sensor pad	clean + low-level disinfect	• between patients and when soiled	
Arrest cart	see "resuscitation cart"		
Basin: bath or wash	clean + low-level disinfect	• after each use	• dry completely before use
Bassinette	clean + low-level disinfect	• weekly • when soiled • between newborns	
Bath seat/raised toilet seat: dedicated to one patient	clean + low-level disinfect	• when soiled • between patients	
Bath seat/raised toilet seat: multiple patient use	clean + low-level disinfect	• between patients	
Bed: bedrail and extender	clean + low-level disinfect	• daily	
Bed:	clean + low-level	• between patients	

Item	Minimum Cleaning and Disinfection Level	Minimum Frequency	Remarks
mattress	disinfect	and when soiled	
Bed: **halo bed**	clean + low-level disinfect	• after each patient and when soiled	
Bed: **visitor cot**	clean + low-level disinfect	• change linen and clean between uses	
Bedpan and urinal: **single patient**	clean only	• clean after each use if designated to patient	• remove gross soil and fluids between cleaning
Bedpan and urinal: **between patients**	clean + low-level disinfect	• between patients	• remove gross soil and fluids before cleaning
Bladder scanner	clean + low-level disinfect	• between patients	
Blood pressure cuff	clean + low-level disinfect	• between patients and when soiled	• ideally stays with patient until discharge
Blood tube holder	clean + low-level disinfect (for re-usable holders)	• after each use	• single-use preferred • for re-usable holders, discard if visibly soiled
Call bell	clean + low-level disinfect	• daily and between patients	
Cardiac monitor	clean + low-level disinfect	• daily and between patients	
Cast cutting: **blades**	clean only or disposable	• when soiled	• send for sterilization if contact with blood or body fluids
Cast cutting: **saws**	clean only	• when soiled	
Chair (includes recliners, patient chairs and shower chairs)	clean + low-level disinfect	• daily and when soiled	
Chart cover: **binder and/or clipboard**	clean + low-level disinfect	• when soiled	• charts and clipboards should not go into rooms on Additional Precautions • replace worn binders
Clippers: **surgical**	clean + low-level disinfect	• between patients	• disposable heads are preferred
Commode chairs: **dedicated to one patient**	clean + low-level disinfect	• when soiled • between patients	• patients with VRE or *C. difficile* must have dedicated commode • for *C. difficile*, consider cleaning with a sporicidal agent • remove gross soil and fluids before cleaning and disinfection

Item	Minimum Cleaning and Disinfection Level	Minimum Frequency	Remarks
Commode chairs: multiple patient use	clean + low-level disinfect	• when soiled • between patients	• it is preferable to dedicate a commode chair to each patient • remove gross soil and fluids before cleaning and disinfection
Cord clamp			• must be single-use, disposable and discarded after use
Cyclers (peritoneal dialysis)	clean + low-level disinfect	• between patients	
Defibrillator	see "resuscitation cart"		
Diagnostic imaging: portable – machine	clean + low-level disinfect	• when soiled and on leaving Additional Precautions room	
Diagnostic imaging: portable – portable grid/film cassette	clean + low-level disinfect	• between patients if not covered	• ideally should be covered (e.g., pillowcase)
Diagnostic imaging: mammography – paddles	clean + low-level disinfect	• between patients	
Dopplers: transducers	clean + low-level disinfect	• after each use	• wipe immediately after use to remove residual ultrasound gel before cleaning
Dopplers: probes	clean + low-level disinfect	• after each use	• probes that contact mucous membranes or non-intact skin require high-level disinfection
Electrocardiogram: machine and cables	clean + low-level disinfect	• between patients	
Electric razor: razor body and handle	clean + low-level disinfect	• as required	• must be single patient use
Examination table	clean + low-level disinfect	• between patients and when soiled	
Glucometer	clean + low-level disinfect	• after each us	
Halo bed	see "bed"		
Hydraulic lift: machine	clean + low-level disinfect	• as required	
Hydraulic lift: sling	launder	• between patients and when soiled	• dedicated to patient if possible • launder if visibly soiled
Ice machine: interior	clean + low-level disinfect	• every 3 months	• drain and thoroughly clean with a de-limer

Item	Minimum Cleaning and Disinfection Level	Minimum Frequency	Remarks
			• see Appendix 12 for sample cleaning procedure
Ice machine: exterior	clean + low-level disinfect	• every 3 days	
Intravenous (IV): pumps, poles, warmers	clean + low-level disinfect	• between patients • when soiled	
Isolette	clean + low-level disinfect	• weekly • when soiled • between patients	• see Appendix 20 for sample cleaning procedure
Laryngoscope: handle	clean + low-level disinfect	• between patients	• laryngoscope blade requires high-level disinfection
Mattress	See "bed"		
Measuring container (urine): single patient use	clean only	• after each use	
Measuring container (urine): multiple patient use	clean + low-level disinfect	• after each use	• one container per patient, labelled with name
Ophthalmoscope	clean + low-level disinfect	• between patients	
Orthopedic equipment: crutches, traction etc.	clean + low-level disinfect	• between patients	
Otoscope: handle	clean + low-level disinfect	• between patients	• ear speculum of otoscope requires high-level disinfection
Otoscope: optoacoustic emission (OAE) screening tips	disposable, or clean + high-level disinfect	• between patients	
Oximeter probes	clean + low-level disinfect	• daily and between patients	• if single-use, discard after use • refer to manufacturer's instructions for cleaning
Pillow	clean + low-level disinfect	• between patients and when soiled	• discard if cracked
Reflex hammer	clean + low-level disinfect	• between patients	
Restraints	clean only	• between patients and when soiled	• launder
Resuscitation cart/arrest cart	clean + low-level disinfect	• weekly and after use	• avoid taking cart into Contact Precautions room, have a designated clean person to pass supplies as required

Item	Minimum Cleaning and Disinfection Level	Minimum Frequency	Remarks
Resuscitation cart/arrest cart: defibrillator	clean + low-level disinfect	• after each use	
Resuscitation cart/arrest cart: trays	clean + low-level disinfect	• after each use	• all items taken into Contact Precautions room must be discarded and not returned to the cart, even if unopened
Scales: adult	clean + low-level disinfect	• daily and when soiled	
Scales: diaper	clean + low-level disinfect	• after each use	
Scales: newborn	clean + low-level disinfect	• after each use	• do not use phenolics
Stretcher	clean + low-level disinfect	• after each use	
Stethoscope	clean + low-level disinfect	• after each use	• ideally use own stethoscope • if shared, disinfect ear pieces
Suction machines	clean + low-level disinfect	• between patients and when soiled	
Table: bedside and over bed	clean + low-level disinfect	• daily • when soiled • between patients	
Telemetry equipment: monitor and cables	clean + low-level disinfect	• between patients and when soiled	
Tourniquet	clean + low-level disinfect	• between patients or disposable	• preferably dedicate to patient • discard when soiled/ cracked
Transfer boards	clean + low-level disinfect	• between patients and when soiled	
Transport equipment: walker, wheelchair	clean + low-level disinfect	• after each use	
Tub: bath board	clean + low-level disinfect	• after each use	• iodine and chlorine products may damage tub surfaces
Ultrasound transducers: handle, cable, and external	clean + low-level disinfect	• between patients	• use high-level disinfection for transducer probes if they touch mucous membranes or non-intact skin
Urinal	see “bedpan”		
Urine measuring container	see “measuring container”		

Item	Minimum Cleaning and Disinfection Level	Minimum Frequency	Remarks
Walker	see “transport equipment”		
Wall-mounted oxygen and suction fixtures	clean + low-level disinfect	• between patient and when soiled	
Water jug	clean only	• daily	• clean in dishwasher
Wheelchair	see “transport equipment”		

Appendix 9: Sample Procedure for Mopping Floors Using Dry Dust Mop

Working from clean areas to dirty areas:

- Remove debris from floor and dry any wet spots with paper towel.
- Remove gum or other sticky residue from floor.
- Starting in the furthest corner of the room, drag the mop toward you, then push it away, working in straight, slightly overlapping lines and keeping the mop head in full contact with the floor.
- Do not lift dust mop off the floor once you have started, use swivel motion of frame and wrist to change direction.
- Move furniture and replace after dust mopping, including under and behind bed.
- Carefully dispose of debris, being careful not to stir up dust.
- Replace mop head/pad when soiled and after mopping a room.

Appendix 10: Sample Procedure for Mopping Floors Using Wet Loop Mop and Bucket

Working from clean areas to dirty areas:

- Prepare fresh cleaning solution according to the manufacturer's instructions using appropriate personal protective equipment according to the safety data sheet.
- Place "wet floor" caution sign outside of room or area being mopped.
- Immerse mop in cleaning solution and wring out.
- Push mop around baseboards first, paying particular attention to removing soil from corners; avoid splashing walls or furniture.
- In open areas use a figure eight stroke, overlapping each stroke; turn mop head over every five or six strokes.
- Mop a three metre by three metre (nine feet by nine feet) area, then rinse and wring mop.
- Repeat until entire floor is done.
- Change the mop head when heavily soiled and at the end of the day.
- Change cleaning solution frequently enough to maintain appropriate concentration of solution.

Appendix 11: Sample Procedure for Mopping Floors Using a Microfibre Mop

Working from clean areas to dirty areas:

- Fill plastic basin with cleaning solution.
- Place microfibre pad(s) to soak in basin.
- Take a clean pad from the basin, wring out and attach to mop head using Velcro strips.
- Remove pad when soiled and set aside for laundering.
- Use a fresh microfibre pad for each room.
- Send soiled, reusable microfibre pads for laundering at the end of the day.

Appendix 12: Sample Procedure for Cleaning Ice Machines

Daily:

- Visually inspect ice machines daily and report any signs of mould or scale.
- Replace ice scoop daily and send for cleaning (for ice machines requiring a scoop).
- Do not store food or other items in ice chests or machines.

Quarterly:

- Disconnect power supply to ice machine.
- Remove machine away from patient/resident care area.
- Remove and discard ice from bin.
- Allow unit to warm to room temperature.
- Disassemble removable parts of machine.
- Thoroughly clean machine and parts with water and detergent.
- Remove scale from machine components.
- Rinse components with fresh potable tap water.
- Clean ice storage chest or bin with fresh water and detergent; rinse with fresh potable tap water.
- Sanitize machine by circulating a 100 ppm solution of sodium hypochlorite through the ice-making and storage systems for two hours.
- Drain sodium hypochlorite solution and flush with fresh potable tap water.
- Allow all surfaces to air dry.
- Check for required repairs or maintenance (e.g., filter changes).
- Apply a label to the ice machine noting date of cleaning.

Notes:

This tool is adapted from Sunnybrook Health Sciences Centre, Toronto, Ontario (policy II-Q-1200), revised 2007; and the US Centers for Disease Control and Prevention's *Guidelines for Environmental Infection Control in Health Care Facilities, 2003*.

Appendix 13: Sample Procedure for Cleaning Toys

For high-touch surfaces (e.g., electronic games, keyboards, joysticks; playhouses/climbers/rocking horses; or tables/chairs/doorknobs in playrooms):

- Clean and disinfect at least daily using a hospital disinfectant.

For shared books, magazines, puzzles, cards, and comics:

- Discard when visibly soiled.
- Discard after use in rooms where the resident/patient is on Additional Precautions.

For toy storage bins/boxes/cupboards/shelves:

- Ensure a regular, scheduled clean is performed.

For toys that may be "mouthed" (e.g., infant and toddler toys):

- Clean, disinfect and rinse thoroughly after each use.

Notes:

This tool is adapted from IPAC-Canada's *Practice Recommendations: Toys, 2011*.

Appendix 14: Sample Procedure for Cleaning an Ambulance

Routine Clean Following Each Transport:

- Place biomedical waste (e.g., dressings, bandages, contaminated sheets that are saturated with blood) in a clearly marked biohazardous waste receptacle.
- Carefully dispose of sharps that are found during cleaning in appropriate sharps container.
- Remove used linens/blankets for laundering.
- Clean and disinfect/sterilize equipment used during the call.
- Clean and disinfect the cab and patient compartment as required.
- If the vehicle is heavily contaminated it will be taken out of service and deep cleaned.
- Restock vehicle as required.

Deep Clean as Required and When Scheduled:

Driver's Compartment

- Remove all equipment from the front of the vehicle.
- Clean and vacuum floor.
- Clean and disinfect all interior surfaces, including walls, doors, radio equipment, dash and windows.

Patient Compartment

- Remove stretchers, clean and disinfect including mattress and belts; check for wear or damage.
- Remove wall suction, clean and disinfect.
- Remove contents of cupboards and shelves; clean and disinfect all surfaces.
- Clean, disinfect and dry all hard surface items before returning to cupboard or shelf; inspect for damage and expiration dates; repair/replace as needed.
- Sweep, vacuum, clean and disinfect floor.
- Clean and disinfect chairs, bench seats, seat belts.
- Clean and disinfect all interior surfaces, including ceiling and walls.
- Remove scuff marks.
- Check interior lighting.
- Empty, clean and disinfect waste containers.
- Clean interior windows.

Equipment Storage Compartment

- Remove all equipment and sweep out compartment
- Clean and disinfect compartment and restock

Notes:

This tool is adapted from Ministry of Health and Long-Term Care, Emergency Health Services Branch's *Infection Prevention and Control Best Practices Manual for Land Ambulance Paramedics*, Version 1.0 (March 2007); Greater Sudbury Emergency Medical Services *Vehicle and Equipment Policy and Procedure Manual*, Section 4 (revised August 2006); and Algoma Emergency Medical Services, *Standardized Vehicle Deep Clean Procedure*.

Appendix 15: Sample Procedure for Cleaning Operating Rooms Between Cases

- Prepare fresh disinfectant solution according to manufacturer's instructions.
- Clean hands and put on gloves.
- Collect and remove waste.
- Collect and remove all soiled linen.
- Remove gloves and clean hands.
- Use a cloth dampened in hospital disinfectant solution to clean and disinfect horizontal surfaces that have come in contact with a patient or body fluids, including tops of surgical lights, blood pressure cuffs, tourniquets and leads.
- Clean reflective portion of surgical lights.
- Discard suction canisters (and liners if used).
- Clean and disinfect bed.
- Clean electronic equipment (i.e., monitors) according to manufacturer's instructions.
- Damp mop floor in a 1 to 1.3 metre (3 to 4 feet) perimeter around the bed (larger area if contamination present); use a separate mop head per case.
- Insert new waste liner bags.
- Damp-dust equipment from other areas such as X-ray machines and compressed gas tanks before being brought into the operating room and prior to leaving.
- When cleaning is complete, remove gloves and clean hands.
- Place a cautionary "Wet Floor" sign at the entrance to the room.
- Remove gloves and clean hands.

Notes:

This tool is adapted from: Operating Room Nurses Association of Canada (ORNAC). Section 2: Infection prevention and control. In: *The ORNAC Standards, Guidelines, and Position Statements for Perioperative Registered Nurses*. 13th ed. Kingston, ON: Operating Room Nurses Association of Canada; 2017.

Appendix 16: Sample Procedure for Discharge/Terminal Cleaning of Operating Room (End of Day)

- Prepare fresh hospital disinfectant solution according to manufacturer's instructions.
- Clean hands and put on gloves.
- Collect and remove waste.
- Collect and remove all soiled linen.
- Clean hands and change gloves.
- Clean and disinfect lights and ceiling-mounted tracks.
- Clean and disinfect all door handles, push plates, light switches and controls.
- Clean and disinfect telephones and computer keyboards.
- Spot-check walls for cleanliness.
- Clean and disinfect all exterior surfaces of machines and equipment (e.g., anaesthesia carts), allowing adequate drying time for the disinfectant before storage.
- Clean and disinfect all furniture including wheels/casters.
- Clean and disinfect exterior of cabinets and doors, especially around handles.
- Clean and disinfect all horizontal surfaces.
- Clean scrub sinks and surrounding walls.
- Mop floor, making sure the bed is moved and the floor is washed underneath; move all furniture to the centre of the room and continue cleaning the floor; follow the detergent and disinfectant manufacturers' instructions for dilution and contact time; use a fresh mop/mop head and fresh solution for each room.
- Replace all furniture and equipment to its proper location.
- Damp wipe waste receptacles, dry thoroughly and re-line.
- Report any needed repairs,
- Clean and store cleaning equipment.
- Place a cautionary "Wet Floor" sign at the entrance to the room.
- Remove gloves and clean hands.

Notes:

This tool is adapted from: Operating Room Nurses Association of Canada (ORNAC). Section 2: Infection prevention and control. In: *The ORNAC Standards, Guidelines, and Position Statements for Perioperative Registered Nurses*. 13th ed. Kingston, ON: Operating Room Nurses Association of Canada; 2017.

Appendix 17: Sample Cleaning Schedule for Medical Device Reprocessing Departments and Other Sterile Storage Areas

Sterile Processing Areas:

- Clean all counters and floors daily.
- Clean shelves daily in sterilization areas, preparation and packing areas and decontamination areas.
- Clean shelves every three months in sterile storage areas.
- Clean case carts after every use.
- Clean walls every six months.
- Clean light fixtures, sprinkler heads and other fixtures every six months.

User Units/Clinics, Endoscopy Suites and Other Sterile Storage Areas:

- Clean counters and floors daily.
- Clean shelves monthly.
- Clean walls every six months.
- Clean light fixtures, sprinkler heads and other fixtures every six months.

Notes:

This tool is adapted from Canadian Standards Association, *Z314.3-09, Effective Sterilization in Health Care Facilities by the Steam Process*: Table 1, Cleaning Frequencies.

Appendix 18: Sample Routine Environmental Cleaning in the Clinical Laboratory (Levels One and Two)

Laboratory Staff

- Minimize storage of materials that are not pertinent to the work and cannot be easily decontaminated (e.g., journals, books, correspondence).
- Laboratory clothing must not be stored in contact with street clothing.
- Contaminated clothing must be decontaminated before laundering.
- Clean and decontaminate work surfaces with a hospital disinfectant at end of the day and after any spill of potentially biohazardous material.
- Replace or repair work surfaces that have become permeable (i.e., cracked, chipped, loose) to biohazardous material.

Environmental Service Workers

- Remove waste, including biomedical waste and filled sharps containers.
- Replace soap, paper towels, alcohol-based hand rub as required.
- Clean hand washing sinks.
- Mop floors.
- Clean eyewash stations, lights, tops of shelves, desks, file cabinets, chairs, baseboards, radiators, telephones weekly.

Notes:

This tool is adapted from Public Health Agency of Canada's *Laboratory Biosafety Guidelines, 2004* and the Ontario Health-Care Housekeepers' Association Inc. *Cleaning Standards for Health Care Facilities, 2008*.

Appendix 19: Sample Routine Environmental Cleaning in the Hemodialysis Unit

Nursing Staff

- Take only what is required for a patient's treatment into the hemodialysis station; minimize materials that cannot be easily decontaminated (e.g., patient chart).
- Dedicate equipment to individual patients whenever possible.
- Clean and disinfect equipment before returning it to a common clean area or for use on another patient (e.g., scissors, stethoscopes, blood pressure cuffs, electronic thermometers).
- Dispose of unused medications or supplies (e.g., syringes, alcohol swabs, tape) after each treatment.

Environmental Service Workers—after each hemodialysis treatment or procedure

- **Allow sufficient time between patients for adequate cleaning.**
- Remove waste, including biomedical waste and filled sharps containers.
- Replace soap, paper towels, alcohol-based hand rub as required.
- Clean surfaces at the dialysis station, including the bed or chair, countertops, tables and external surfaces of the dialysis machine (including waste containers) with a hospital disinfectant, allowing sufficient contact time with the disinfectant.
- Clean spills of blood as described in Appendix 23.

Environmental Service Workers – at end of day

- Clean remainder of the hemodialysis facility using a health care clean regimen (see Components of Health Care Clean).
- Clean hand washing sinks.
- Mop floors.

Scheduled Cleaning

- Weekly clean eyewash stations, lights, tops of shelves, desks, file cabinets, chairs, baseboards, radiators, telephones weekly.
- Weekly deep cleaning of equipment and furnishings.

Notes:

This tool is adapted from Recommendations for Preventing Transmission of Infections Among Chronic Hemodialysis Patients, *MMWR* April 27, 2001/50(RR05):p.17-22.

Appendix 20: Sample Routine Environmental Cleaning of Isolettes

Nursing Staff

- Detach medical gas lines and other external equipment from the isolette.
- Remove medical equipment from inside the isolette and disinfect or send for reprocessing.

Environmental Service Workers

DO NOT USE PHENOLIC DISINFECTANTS

- Check for items in the isolette, including sharps.
- Remove all items from inside the isolette.
- Remove grommets and door rings; clean and disinfect for required contact time.
- Remove tape from glass with alcohol, then wash off.
- Clean and disinfect glass.
- Detach all removable parts from inside of isolette, clean and disinfect, allowing sufficient contact time with the disinfectant.
- Clean outside of isolette completely, including wheels.
- Re-wash glass with a clean cloth dampened with water to remove any residue from disinfectant.
- Replace pieces of isolette.
- Cover isolette with a baby blanket, and indicate cleaning date.

Scheduled Cleaning

- Change filters every three months (or according to manufacturer's recommendations), when wet or if infant was on Contact Precautions.
- Humidity trays are reprocessed in central processing (CPS/SPD) after use.

Notes:

This tool is adapted from Kingston General Hospital's Environmental Services Department, *Isolette Cleaning*, revised January 2009.

Appendix 21: Risk Stratification Matrix to Determine Frequency of Cleaning

For each client/patient/resident area or department:

Step 1: Categorize the factors that will impact on environmental cleaning:

Probability of Contamination with Pathogens

Heavy Contamination (score = 3)

An area is designated as being heavily contaminated if surfaces and/or equipment are routinely exposed to copious amounts of fresh blood or other body fluids (e.g., birthing suite, autopsy suite, cardiac catheterization laboratory, hemodialysis station, Emergency room, client/patient/resident bathroom if visibly soiled).

Moderate Contamination (score = 2)

An area is designated as being moderately contaminated if surfaces and/or equipment does not routinely (but may) become contaminated with blood or other body fluids and the contaminated substances are contained or removed (e.g., wet sheets). All client/patient/resident rooms and bathrooms should be considered to be, at a minimum, moderately contaminated.

Light Contamination (score = 1)

An area is designated as being lightly contaminated if surfaces are not exposed to blood, other body fluids or items that have come into contact with blood or body fluids (e.g., lounges, libraries, offices).

Vulnerability of Population to Environmental Infection

More Susceptible (score = 1)

Susceptible clients/patients/residents are those who are most susceptible to infection due to their medical condition or lack of immunity. These include those who are immunocompromised (oncology, transplant and chemotherapy units), neonates (level 2 and 3 nurseries) and those who have severe burns (i.e., requiring care in a burn unit).

Less Susceptible (score = 0)

For the purpose of risk stratification for cleaning, all other individuals and areas are classified as less susceptible.

Potential for Exposure

High-touch surfaces (score = 3)

High-touch surfaces are those that have frequent contact with hands. Examples include doorknobs, telephone, call bells, bedrails, light switches, wall areas around the toilet and edges of privacy curtains.

Low-touch surfaces (score = 1)

Low-touch surfaces are those that have minimal contact with hands. Examples include walls, ceilings, mirrors and window sills.

Step 2: Determine the Total Risk Stratification Score:

For each functional area or department, the frequency of cleaning is based on the factors listed in the boxes above. A score is given if the factors are present, and the frequency of cleaning is based on the total score as derived in the following matrix:

Table 12: Risk Stratification Scores for High-Touch Surfaces (Score for Potential for Exposure = 3)

Probability of contamination with pathogens	More susceptible population (score = 1)	Less susceptible population (score = 0)
Heavy (score = 3)	7 (3+3+1)	6 (3+3+0)
Moderate (score = 2)	6 (3+2+1)	5 (3+2+0)
Light (score = 1)	5 (3+1+1)	4 (3+1+0)

Table 13: Risk Stratification Scores for Low-Touch Surfaces (Score for Potential for Exposure = 1)

Probability of contamination with pathogens	More susceptible population (score = 1)	Less susceptible population (score = 0)
Heavy (score = 3)	5 (1+3+1)	4 (1+3+0)
Moderate (score = 2)	4 (1+2+1)	3 (1+2+0)
Light (score = 1)	3 (1+1+1)	2 (1+1+0)

STEP 3: Determine the cleaning frequency based on the risk stratification matrix:

Cleaning frequencies for each functional area or department are derived from the total score that results from the risk stratification matrix above:

Table 14: Cleaning Frequencies Based on Total Risk Score

Total Risk Score	Risk Type	Minimum Cleaning Frequency
7	High Risk	Clean after each case/event/procedure and at least twice per day Clean additionally as required
4-6	Moderate Risk	Clean at least once daily Clean additionally as required (e.g., gross soiling)
2-3	Low Risk	Clean according to a fixed schedule Clean additionally as required (e.g., gross soiling)

Table 15: Examples Using the Risk Stratification Matrix to Determine the Cleaning Frequency of Specific Areas

Location	Probability of Contamination: Light = 1 Moderate = 2 Heavy = 3	Potential for Exposure: High-touch = 3 Low-touch = 1	Population: Less susceptible = 0 More susceptible = 1	Total Score	Interpretation
Admission/discharge units	1	1	0	2	Clean according to a fixed schedule Clean additionally as required
Autopsy/morgue	3	3	0	6	Clean at least once daily Clean additionally as required
Burn unit	2	3	1	6	Clean at least once daily Clean additionally as required
Cardiac catheterization and angiodynography area	3	3	1	7	Clean after each case/event/procedure and at least twice per day Clean additionally as required
Chemotherapy unit	2	3	1	6	Clean at least once daily Clean additionally as required
Clean linen handling and storage area	1	1	0	2	Clean according to a fixed schedule Clean additionally as required
Cystoscopy	3	3	0	6	Clean at least once daily Clean additionally as

Location	Probability of Contamination: Light = 1 Moderate = 2 Heavy = 3	Potential for Exposure: High-touch = 3 Low-touch = 1	Population: Less susceptible = 0 More susceptible = 1	Total Score	Interpretation
					required
Cystoscopy	3	3	1	7	Clean after each case/event/procedure and at least twice per day Clean additionally as required
Dental procedure room	3	3	0	6	Clean at least once daily Clean additionally as required
Dental procedure room	3	3	1	7	Clean after each case/event/procedure and at least twice per day Clean additionally as required
Diagnostic imaging	1	1	0 or 1	2 or 3	Clean according to a fixed schedule Clean additionally as required
Dining room/cafeteria and food preparation areas	1	3	0	4	Clean at least once daily Clean additionally as required
Echocardiography	1	1	0 or 1	2 or 3	Clean according to a fixed schedule Clean additionally as required
Emergency room: patient cubicle	2	3	0 or 1	5 or 6	Clean at least once daily Clean additionally as required
Emergency room: patient cubicle	3	3	0	6	Clean at least once daily Clean additionally as required
Emergency room: patient cubicle	3	3	1	7	Clean after each case/event/procedure and at least twice per day Clean additionally as required
Emergency room: trauma room	3	3	1	7	Clean after each case/event/procedure and at least twice per day Clean additionally as

Location	Probability of Contamination: Light = 1 Moderate = 2 Heavy = 3	Potential for Exposure: High-touch = 3 Low-touch = 1	Population: Less susceptible = 0 More susceptible = 1	Total Score	Interpretation
					required
Emergency room: other emergency areas	1	3	0	4	Clean at least once daily Clean additionally as required
Equipment reprocessing area (CPS/SPD)	3	3	0	6	Clean at least once daily Clean additionally as required
Hemodialysis: dialysis station	3	3	1	7	Clean after each case/event/procedure and at least twice per day Clean additionally as required
Hemodialysis: other dialysis areas	2	3	0	5	Clean at least once daily Clean additionally as required
Intensive care unit	3	3	1	7	Clean after each case/event/procedure and at least twice per day Clean additionally as required
Laboratory	3	3	0	6	Clean at least once daily Clean additionally as required
Labour and birthing rooms	3	3	1	7	Clean after each case/event/procedure and at least twice per day Clean additionally as required
Laundry: soiled linen	3	3	0	6	Clean at least once daily Clean additionally as required
Nuclear medicine	1	1	0 or 1	2 or 3	Clean according to a fixed schedule Clean additionally as required
Nursery (well baby)	1	1	0	2	Clean according to a fixed schedule Clean additionally as required
Occupational	1	3	0	4	Clean at least once daily

Location	Probability of Contamination: Light = 1 Moderate = 2 Heavy = 3	Potential for Exposure: High-touch = 3 Low-touch = 1	Population: Less susceptible = 0 More susceptible = 1	Total Score	Interpretation
therapy					Clean additionally as required
Offices	1	1	0	2	Clean according to a fixed schedule Clean additionally as required
On call rooms	1	1	0	2	Clean according to a fixed schedule Clean additionally as required
Operating room suite	3	3	1	7	Clean after each case/event/procedure and at least twice per day Clean additionally as required
Pacemaker insertion room	3	3	0	6	Clean at least once daily Clean additionally as required
Pacemaker insertion room	3	3	1	7	Clean after each case/event/procedure and at least twice per day Clean additionally as required
Patient/resident room	2	3	0 or 1	5 or 6	Clean at least once daily Clean additionally as required
Pharmacy: admixture room	1	3	1	5	Clean at least once daily Clean additionally as required
Pharmacy: general purpose area	1	3	0	4	Clean at least once daily Clean additionally as required
Physical plant workshops	1	3	0	4	Clean at least once daily Clean additionally as required
Physiotherapy	1	3	0	4	Clean at least once daily Clean additionally as required
Procedure room	3	3	0	6	Clean at least once daily Clean additionally as

Location	Probability of Contamination: Light = 1 Moderate = 2 Heavy = 3	Potential for Exposure: High-touch = 3 Low-touch = 1	Population: Less susceptible = 0 More susceptible = 1	Total Score	Interpretation
					required
Procedure room	3	3	1	7	Clean after each case/event/procedure and at least twice per day Clean additionally as required
Public areas: corridors, elevators, stairwells, lobbies, libraries, meeting rooms, locker rooms	1	1	0	2	Clean according to a fixed schedule Clean additionally as required
Resident activity room (long-term care home)	2	3	0 or 1	5 or 6	Clean at least once daily Clean additionally as required
Respiratory therapy	3	3	0	6	Clean at least once daily Clean additionally as required
Respiratory therapy	3	3	1	7	Clean after each case/event/procedure and at least twice per day Clean additionally as required
Sterile supply area	1	1	0	2	Clean according to a fixed schedule Clean additionally as required
Transplant unit	2	3	1	6	Clean at least once daily Clean additionally as required

Appendix 22: Sample Environmental Cleaning Checklists

The use of checklists by staff when cleaning areas that require Hospital Clean will ensure that all steps have been followed and allow for self-assessment and improvement. All of the steps involved in the cleaning process should be included in the checklist.

Cleaning checklist #1 is a sample checklist for routine daily cleaning for a patient/resident room. The items in this list are compatible with the procedure listed in Appendix 4.

Cleaning checklist #2 is a sample checklist for discharge/transfer cleaning for a patient/resident room contaminated with VRE. The items in this list are compatible with the procedures listed in Appendix 4 and Appendix 6.

Checklist #1: Daily Routine Cleaning of a Patient/Resident Room:

- ☐ Check for Additional Precautions signs and follow the precautions indicated.
- ☐ Walk through room to determine what needs to be replaced.
- ☐ Ensure an adequate supply of clean cloths is available.
- ☐ Prepare fresh disinfectant solution according to manufacturer's instructions.
- ☐ Clean hands using alcohol-based hand rub and put on gloves.
- ☐ Clean doors, door handles, push plate and touched areas of frame.
- ☐ Check walls for visible soiling and clean if required.
- ☐ Clean light switches and thermostats.
- ☐ Clean wall mounted items such as alcohol-based hand rub dispenser, glove box holder.
- ☐ Check and remove fingerprints and soil from interior glass partitions, glass door panels, mirrors and windows with glass cleaner.
- ☐ Check privacy curtains for visible soiling and replace if required.
- ☐ Clean all furnishings and horizontal surfaces in the room including:
    - ☐ chairs
    - ☐ window sill
    - ☐ television and cords
    - ☐ telephone
    - ☐ computer keypads
    - ☐ night table and other tables or desks
- ☐ Wipe equipment on walls such as top of suction bottle, intercom and blood pressure manometer as well as IV pole.
- ☐ Clean bedrails, bed controls and call bell, including cord.
- ☐ Clean bathroom/shower (see Appendix 5).
- ☐ Clean floors (see Appendix 9, Appendix 10, Appendix 11 for floor cleaning procedure).
- ☐ Place soiled cloths in designated container for laundering.
- ☐ Check sharps container and change when ¾ full (do not dust the top of a sharps container).
- ☐ Remove soiled linen if bag is full.
- ☐ Place obvious waste in receptacles.
- ☐ Remove waste.
- ☐ Remove gloves and clean hands.
- ☐ Replenish supplies as required (e.g., toilet paper, paper towel, soap, alcohol-based hand rub, gloves).
- ☐ Replace privacy curtains.
- ☐ Clean hands with alcohol-based hand rub on leaving the room

Checklist #2: Discharge/Transfer Cleaning of Contact Precautions Room for *C. difficile* and VRE

- ☐ Use a fresh bucket, cloth(s), mop head. Use each cloth one time only. **DO NOT RE-USE CLOTHS**.
- ☐ Prepare fresh disinfectant according to manufacturer's instructions. For *C. difficile*, use a sporicidal agent; for VRE, use a low-level hard surface disinfectant.
- ☐ Clean hands using alcohol-based hand rub and put on gloves.
- ☐ Remove all dirty/used items (e.g., suction container, disposable items).
- ☐ Remove curtains (privacy, window, shower).
- ☐ Remove dirty linen (sheets, towels); roll sheets carefully to prevent aerosols.
- ☐ Discard soap, toilet paper, paper towels, glove box.
- ☐ **Discard gloves, clean hands and apply clean gloves**.
- ☐ Clean and disinfect all surfaces and allow for the appropriate contact time with the disinfectant:
    - ☐ doors, door handles, push plate and touched areas of frame
    - ☐ walls, if visibly soiled; remove tape from walls
    - ☐ light switches and thermostats
    - ☐ wall mounted items:
        - ☐ alcohol-based hand rub dispenser
        - ☐ soap dispenser
        - ☐ glove box holder
        - ☐ top of suction bottle
        - ☐ sharps container (sides and bottom)
        - ☐ blood pressure manometer (including cuff)
    - ☐ low level interior glass partitions, glass door panels, mirrors and windows
    - ☐ chairs
    - ☐ tables (bedside table, over bed table, desks)
    - ☐ window sill
    - ☐ television, including cords and remote control
    - ☐ telephone
    - ☐ computer keyboards
    - ☐ light cord
    - ☐ toys, electronic games (pediatrics)
    - ☐ wheelchair, walker
    - ☐ monitors
    - ☐ IV pole and pump
    - ☐ inside and outside of patient/resident cupboard or locker and inside drawers
    - ☐ commode

- ☐ Clean bed:
  - ☐ Check for cracks or holes in mattress and have mattress replaced as required
  - ☐ Clean the following, allowing for the appropriate contact time with the disinfectant:
    - ☐ top and sides of mattress, turn over and clean underside
    - ☐ exposed bed springs and frame, including casters
    - ☐ headboard and foot board
    - ☐ bed rails, including underside of rail
    - ☐ call bell and cord
    - ☐ bed controls
  - ☐ allow mattress to dry
- ☐ Clean bathroom/shower (**see bathroom cleaning procedure**).
  - ☐ discard toilet brush
- ☐ Clean floor (see Appendix 9, Appendix 10, Appendix 11 for floor cleaning procedure).
- ☐ Disposal:
  - ☐ remove and replace sharps container if ¾ full
  - ☐ remove soiled linen bag
  - ☐ remove waste
- ☐ **Remove gloves and clean hands**.
  - ☐ Remake bed
  - ☐ Replace curtains
  - ☐ Replenish supplies:
    - ☐ soap
    - ☐ toilet paper
    - ☐ paper towels
    - ☐ glove box
    - ☐ toilet brush
- ☐ Return cleaned equipment (e.g., IV poles and pumps, walkers, commodes) to clean storage room.

Appendix 23: Sample Procedure for Cleaning a Biological Spill

- Assemble materials required for dealing with the spill prior to putting on personal protective equipment.
- Inspect the area around the spill thoroughly for splatters or splashes.
- Restrict the activity around the spill until the area has been cleaned and disinfected and is completely dry.
- Put on gloves; if there is a possibility of splashing, wear a gown and facial protection (mask and eye protection or face shield).
- Confine and contain the spill; wipe up any blood or body fluid spills immediately using either disposable towels or a product designed for this purpose. Dispose of materials by placing them into regular waste receptacle, unless the soiled materials are so wet that blood can be squeezed out of them, in which case they must be segregated into the biomedical waste container (i.e., yellow bag).
- Disinfect the entire spill area with a hospital disinfectant and allow it to stand for the amount of time recommended by the manufacturer.
- Wipe up the area again using disposable towels and discard into regular waste.
- Care must be taken to avoid splashing or generating aerosols during the cleanup.
- Remove gloves and perform hand hygiene.

Notes:

This tool is adapted from Health Canada's *Hand Washing, Cleaning, Disinfection and Sterilization in Health Care*, 1998 (p. 32) and Fallis, P. *Infection prevention and control in office-based health care and allied systems,* 2004.

Appendix 24: Sample Procedure for Cleaning a Biological Spill on Carpet

- Assemble materials required for dealing with the spill prior to putting on personal protective equipment.
- Restrict the activity around the spill until the area has been cleaned and disinfected and is completely dry.
- Put on gloves; if there is a possibility of splashing, wear a gown and facial protection (mask and eye protection or face shield).
- Mop up as much of the spill as possible using disposable towels.
- Disinfect the entire spill area with a hospital disinfectant and allow it to stand for the amount of time recommended by the manufacturer.
- Safely dispose of the cleanup materials and gloves by placing them in the waste receptacle, unless the soiled materials are so wet that blood can be squeezed out of them, in which case they must be segregated into the biomedical waste container (i.e., yellow bag).
- Remove gloves and perform hand hygiene.
- Carpeting should be removed, discarded, and not replaced by a new carpet (preferred) or cleaned with an industrial carpet cleaner as soon as possible.

NOTE: Carpeting must not be used in areas where spills of blood or other body substances may be anticipated (e.g., procedure rooms, intensive care units).

If sodium hypochlorite (bleach) is used to disinfect an area after a spill, follow the dilution ratios below:

- For a minor blood spill, use a bleach solution with 500 ppm free available chlorine:
  - Add 1 part of bleach (5.25%) to 99 parts of water to achieve a concentration of 500 ppm.[3,92]
- For a major blood spill, use a bleach solution with 5000 ppm free available chlorine:
  - Add 1 part of bleach (5.25%) to 9 parts of water to achieve a concentration of 5000 ppm.[3,92]

Notes:

This tool is adapted from Department of Health, New South Wales. *Cleaning Service Standards, Guidelines and Policy for NSW Health Facilities*. 1996.

Appendix 25: Sample Procedure for Infection Prevention and Control in the Event of a Flood or Water Activity

- Assess patient, visitor and staff safety; evacuate the area if required.
- Protect potentially affected equipment with plastic sheeting or move if possible.
- Contain the flood or leak if possible.
- In long-term care homes, report the incident to the facility manager.
- Disinfect surfaces of equipment and furniture before moving it from the affected area.
- Notify Infection Prevention and Control to assess the risk of contamination:
  - If water is contaminated with faecal material, the infection prevention and control professional will determine the need for personal protective equipment, hoarding, negative/positive pressure requirements, etc.
  - Infection prevention and control professional and occupational health and safety may be consulted regarding staff and patient safety.
  - Infection prevention and control professional will arrange for ongoing patient surveillance dependent on the patient population affected by the flood.
  - Infection prevention and control professional will recommend relocation of patients if required dependent on patient population.
- Following containment:
  - Discard all contaminated single-use sterile supplies.
  - Send contaminated reusable sterile supplies to be reprocessed.
  - Remove and discard contaminated carpeting.
  - Assess furniture and equipment to determine if it can be salvaged.
  - Assess building materials (e.g., ceiling tiles, drywall) and remove if required.
- Clean and sanitize the area. There must be proactive management of potential mould. Infection prevention and control professional to provide direction to remediation company.

Adapted from Sunnybrook Health Sciences Centre's Emergency Response Plan Manual (last revised November 5, 2010.)

Appendix 26: Safe Disposal of Sharps

To remove a needle and syringe that has been disposed of incorrectly:

- Put on a pair of gloves.
- Ideally, take a sharps container to the needle and syringe.
- NEVER re-cap a needle and syringe even if a cap is available.
- Use tongs, or puncture-resistant gloves, to pick up the needle and syringe.
- Carefully place the needle and syringe in the sharps container.
- Report the incident to your supervisor or manager.

Section Five:

Methodology, Evidence and References

Appendix 27: Search Strategies

A 27.1. Research Question: What Is the Role of Antimicrobial Materials and/or Antimicrobial Surfaces in Reducing Health Care-Associated Infections Within the Health Care Environment?

A 27.1.1 SEARCH STRATEGIES

Library Services of Public Health Ontario searched four databases from inception to November 30,2014 for peer-reviewed publications on the research question:

A 27.1.1.1 Database: Medical Literature Analysis and Retrieval System Online (MEDLINE)

1. (clean* or disinfect* or sanit* or decontaminat* or contaminat* or hygien* or steril* or ((universal or additional or housekeeping) adj3 (method* or practices or procedure* or policy or policies or precaution* or guideline* or guidance))).mp.
2. limit 1 to ("in data review" or in process or "pubmed not medline")
3. Decontamination/or Virus Inactivation/or exp Sanitation/ or exp Infection Control/or Housekeeping, Hospital/or Fomites/or "Hospital Design and Construction"/
4. "environmental cleaning".mp.
5. 2 or 3 or 4
6. (hospital* or ((surgical or patient* or outpatient or health* or tertiary or critical or medical or isolat* or intensive) adj2 (care or facility or clinic* or ward* or unit)) or launder* or laundry).mp.
7. limit 6 to ("in data review" or in process or "pubmed not medline")
8. exp health facilities/or exp health personnel/or exp housekeeping/
9. 7 or 8
10. ("health care acquired" or "health care associated" or "healthcare acquired" or "health care associated" or "hospital acquired" or "hospital associated" or nosocomial).mp.
11. exp Cross Infection/ or exp Disease Transmission, Infectious/
12. ((healthcare or "health care" or hospital) adj3 (transmission or transmit or infect* or outbreak)).mp.
13. 11 and 12
14. 10 or 13
15. exp Anti-Infective Agents/or Benzalkonium Compounds/ or Benzethonium/or Chlorhexidine/ or Hydrogen Peroxide/or Quaternary Ammonium Compounds/
16. (antimicro* or anti-micro* or biocidal or antibacterial or anti-bacterial or antiviral or anti-viral or antifungal or anti-fungal or bactericidal or fungicidal or virucidal or bacteriostatic or resistan*).mp.
17. (equipment or supplies or supply or coating* or surface* or material or product or paint* or plastic* or adhes* or copper or silver or alloy or novel or experiment* or polymer*).mp.
18. (15 or 16) and 17
19. 14 and 18
20. 5 and 9 and 18
21. 19 or 20
22. limit 21 to english language
23. remove duplicates from 22

A 27.1.1.2 Database: Excerpta Medica database (EMBASE)

1. (clean* or disinfect* or sanit* or decontaminat* or contaminat* or hygien* or steril* or ((universal or additional or housekeeping) adj3 (method* or practices or procedure* or policy or policies or precaution* or guideline* or guidance))).mp.
2. waste management/ or virus inactivation/or exp sanitation/or exp infection control/or hospital service/or fomite/or hospital design/
3. "environmental cleaning".mp.
4. 1 or 2 or 3
5. (hospital* or ((surgical or patient* or outpatient or health* or tertiary or critical or medical or isolat* or intensive) adj2 (care or facility or clinic* or ward* or unit)) or launder* or laundry).mp.
6. exp health care facility/ or exp health care personnel/or exp hospital service/
7. 5 or 6
8. ("health care acquired" or "health care associated" or "healthcare acquired" or "health care associated" or "hospital acquired" or "hospital associated" or nosocomial).mp.
9. exp cross infection/ or exp disease transmission/
10. ((healthcare or "health care" or hospital) adj3 (transmission or transmit or infect* or outbreak)).mp.
11. 9 and 10
12. 8 or 11
13. exp antiinfective agent/or benzalkonium/or benzethonium chloride/or chlorhexidine/or hydrogen peroxide/or quaternary ammonium derivative/
14. (antimicro* or anti-micro* or biocidal or antibacterial or anti-bacterial or antiviral or anti-viral or antifungal or anti-fungal or bactericidal or fungicidal or virucidal or bacteriostatic or resistan*).mp.
15. (equipment or supplies or supply or coating* or surface* or material or product or paint* or plastic* or adhes* or copper or silver or alloy or novel or experiment* or polymer*).mp.
16. (13 or 14) and 15
17. 12 and 16
18. 4 and 7 and 16
19. 17 or 18
20. limit 19 to english language
21. limit 20 to exclude medline journals
22. remove duplicates from 21

A 27.1.1.3 Database: Cumulative Index to Nursing and Allied Health Literature (CINAHL)

S20. S17 OR S18

S19. S17 OR S18

S18. S4 AND S7 AND S16

S17. S12 AND S16

S16. (S13 OR S14) AND S15

S15. (equipment OR supplies OR supply OR coating* OR surface* OR material OR product OR paint* OR plastic* OR adhes* OR copper OR silver OR alloy OR novel OR experiment* OR polymer*)

S14. (antimicro* OR anti-micro* OR biocidal OR antibacterial OR anti-bacterial OR antiviral OR anti-viral OR antifungal OR anti-fungal OR bactericidal OR fungicidal OR virucidal OR bacteriostatic OR resistan*)

S13. (MH "Antiinfective Agents+") OR (MH "Benzalkonium Compounds") OR "Benzethonium" OR (MH "Chlorhexidine") OR (MH "Hydrogen Peroxide") OR (MH "Quaternary Ammonium Compounds")

S12. S8 OR S11

S11. S9 AND S10

S10. ((healthcare OR "health care" OR hospital) N3 (transmission OR transmit OR infect* OR outbreak))

S9. (MH "Cross Infection+") OR (MH "Disease Transmission, Horizontal+")

S8. ("health care acquired" OR "health care associated" OR "healthcare acquired" OR "health care associated" OR "hospital acquired" OR "hospital associated" OR nosocomial)

S7. S5 OR S6

S6. (MH "Health Facilities+") OR (MH "Health Personnel+") OR (MH "Home Maintenance")

S5. (hospital* OR ((surgical OR patient* OR outpatient OR health* OR tertiary OR critical OR medical OR isolat* OR intensive) N2 (care OR facility OR clinic* OR ward* OR unit)) OR launder* OR laundry)

S4. S1 OR S2 OR S3

S3. "environmental cleaning"

S2. (MH "Decontamination, Hazardous Materials") OR (MH "Virus Inactivation") OR (MH "Sanitation+") OR (MH "Infection Control+") OR (MH "Housekeeping Department") OR "fomites" OR (MH "Hospital Design and Construction")

S1. (clean* OR disinfect* OR sanit* OR decontaminat* OR contaminat* OR hygien* OR steril* OR ((universal OR additional OR housekeeping) N3 (method* OR practices OR procedure* OR policy OR policies OR precaution* OR guideline* OR guidance)))

A 27.1.1.4 Database: Cochrane Database of Systematic Reviews (CDSR)

S19. S5 OR S7
S18. S16 OR S17
S17. S3 AND S6 AND S15
S16. S11 AND S15
S15. (S12 OR S13) AND S14
S14. (equipment OR supplies OR supply OR coating* OR surface* OR material OR product OR paint* OR plastic* OR adhes* OR copper OR silver OR alloy OR novel OR experiment* OR polymer*)
S13. (antimicro* OR anti-micro* OR biocidal OR antibacterial OR anti-bacterial OR antiviral OR anti-viral OR antifungal OR anti-fungal OR bactericidal OR fungicidal OR virucidal OR bacteriostatic OR resistan*)
S12. ((ZU "anti-infective agents administration & dosage" OR (ZU "quaternary ammonium compounds therapeutic use") OR (ZU "hydrogen peroxide administration & dosage")) OR (ZU "chlorhexidine")
S11. S7 OR S10
S10. S8 AND S9
S9. ((healthcare OR "health care" OR hospital) N3 (transmission OR transmit OR infect* OR outbreak))
S8. (ZU "cross infection transmission") OR (ZU "cross infection prevention & control") OR (ZU "disease transmission, infectious")
S7. ("health care acquired" OR "health care associated" OR "healthcare acquired" OR "health care associated" OR "hospital acquired" OR "hospital associated" OR nosocomial)
S6. S4 OR S5
S5. (ZU "health facility environment") OR (ZU "health personnel") OR (ZU "housekeeping methods")
S4. (hospital* OR ((surgical OR patient* OR outpatient OR health* OR tertiary OR critical OR medical OR isolat* OR intensive) N2 (care OR facility OR clinic* OR ward* OR unit)) OR launder* OR laundry)
S3. S1 OR S2
S2. ((ZU "decontamination")) or ((ZU "infection control"))
S1. (clean* OR disinfect* OR sanit* OR decontaminat* OR contaminat* OR hygien* OR steril* OR ((universal OR additional OR housekeeping) N3 (method* OR practices OR procedure* OR policy OR policies OR precaution* OR guideline* OR guidance)))

A 27.2. Research Question: What Is the Role of No-Touch Disinfection Systems in Addition to, or As Compared With, Standard Methods of Cleaning and Disinfection?

A 27.2.1 SEARCH STRATEGIES

Library Services of Public Health Ontario searched four databases from inception to July 31, 2015 for peer-reviewed publications on the research question:

A 27.2.1.1 Database: Medical Literature Analysis and Retrieval System Online (MEDLINE)

1. (clean* or disinfect* or sanit* or decontaminat* or contaminat* or hygien* or steril* or germicid* or bactericid* or inactivat* or ((universal or additional or housekeeping) adj3 (method* or practice* or procedure* or policy or policies or precaution* or guideline* or guidance))).mp.
2. limit 1 to ("in data review" or in process or "pubmed not medline")
3. Decontamination/or Virus Inactivation/or exp Sanitation/ or exp Infection Control/or Housekeeping, Hospital/or Fomites/or "Hospital Design and Construction"/or exp Anti-Infective Agents/or Benzalkonium Compounds/or Benzethonium/or Chlorhexidine/or Hydrogen Peroxide/or Quaternary Ammonium Compounds/or Disinfection/or Disinfectants/or Environmental Microbiology/or exp Equipment Contamination/or Viral Load/or Bacterial Load/
4. "environmental cleaning".mp.
5. 2 or 3 or 4
6. (hospital* or ((surgical or patient* or outpatient or health* or tertiary or critical or medical or isolat* or intensive) adj2 (care or facility or clinic* or ward* or unit)) or launder* or laundry).mp.
7. limit 6 to ("in data review" or in process or "pubmed not medline")
8. exp health facilities/or exp health personnel/or exp housekeeping/
9. 7 or 8
10. ("health care acquired" or "health care associated" or "healthcare acquired" or "health care associated" or

"hospital acquired" or "hospital associated" or nosocomial).mp.

11. exp Cross Infection/ or exp Disease Transmission, Infectious/
12. ((healthcare or "health care" or hospital) adj3 (transmission or transmit or infect* or outbreak)).mp.
13. 11 and 12
14. 10 or 13
15. ("no touch" or touchless or automat* or "hands free").mp.
16. (("ultra violet" or ultraviolet or "UV radiation" or light or vapo?r* or mist or aerosol* or ozone or spectrum or fumigat* or fog* or plasma or "air ion*") adj5 (clean* or disinfect* or sanit* or decontaminat* or contaminat* or hygien* or steril* or germicid* or bactericid* or inactivat* or effic* or reduc* or infect* or virus*)).mp.
17. 5 and (9 or 14) and 15
18. (9 or 14) and 16
19. 17 or 18
20. limit 19 to english language
21. remove duplicates from 20

A 27.2.1.2 Database: Excerpta Medica database (EMBASE)

1. (clean* or disinfect* or sanit* or decontaminat* or contaminat* or hygien* or steril* or germicid* or bactericid* or inactivat* or ((universal or additional or housekeeping) adj3 (method* or practice* or procedure* or policy or policies or precaution* or guideline* or guidance))).mp.
2. Waste management/or virus inactivation.mp. or sanitation/or exp microbial contamination/or environmental sanitation/or cleaning/or contamination/ or infection control/or hospital service/or fomite/or hospital design/or exp antiinfective agent/or benzalkonium/or benzethonium chloride/or chlorhexidine/or hydrogen peroxide/or exp quaternary ammonium derivative/or disinfection/or disinfectant agent/or microbiology/or medical device contamination/or virus load/or bacterial load/ [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword]
3. environmental cleaning.mp.
4. or/1-3
5. (hospital* or ((surgical or patient* or outpatient or health* or tertiary or critical or medical or isolat* or intensive) adj2 (care or facility or clinic* or ward* or unit)) or launder* or laundry).mp.
6. exp health care facility/or exp health care personnel/
7. or/5-6
8. ("health care acquired" or "health care associated" or "healthcare acquired" or "health care associated" or "hospital acquired" or "hospital associated" or nosocomial).mp.
9. Cross infection/or exp disease transmission/
10. ((healthcare or "health care" or hospital) adj3 (transmission or transmit or infect* or outbreak)).mp.
11. and/9-10
12. or/8,11
13. ("no touch" or touchless or automat* or "hands free").mp.
14. (("ultra violet" or ultraviolet or "UV radiation" or light or vapo?r* or mist or aerosol* or ozone or spectrum or fumigat* or fog* or plasma or "air ion*") adj5 (clean* or disinfect* or sanit* or decontaminat* or contaminat* or hygien* or steril* or germicid* or bactericid* or inactivat* or effic* or reduc* or infect* or virus*)).mp.
15. 4 and (7 or 12) and 13
16. (7 or 12) and 14
17. or/15-16
18. limit 17 to english language
19. limit 18 to exclude medline journals
20. remove duplicates from 19
21. limit 20 to dd=20141211-20150729
22. limit 21 to yr="2014 -Current"

A 27.2.1.3 Database: Cumulative Index to Nursing and Allied Health Literature (CINAHL)

S20. S15 OR S16

S19. S15 OR S16

S18. S15 OR S16

S17. S15 OR S16

S16. (S7 OR S12) AND S14

S15. S4 AND (S7 OR S12) AND S13

S14. TI ((("ultra violet" or ultraviolet or "UV radiation" or light or vapo?r* or mist or aerosol* or ozone or spectrum or fumigat* or fog* or plasma or "air ion*") N5 (clean* or disinfect* or sanit* or decontaminat* or contaminat* or hygien* or steril* or germicid* or bactericid* or inactivat* or effic* or reduc* or infect* or virus*))) OR AB ((("ultra violet" or ultraviolet or "UV radiation" or light or vapo?r* or mist or aerosol* or ozone or spectrum or fumigat* or fog* or plasma or "air ion*") N5 (clean* or disinfect* or sanit* or decontaminat* or contaminat* or hygien* or steril* or germicid* or bactericid* or inactivat* or effic* or reduc* or infect* or virus*))) OR MW ((("ultra violet" or ultraviolet or "UV radiation" or light or vapo?r* or mist or aerosol* or ozone or spectrum or fumigat* or fog* or plasma or "air ion*") N5 (clean* or disinfect* or sanit* or decontaminat* or contaminat* or hygien* or steril* or germicid* or bactericid* or inactivat* or effic* or reduc* or infect* or virus*)))

S13. TI (("no touch" or touchless or automat* or "hands free")) OR AB (("no touch" or touchless or automat* or "hands free")) OR MW (("no touch" or touchless or automat* or "hands free"))

S12. S8 OR S11

S11. S9 AND S10

S10. TI (((healthcare or "health care" or hospital) N3 (transmission or transmit or infect* or outbreak))) OR AB (((healthcare or "health care" or hospital) N3 (transmission or transmit or infect* or outbreak))) OR MW (((healthcare or "health care" or hospital) N3 (transmission or transmit or infect* or outbreak)))

S9. (MH "Cross Infection") OR (MH "Disease Transmission+")

S8. TI (("health care acquired" or "health care associated" or "healthcare acquired" or "health care associated" or "hospital acquired" or "hospital associated" or nosocomial)) OR AB (("health care acquired" or "health care associated" or "healthcare acquired" or "health care associated" or "hospital acquired" or "hospital associated" or nosocomial)) OR MW (("health care acquired" or "health care associated" or "healthcare acquired" or "health care associated" or "hospital acquired" or "hospital associated" or nosocomial))

S7. S5 OR S6

S6. (MH "Health Facilities+") OR (MH "Health Personnel+")

S5. AB ((hospital* or ((surgical or patient* or outpatient or health* or tertiary or critical or medical or isolat* or intensive) N2 (care or facility or clinic* or ward* or unit)) or launder* or laundry)) OR TI ((hospital* or ((surgical or patient* or outpatient or health* or tertiary or critical or medical or isolat* or intensive) N2 (care or facility or clinic* or ward* or unit)) or launder* or laundry)) OR MW ((hospital* or ((surgical or patient* or outpatient or health* or tertiary or critical or medical or isolat* or intensive) N2 (care or facility or clinic* or ward* or unit)) or launder* or laundry))

S4. S1 OR S2 OR S3

S3. TI "environmental cleaning" OR AB "environmental cleaning" OR "environmental cleaning"

S2. TI ((clean* or disinfect* or sanit* or decontaminat* or contaminat* or hygien* or steril* or germicid* or bactericid* or inactivat* or fomite* or “bacterial load” or benzethonium or ((universal or additional or housekeeping) N3 (method* or practice* or procedure* or policy or policies or precaution* or guideline* or guidance)))) OR AB ((clean* or disinfect* or sanit* or decontaminat* or contaminat* or hygien* or steril* or germicid* or bactericid* or inactivat* or fomite* or “bacterial load” or benzethonium or ((universal or additional or housekeeping) N3 (method* or practice* or procedure* or policy or policies or precaution* or guideline* or guidance)))) OR MW ((clean* or disinfect* or sanit* or decontaminat* or contaminat* or hygien* or steril* or germicid* or bactericid* or inactivat* or fomite* or “bacterial load” or benzethonium or ((universal or additional or housekeeping) N3 (method* or practice* or procedure* or policy or policies or precaution* or guideline* or guidance))))

S1. (MH "Virus Inactivation") OR (MH "Sanitation") OR (MH "Infection Control+") OR (MH "Housekeeping Department") OR (MH "Hospital Design and Construction") OR (MH "Antiinfective Agents+") OR (MH "Benzalkonium Compounds") OR (MH "Chlorhexidine") OR (MH "Hydrogen Peroxide") OR (MH "Quaternary Ammonium Compounds") OR (MH "Disinfectants") OR (MH "Environmental Microbiology") OR (MH "Equipment Contamination") OR (MH "Microbial Contamination+") OR (MH "Viral Load")

A 27.2.1.4 Database: Cochrane Database of Systematic Reviews (CDSR)

S7. S1 AND S4 AND S5

S6. S1 AND S4 AND S5

S5. S2 OR S3

S4. "no touch" or touchless or automat* or "hands free" OR (("ultra violet" or ultraviolet or "UV radiation" or light or vapo?r* or mist or aerosol* or ozone or spectrum or fumigat* or fog* or plasma or "air ion*") N5 (clean* or disinfect* or sanit* or decontaminat* or contaminat* or hygien* or steril* or germicid* or bactericid* or inactivat* or effic* or reduc* or infect* or virus*))

S3. "health care acquired" or "health care associated" or "healthcare acquired" or "health care associated" or "hospital acquired" or "hospital associated" or nosocomial OR cross infect* OR disease transmission OR ((healthcare or "health care" or hospital) N3 (transmission or transmit or infect* or outbreak))

S2. (hospital* or ((surgical or patient* or outpatient or health* or tertiary or critical or medical or isolat* or intensive) N2 (care or facility or clinic* or ward* or unit)) or launder* or laundry OR physician* OR doctor* OR nurse* OR pharmacist* OR dieti?ian* OR therapist* OR physiotherapist* OR health* N2 worker*) OR (health* N2 personnel) OR (health* N2 practitioner*)OR housekeeping

S1. (clean* or disinfect* or sanit* or decontaminat* or contaminat* or hygien* or steril* or germicid* or bactericid* or inactivat* or ((universal or additional or housekeeping) N3 (method* or practice* or procedure* or policy or policies or precaution* or guideline* or guidance)) OR virus inactivat* OR infection control* OR housekeeping OR fomite* OR hospital design* OR anti-infective agent* OR benzalkonium OR kenzethonium OR chlorhexidine OR hydrogen peroxide OR quaternary ammonium OR viral load* OR bacterial load*)

Appendix 28: Criteria for Literature Inclusion and Exclusion

B 28.1 Antimicrobial Surfaces

Literature retrieved on antimicrobial surfaces were selected for evidence review based on the following criteria:

B 28.1.1 INCLUSION CRITERIA

- Antimicrobial coating on surfaces (those within the health care environment and that have an impact on transmission of infections) or fabrics, or surface treatment with lingering effects.
- Conducted in the health care setting.
- Written in English.
- Peer-reviewed studies of the following designs: controlled trials, interrupted time series, controlled or uncontrolled before-after; systematic reviews and meta-analyses.
- Dealing with the reduction in antibiotic-resistant organism colonization or infection, or the reduction in health care-associated infections.

B 28.1.2 EXCLUSION CRITERIA

- Ambulatory care setting due to its limited capacity to conduct surveillance of health care-associated infections.
- No potential application in the health care setting.
- Related to medical device, i.e., semi-critical and critical devices.
- Related to sanitation, e.g., food, water, sewage, etc.
- Antimicrobial fabrics that are not housekeeping surfaces, e.g., scrubs, gowns, gloves.
- Any study types not mentioned in the inclusion criteria.

B 28.2 No-Touch Disinfection Systems

Literature retrieved on no-touch disinfection systems were selected for evidence review based on the following criteria:

B 28.2.1 INCLUSION CRITERIA

- Comparison between a no touch disinfection system with manual cleaning and disinfection or another no touch disinfection system.
- Conducted in patient rooms within an inpatient setting in a hospital or long-term care home.
- Disinfection systems designed to disinfect surfaces using physical or chemical agents that act across distances and do not require direct physical application to surfaces.
- Dealing with the reduction in antibiotic-resistant organism colonization or infection, or the reduction in health care-associated infections, using standard (e.g., Centers for Disease Control and Prevention) definitions; or the reduction in surface microbial contamination that occurs as a result of usual clinical care.
- Peer-reviewed studies of the following designs: controlled trials, interrupted time series, controlled or uncontrolled before-after.
- Written in English.

B 28.2.2 EXCLUSION CRITERIA

- Air purification or disinfection systems.
- Deliberately contaminated surfaces with test pathogens before applying no touch disinfection.

Appendix 29: Evidence Tables

A 29.1 Antimicrobial Surfaces

A 29.1.1 STUDY DESIGN

Table 16: Study Design of Articles on Antimicrobial Surfaces with Health Care-Associated Infections as Outcomes

Author	Design	GRADE Rating	Population, Setting, and Sample Size	Intervention	Comparison	Outcome Measure	Duration	Funding
Salgado [380]	NCRT[a]	Low quality[b]	3 ICU at 3 hospitals 650 "randomized" and 615 analyzed by ITT[c]	8 rooms contained 6 items surfaced with copper alloy[d] Patients admitted to ICU were assigned to an intervention room, a control room, or a nonstudy room using the hospital process for room assignment (i.e., not randomized).	Items made of standard materials (not specified) in 8 control rooms	HAI incidence or new MRSA/VRE colonization HAI, MRSA or VRE considered ICU acquired using NHSN definitions	11 month study Patients followed throughout ICU stay and until 48 hours of discharge	US department of defense Authors affiliated with the copper development association
Lazary [385]	UCBA	Very low quality	LTCF ward 108 patients	Copper containing linens (sheets and pillowcases; patient shirts, pants and gowns; towels; underpads; personnel robes	Standard items	HAI defined using Embry/ Chinnes and McGeer criteria	6 month baseline period and 6 month non-contiguous intervention period	Cuprion Inc.

Abbreviations used: NCRT = nonrandomized controlled trial; ICU = intensive care unit; ITT = interrupted time series; HAI = health care-associated infection; MRSA = methicillin-resistant *Staphylococcus aureus*; VRE = vancomycin-resistant enterococci; NHSN = National Healthcare Safety Network; UCBA = uncontrolled before-after; LTCF = long-term care facility

a. Study described as randomized but no mechanism of randomization—therefore classified as nonrandomized controlled trail.

b. Study is incompletely blinded, no patient level data collected to allow for assessment of confounding, no control for confounding based on patient risk of health care-associated infections—therefore does not qualify for consideration of upgrading evidence level despite large treatment effect.

c. Not true ITT; no sensitivity analysis.

d. All rooms included copper-surfaced bed rails, overbed tables, iv poles and arms of visitors chair. In addition, 2 of the following were also surfaced with copper in each room: call button, computer mouse or bezel of touch screen monitor.

A 29.1.2 RESULTS AND COMMENTS

Table 17: Results of Studies on Antimicrobial Surfaces with Health Care-Associated Infections as Outcomes

Author	Comment on Design	Results	Overall Comments
Salgado [380]	Not blinded Some cross-over of objects occurred with copper objects entering noncopper rooms and vice versa	7.14% (21/294) had HAI/MRSA/VRE in intervention group vs. 12.81% (41/320) in the control group (p=0.02) Relative risk reduction = 44%[a] Absolute risk reduction = 5.7%	Reduction was seen for both HAI and MRSA/VRE but in subgroup analysis significant only for HAI. The plausibility is questionable for the degree of benefit given the multifactorial nature of HAI causation, the limited number of copper coated surfaces, and some cross-over of copper and noncopper items. Not sure if the patients in the intervention and the control groups are equal, e.g., who were on antibiotic treatment The study may not be powered to detect HAI alone, hence the composite outcome HAI/ARO was used. Note that the outcome of ARO colonization was not significant.
Lazary [385]	Significant differences in intervention and control groups at baseline biased against null hypothesis	20.8 HAI per 1000 pt-days (intervention) vs. 27.4 HAI per 1000 pt-days (control) p=0.046 Relative risk reduction = 24% Absolute risk reduction = 6.6%	Patients during the intervention phase were less likely to have urinary catheters (22% vs. 31%), less likely to have pressure sores (17% vs. 26%), and less likely to be on steroids (19% vs. 30%)

a. Such a large effect is not plausible; unexplained confounders may be present, as multiple factors contribute to transmission of HAI and ARO, and modification of several environmental surfaces alone is not expected to have caused such a large effect. Also, a smaller impact on ARO colonization than on HAI is not usually seen. In addition, one of the infections (pneumonia) is endogenous and should not be affected by environmental surfaces.

C 29.2 No-Touch Disinfection Systems

C 29.2.1 HYDROGEN PEROXIDE VAPOUR SYSTEMS

Table 18: Studies of Hydrogen Peroxide Vapour Systems in Non-Outbreak Circumstances Using Antibiotic-Resistant Organisms or Health Care-Associated Infections as Outcomes

Study	Design	Setting	HPV System	Pre-intervention	Intervention	Details	Outcome
Horn[400]	UCBA: 12M + 24M	1 H	Bioquell	C/D	C/D + HPV(SD) + hand hygiene monitoring	C/D: QAC for most rooms, liquid HP for CDI rooms (as Passaretti et al., 2013) HPV(SD): used for discharge cleaning for CDI, MRSA, VRE, and ESBL-E patients	For all 4 combined: 1.97 vs. 1.05 cases/1,000 PtD[†] (47% reduction[†])
Manian[403]	UCBA: 23M+12 M	1 H: 8 W	Bioquell	C/D	C/D + HPV(SD)	C/D: QAC or bleach Order for HPV(SD) room treatment priority: CDI/MRSA/VRE, ICU, other MDR-GNB, oncology, other rooms	CDI: 0.88 vs. 0.55 cases/1,000 PtD[†]
Mitchell[76]	Retro-spective UCBA: 46M+26 M	1 H	Nocospray	C	C + HPV(SD) + hand hygiene monitoring	C: clean with detergent HPV(SD):MRSA private rooms (or liquid HP for MRSA shared rooms) Comparison C: 2x clean with pH-neutral detergent	MRSA bacteremia: 0.016 vs. 0.011 cases/1000 PtD[‡] MRSA: 0.9 vs 0.53 cases/1,000 PtD[†]
Passaretti[404]	CBA (Non-standard design)[a]: 12M + 18M	6 W	Bioquell	C/D (as well as intervention period controls)	HPV(W) then C/D + HPV(SD)	C/D: QAC for most, liquid HP for CDI rooms HPV(W): whole ward disinfection, then HPV(SD): MRSA, VRE, CDI, MDR-GNB rooms where possible	MDRO: 15.7 vs. 6.2 cases/1,000 PtD[†, a]

Abbreviations: UCBA= uncontrolled before/after study, CBA= controlled before/after study, W= ward, H= hospital, ICU= intensive care unit, C/D= cleaning and disinfection, C= cleaning, QAC= quaternary ammonium compound, HPV= hydrogen peroxide vapour, HP= hydrogen peroxide, IC= infection control, HPV(W)= HPV for whole ward disinfection (entire ward treated simultaneously), HPV(WR)= entire ward treated on room-by-room basis, HPV(SD)= HPV for room disinfection after selected discharges, M= month, PtD= patient days, MRSA= methicillin-resistant *Staphylococcus aureus*, VRE= vancomycin-resistant *Enterococcus*, CDI= *Clostridium difficile* infection, ESBL-E= extended-spectrum–beta-lactamase-producing *Enterobacteriaceae*, MDR-GNB= multidrug-resistant Gram-negative bacteria, MDR-GNR= multidrug-resistant Gram-negative rods, MDR-AB= multidrug-resistant *Acinetobacter* species, MDRO= multidrug-resistant organisms.

[a] nontraditional study design with study set up as CBA study (12 month pre-intervention phase on all 6 units followed by 18 month intervention phase with HPV on 3 units and 3 control units) however analysis performed by combining pre-intervention data from 6 units with post-intervention data from control unit (i.e., MDRO incidence in patients admitted to MDRO room cleaned by standard methods) and comparing this with data from the intervention phase (i.e., MDRO incidence in patients admitted to MDRO room cleaned with HPV)

[b] pre- and post-intervention periods not contiguous (June-March of successive years)

† P<.05 (statistically significant)
‡ P>.05 (not statistically significant)
◊ statistical significance not reported

Table 19: Studies of Hydrogen Peroxide Vapour Systems in Outbreak Circumstances and Beyond Using Antibiotic-Resistant Organisms or Health Care-Associated Infections as Outcomes

Study	Design	Setting	HPV System	Pre-intervention	Intervention	Details	Outcome
Barbut [402]	UCBA: 21M+ 16M	1 W	Bioquell	C/D + IC bundle	HPV(W) then C/D + HPV(SD) + enhanced IC bundle	*HPV intervention triggered by an outbreak of MRSA C/D: detergent disinfectant HPV(SD): for MRSA, ESBL-E, MDR-AB rooms	MDRO: 15.3 vs. 2.3 cases/1,000 PtD†
Boyce [411]	UCBA: 10M+ 10M[b]	5 W	Bioquell	C/D, and C/D + IC bundle (midway through pre-int. period)	C + HPV(W) C + HPV(SD) + IC bundle	*HPV intervention triggered by CDI outbreak (NAP1 strain) C: cleaning to remove visible dirt HPV(SD): CDI patient rooms C/D: "traditional cleaning and disinfection" – bleach only introduced as part of IC bundle near end of pre-int. period	CDI: 1.4 vs. 0.84 cases/1,000 PtD‡ *Pre-int. period included the outbreak cases

Abbreviations: UCBA= uncontrolled before/after study, CBA= controlled before/after study, W= ward, H= hospital, ICU= intensive care unit, C/D= cleaning and disinfection, C= cleaning, QAC= quaternary ammonium compound, HPV= hydrogen peroxide vapour, HP= hydrogen peroxide, IC= infection control, HPV(W)= HPV for whole ward disinfection (entire ward treated simultaneously), HPV(WR)= entire ward treated on room-by-room basis, HPV(SD)= HPV for room disinfection after selected discharges, M= month, PtD= patient days, MRSA= methicillin-resistant *Staphylococcus aureus*, VRE= vancomycin-resistant *Enterococcus*, CDI= *Clostridium difficile* infection, ESBL-E= extended-spectrum–beta-lactamase-producing *Enterobacteriaceae*, MDR-GNB= multidrug-resistant Gram-negative bacteria, MDR-GNR= multidrug-resistant Gram-negative rods, MDR-AB= multidrug-resistant *Acinetobacter* species, MDRO= multidrug-resistant organisms

[a] nontraditional study design with study set up as CBA study (12 month pre-intervention phase on all 6 units followed by 18 month intervention phase with HPV on 3 units and 3 control units) however analysis performed by combining pre-intervention data from 6 units with post-intervention data from control unit (i.e., MDRO incidence in patients admitted to MDRO room cleaned by standard methods) and comparing this with data from the intervention phase (i.e., MDRO incidence in patients admitted to MDRO room cleaned with HPV)

[b] pre- and post-intervention periods not contiguous (June-March of successive years)

† P<.05 (statistically significant)

‡ P>.05 (not statistically significant)

Table 20: Studies of Hydrogen Peroxide Vapour Systems in Outbreak Circumstances Only Using Antibiotic-Resistant Organisms or Health Care-Associated Infections as Outcomes

Study	Design	Setting	HPV System	Pre-intervention	Intervention	Details	Outcome
Chmielarczyk[405]	UCBA: 9M+ 13M	2 W	Steris	C/D	C/D + HPV(W) + IC bundle	For outbreak control; both wards vacated/treated (on two separate occasions) C/D: HP, QAC, bleach, or others	MDR-AB: transmission terminated for 8 and 13+ months post-HPV
Otter[409]	UCBA: 9M+6M	1 W	Bioquell	C/D, C/D + IC bundle	C/D + HPV(W)	For outbreak control; ward vacated/treated (1x) C/D: detergent or 2000 ppm bleach	MDR-GNR: outbreak(9M) vs. post-HPV(6M): 1.7 vs. 1 cases/M[◊]
Ray[410]	UCBA: 7M	2W	Steris	C/D, C/D + IC bundle	C + HPV(SW)	For outbreak control; wards vacated/treated (1x) C/D: QAC used	MDR-AB: transmission stopped for 7M

Abbreviations: UCBA= uncontrolled before/after study, CBA= controlled before/after study, W= ward, H= hospital, ICU= intensive care unit, C/D= cleaning and disinfection, C= cleaning, QAC= quaternary ammonium compound, HPV= hydrogen peroxide vapour, HP= hydrogen peroxide, IC= infection control, HPV(W)= HPV for whole ward disinfection (entire ward treated simultaneously), HPV(WR)= entire ward treated on room-by-room basis, HPV(SD)= HPV for room disinfection after selected discharges, M= month, PtD= patient days, MRSA= methicillin-resistant *Staphylococcus aureus*, VRE= vancomycin-resistant *Enterococcus*, CDI= *Clostridium difficile* infection, ESBL-E= extended-spectrum–beta-lactamase-producing *Enterobacteriaceae*, MDR-GNB= multidrug-resistant Gram-negative bacteria, MDR-GNR= multidrug-resistant Gram-negative rods, MDR-AB= multidrug-resistant *Acinetobacter* species, MDRO= multidrug-resistant organisms

[a] nontraditional study design with study set up as CBA study (12 month pre-intervention phase on all 6 units followed by 18 month intervention phase with HPV on 3 units and 3 control units) however analysis performed by combining pre-intervention data from 6 units with post-intervention data from control unit (i.e., MDRO incidence in patients admitted to MDRO room cleaned by standard methods) and comparing this with data from the intervention phase (i.e., MDRO incidence in patients admitted to MDRO room cleaned with HPV)

[b] pre- and post-intervention periods not contiguous (June-March of successive years)

[†] P<.05 (statistically significant)

[‡] P>.05 (not statistically significant)

[◊] statistical significance not reported

Table 21: Studies of Hydrogen Peroxide Vapour Systems Using Microbial Contamination as Outcomes

Study	Setting	HPV system	Sampling	Details	Sampling method (area)	Outcome
Ali[398]	20 PR	Bioquell and Deprox	Post-C/D (pre-HPV), and post-HPV	C/D: peracetic acid disinfectant HPV: 10 rooms used to test each HPV system	CAP ($25\ cm^2$)	Total aerobic bacteria: Post-C/D, 96% of samples had detectable growth, compared to 50% (post-Bioquell) and 51% (post-Deprox)
Barbut[85]	2 H	Sterinis-Sterusil	Pre- and post-C/D samples in control and intervention rooms	Control: C/D: detergent, bleach Intervention: C/D: detergent, HPV *When CDI patients were discharged, rooms were cleaned with detergent, then randomized to intervention or control arm	MS ($100\ cm^2$)	CD: 91%[†] (HPV) vs. 50%[†] (bleach) reductions in # of positive samples 75%[†] (HPV) vs. 27%[‡] (bleach) reduction in % rooms with at least 1 positive sample
Barbut[402]	1 W	Bioquell	Whole ward: sampling 1 day pre-cleaning and 4 days post-cleaning Single room discharge: sampling post-C/D (pre-HPV) and post-HPV	C/D: detergent disinfectant HPV: used after C/D for whole ward, and discharge	MS ($100\ cm^2$)	Total aerobic bacteria: Whole ward: 4.0 vs. 0.7 CFU/100 $cm^{2,†,a}$ Discharge: 2.9 vs. 0.1 CFU/100 $cm^{2,†,a}$
Best[401]	1 W	Deprox	Pre-C/D, post-C/D (pre-HPV), post-HPV, and 20 weeks post-HPV	Unit cleaned manually over 1 week followed by HPV of entire unit C/D: chlorine-based sporicidal disinfectant	MSP ($25\ cm^2$)	CD-positive samples: 10.8% vs. 6.1% vs. 0.9% surfaces positive pre-C/D, pre-HPV, and post-HPV[◊] No positive surfaces at 19 days, 3.5% positive at 20 weeks[◊]
Blazejewski [399]	5 W	Bioquell and Anios	Pre-C/D, post-C/D (pre-HPV), and post-HPV	C/D: QAC Crossover design: Arm 1: 3 wards C/D + HPV (Bioquell) Arm 2: 2 wards C/D + HPV (Anios)	MS ($25\ cm^2$)	Total MDRO: statistically significant reductions in # of positive samples for both C/D and HPV stages
Boyce[411]	5 W	Bioquell	Post-C/D (pre-HPV), and post-HPV	C/D: Targeted cleaning of visible dirt with detergent; disinfection with bleach if CD-infected patient room HPV: whole ward	MSP ($1\ m^2$)	CD: 25.6% vs. 0% positive samples pre- and post-HPV[†]

Study	Setting	HPV system	Sampling	Details	Sampling method (area)	Outcome
				disinfection at start of study, then HPV cleaning of CD-infected patient rooms for duration of study		
Chan[408]	1 H	Nocospray	Pre-C, post-C (pre-HPV), and post-HPV or if no HPV used, sampled once, post-C/D	C + HPV: neutral detergent, then HPV C/D: neutral detergent, then 500 ppm chlorine-based disinfectant	CAP ($20\ cm^2$)	Total aerobic bacteria: The C+HPV resulted in less growth per sample than the C/D[◊] For the C+HPV tests, little to no reductions after detergent clean, but very few CFU/sample after HPV[◊]
French[415]	1 W	Bioquell	Control rooms: pre- and post-C/D HPV rooms: pre/post-HPV (no detergent used pre-HPV)	C/D: detergent sanitizer HPV: used after discharge, but before C/D	MS ($25\ cm^2$)	MRSA: 72% vs. 1.2% positive samples before/after HPV[◊] For control rooms, 89% vs. 66% before/after terminal cleaning[◊]
Hardy[414]	1 W	Bioquell	Periodic sampling in 3 months prior to HPV, then immediately pre-C, immediately post-C (pre-HPV), and post-HPV	C: detergent only *ICU vacated, deep-cleaned and then treated with HPV	MS ($10\ cm^2$)	MRSA: 11.2% of sites positive in 3 months prior to HPV. No sites positive immediately after HPV, but recolonization to pre-HPV levels within 24 hours Total aerobic bacteria: mean counts reduced from ~150 CFU/cm^2 to ~3 CFU/cm^2, but returned to pre-HPV levels within 1 week
Havill[406]	15 PR	Bioquell	Post-C/D (pre-HPV) and post-HPV	C/D: QAC or 10% bleach wipes	CAP ($33\ cm^2$)	Total aerobic bacteria: Pre-HPV, 93% of samples yielded growth vs. 7% post-HPV[†]. Of samples showing growth, avg. CFU/sample pre-HPV was 33.1 vs. 0.1 post-HPV
Mitchell[76]	1 H	Nocospray	Controls: sampling after 2x C HPV: sampling after C + HPV	C: clean with pH neutral detergent C + HPV: one clean with detergent, then HPV (single rooms) or liquid HP (shared rooms)	MS[n]	MRSA: 24.3% vs. 18.8% rooms had at least one positive sample for controls compared to HPV[†]

Study	Setting	HPV system	Sampling	Details	Sampling method (area)	Outcome
Otter[413]	1 PR	Bioquell	Pre-C/D, post-C/D (pre-HPV), post-HPV	C/D: QAC	MS ($25\ cm^2$)	Percentage of sites with isolates for each sampling period, respectively: MRSA: 60% to 40% to 3.3%[◊] GNR: 30% to 10% to 0%[◊] VRE: 6.7% to 6.7% to 0%[◊]
Otter[409]	1 W	Bioquell	Post-C/D (pre-HPV), and post-HPV	C/D: bleach, with 70% ethanol for equipment *Unit vacated, C/D, then treated with HPV	MSG ($100\ cm^2$)	GNR: HPV reduced positive sites from 48% (10/21) to 0% (0/63)[◊]
Passaretti[404]	6 W	Bioquell	Sporadic environmental sampling in HPV and non-HPV treatment wards	Non-HPV wards C/D: QAC, or liquid HP for CD rooms HPV wards: same C/D, but with added HPV	MS, MSP for CD (both $25\ cm^2$)	Non-HPV wards: 23.7% (pre-int) to 28.5% (int.) of rooms contaminated with any MDRO[‡] HPV wards: 21.2% (pre-int) to 13.9% (int.) of rooms contaminated with any MDRO[†]
Ray [410]	2 W	Steris	Post-C/D (pre-HPV), and post-HPV	C/D: QAC used *Ward vacated, terminally cleaned and then treated with HPV	MS^n	MDR-AB: 8/93 positive pre-clean, no positives until 2 weeks post-HPV[◊]
Shapey[412]	7 W	Sterinis	Post-C/D (pre-HPV), then post-HPV	C/D: detergent, or detergent + bleach if CD room	MS ($100\ cm^2$ or $400\ cm^2$)	CD: 24% vs. 3% surfaces positive[◊] 100% vs 50% rooms with at least 1 positive sample[◊]
Taneja[407]	1 ED	Ecoshield	Post-C (pre-HPV), and post-HPV	C: detergent clean *ED vacated, then cleaned and treated with HP fog	MS ($100\ cm^2$)	SA: 891 vs. 0 colonies[◊] MRSA: 379 vs. 0 colonies[◊] Total aerobic bacteria: 2-6.5 $\log_{10}$ reduction in CFU[◊]

Abbreviations: H= hospital, W= ward, ED= emergency department, PR= patient rooms, ICU= intensive care unit, IC= infection control, C/D= cleaning and disinfection, QAC= quaternary ammonium compound, HPV= hydrogen peroxide vapour, HP= hydrogen peroxide, M= month, PtD= patient days, MRSA= methicillin-resistant *Staphylococcus aureus*, SA= *Staphylococcus aureus*, MDRO= multidrug-resistant organism, MDR-AB= multidrug-resistant *Acinetobacter* species, GNR= Gram-negative rods, ESBL=Extended-spectrum beta-lactamase-producing Gram-negative bacilli, CD= *Clostridium difficile*, CDI= *Clostridium difficile* infection, VRE= vancomycin-resistant *Enterococcus*, MS= moistened swab, MSP= moistened sponges, MSG= moistened sterile gauze, CAP= contact agar plates, CFU= colony forming units

[†] P<.05 (statistically significant)
[‡] P>.05 (not statistically significant)

◊ statistical significance not reported
n surface area not specified

C 29.2.2 ULTRAVIOLET SYSTEMS

Table 22: Studies of Ultraviolet Light Systems Using Antibiotic-Resistant Organisms or Health Care-Associated Infections as Outcomes

Study	Design	Setting	System	Pre-intervention	Intervention	Details	Outcome
Haas[416]	UCBA: 30M+22M	1 H	Xenex	Pre-int., C/D	C/D + UVC	C/D: bleach (adult), QAC (ped.), bleach for all discharge cleaning UVC: pulsed xenon, 3 locations/rm *UVC used for contact precaution discharges, dialysis unit, burn unit, and on request	MDRO+CD rate: 2.67 vs. 2.14 cases/1,000 PtD†
Levin[445]	UCBA: 36M+12M	1 H	Xenex	Pre-int., C/D	C/D + UVC	C/D: QAC (non-CD rooms), bleach (CD rooms) UVC: pulsed xenon, 3 locations/rm * contact precaution rooms given highest priority for UVC treatment	HA-CDI: 9.46 cases/10,000 PtD in 2010 vs. 4.45 cases/10,000 PtD in 2011 (53% reduction†)
Miller[444]	UCBA: 24M + 27M	1 H	Xenex	Pre-int., C/D + IC bundle (midway through pre-int. period)	C/D + UVC + IC bundle	C/D: bleach UVC: pulsed xenon, used in several positions *UVC used more frequently in high-traffic and communal areas vs. discharge cleaning	CDI: 23.3 or 19.3 (for each stage pre-UVC) vs. 8.3 cases/10,000 PtD† post-UVC

Study	Design	Setting	System	Pre-intervention	Intervention	Details	Outcome
Nagaraja[443a]	UCBA: 12M + 12M	1 H	Xenex	Pre-int., C/D	C/D + UVC	C/D: bleach (adult), QAC (ped.), bleach for all discharge cleaning UVC: pulsed xenon, 3 locations/rm *UVC used for contact precaution discharges, dialysis unit, burn unit, and on request	HA-CDI: 1.06 vs. 0.86 cases/1,000 (22% decrease‡) *no change in total CDI rates, as there was an increase in community-acquired CDI
Napolitano[4 41]	UCBA: 5M + 6M	125 PR	Infection Prevention Technologies	Pre-int., C	C + UVC	C: "bioload removal" (no other details) UVC: low pressure amalgam	All HAI: 3.7 vs. 2.4 cases/1,000 PtD†
Simmons[77]	UCBA: 16M+17M	3 H	Xenex	Pre-int., C/D	C/D + UVC + IC bundle	C/D: not specified UVC: pulsed xenon, 3 locations/rm	HA-MRSA: reduced overall by 57%†, (in each individual facility: 56%†, 51%‡, 66%‡)
Vianna[442]	UCBA: 22M + 22M	1 H	Xenex	Pre-int., C, C/D	C/D + UVC	C/D: bleach for CDI rooms, standard cleaning for other rooms UVC: pulsed xenon, 3 locations/rm *UVC used for all ICU discharges, and CDI rooms outside ICU	CDI, MRSA, VRE rates combined: Whole facility: 1.51 vs. 1.07 cases/1,000 PtD† ICU: 6.77 vs. 2.63 cases/1,000 PtD† Non-ICU: 1.26 vs. 0.99 cases/1,000 PtD‡

Abbreviations: UCBA= uncontrolled before/after study, H= hospital, ICU= intensive care unit, PR= patient rooms, C/D= cleaning and disinfection, C= cleaning, QAC= quaternary ammonium compound, IC= infection control, M= month, PtD= patient days, HAI= healthcare-associated infection, MRSA= methicillin-resistant *Staphylococcus aureus*, HA-MRSA= healthcare-associated MRSA, CD= *Clostridium difficile*, CDI= *Clostridium difficile* infection, HA-CDI= healthcare-associated CDI, MDRO= multidrug-resistant organisms, VRE= vancomycin-resistant *Enterococcus*

[a] Same study as Haas et al., 2014, but with focus on CDI

† P<.05 (statistically significant)

‡ P>.05 (not statistically significant)

Table 23: Studies of Ultraviolet Light Systems Using Microbial Contamination as Outcomes

Study	Setting	System	Sampling	Details	Sampling method (area)	Outcome
Andersen[421]	4 PR	Klean ASA system – Z-300 for ceiling, Z-30 for walls	Pre-C Post-C (pre-D) Post-D (pre-UVC), and post-UVC	C: non-antibacterial soap/water D: 5% chloramine UVC: wall and ceiling-mounted UVC units	CAP (20 cm^2)	Total aerobic bacteria: C: 22.0 CFU/sample (+/- 37.2) C/D: 4.1 CFU/sample (+/- 6.0)† C/UVC: 1.8 CFU/sample (+/- 3.4)† C/D + UVC: 0.5 CFU/sample (+/- 1.0)†
Boyce[418]	25 PR	Lumalier Tru-D	Post-C/D (pre-UVC), and post-UVC	C/D: terminal cleaning not described in-text Expt 1: One-stage UVC Expt 2: Two-stage UVC (bathroom and main room)	CAP (33 cm^2)	Total aerobic bacteria: Expt 1: Overall, # of samples with at least one culture decreased from 90% (90/100) to 47% (42/90) pre/post-UVC†. Mean counts decreased on all 5 surfaces sampled (only 3 of 5 reductions stat. sig.) Expt 2: Slightly better than Expt 1
Havill[406]	15 PR	Lumalier Tru-D	Post-C/D (pre-UVC), and post-UVC	C/D: QAC or 10% bleach wipes UVC: 1 position/PR, sporicidal setting	CAP (33 cm^2)	Total aerobic bacteria: Pre-UVC, 91% of samples yielded growth vs. 49% post-UVC†, and of samples showing growth post-UVC, between 2 and 160 CFU/sample
Jinadatha[417]	20 PR	Xenex	Pre- and post-C/D in arm 1 Pre- and post-aesthetic clean/UVC in arm 2	Arm 1: 10 rooms, C/D (thorough disinfection using bleach wipes) Arm 2: 10 rooms, visibly soiled areas cleaned with bleach wipes, then UVC	CAP (79 cm^2)	Total aerobic bacteria: 76.3% reduction (C/D) vs. 98.1% (UVC) in average counts† MRSA: 91.1% reduction (C/D) vs. 99.4% (UVC) in average counts†
Napolitano[441]	6 PR	Infection Prevention Technologies IRiS 3200m	Pre-C/D, post-C/D (pre-UVC), and post-UVC	C/D: not described UVC: 1 position/PR	MS (25 cm^2)	Total aerobic bacteria: Plates with growth: 55.6% vs. 50% vs. 11.1% (only the UVC reduction was stat. sig.)
Nerandzic[420]	66 PR/ 26 PR	Lumalier Tru-D	66 PR: sampling before/after UVC (no C/D) 26 PR: sampling after C/D (pre-UVC) and post-	C/D: not described	MS (100 cm^2)	66 PR: # sites positive for MRSA, VRE, CD all reduced†, and mean CFU for each reduced† 26 PR: After manual cleaning, 18% of samples from under bedside tables were positive for MRSA (no other sites tested positive). After UVC, none were positive†

Study	Setting	System	Sampling	Details	Sampling method (area)	Outcome
			UVC			
Sitzlar[254]	1 H, 1 LTCH	Lumalier Tru-D	Baseline sampling during pre-intervention period, and sampling during each intervention period	Period 1: (14 M) Fluorescent markings/follow up with cleaning staff Period 2: (4 M) Period 1 plus UVC added for terminal disinfection Period 3: (3 M) Period 1+2 plus a dedicated team for terminal cleaning of CDI rooms	MS[n]	CD: Reduction in # of CDI rooms with positive cultures compared to baseline period: Period 1: 14%[†] Period 2: 48%[†] Period 3: 89%[†]
Stibich[419]	12 PR	Xenex	Pre-C/D, post-C/D (pre-UVC), and post-UVC	C/D: phenol/alcohol disinfectant UVC: system was used in 3 positions/PR	MS (6.5 cm^2)	Total aerobic bacteria: Mean 33.0 CFU/cm^2 to 27.4 CFU/$cm^{2†}$ to 1.2 CFU/$cm^{2†}$ VRE: Number of surfaces positive for VRE were 17/75 (23.3%) to 4/91 (8.2%)[◊] to 0/75 (0%)[◊]
Wong[440]	61 PR	Lumalier Tru-D, and Steriliz R-D Rapid Disinfector	Pre-C/D, post-C/D (pre-UVC), and post-UVC	C/D: neutral detergent for floors, accelerated hydrogen peroxide for surfaces UVC: Not clear when they used each device (Lumalier or Steriliz)	CAP, MMS (both 33 cm^2)	Total aerobic bacteria: Mean CFU of high-touch surfaces: 88.0 vs. 19.6 vs. 1.3 (all reductions stat. sig.) Contamination of surfaces with MRSA, VRE or CD: 63.9% vs. 52.5% vs. 8.2% (only final UVC reduction was stat. sig.)

Abbreviations: H= hospital, W= ward, PR= patient room, ICU= intensive care unit, LTCH= long-term care home, IC= infection control, C= cleaning, D= disinfection, C/D= cleaning and disinfection, QAC= quaternary ammonium compound, M= month, PtD= patient days, MRSA= methicillin resistant *Staphylococcus aureus*, MDRO= multidrug-resistant organism, CD= *Clostridium difficile*, CDI= *Clostridium difficile* infection, MS= moistened swab, MSP= moistened sponges, MSG= moistened sterile gauze, CAP= contact agar plates, MMS= moistened mylar sheet, CFU= colony-forming units

[†] P<.05
[‡] P>.05 (not statistically significant)
[◊] statistical significance not reported
[n] surface area not specified

C 29.2.3 OTHER NO-TOUCH DISINFECTION SYSTEMS

Table 24: Studies using Other No-Touch Disinfection Systems With Microbial Contamination as Outcomes

Study	Setting	System	Sampling	Details	Sampling method (area)	Outcome
Bache[422]	3 PR	HINS-light (2 units installed in ceiling of two inpatient rooms, and one outpatient room)	Sampling during pre-HINS phase, HINS phase, and 2 days post-HINS	C/D: chlorine-based detergents, hard surface disinfectant wipes *HINS units switched on for 14 hours during daylight hours.	CAP ($25\ cm^2$)	In one experiment, SA CFU/plate counts reduced by 89%† In other experiments, reductions of SA not statistically significant
Friedman[425]	33 PR	Spray-fogging with Bactol Micro-Mist (QAC)	Control rooms: Sampling pre- and post-C/D Test rooms: Sampling pre-fogging, post-fogging/C/D	C/D: scrubbed with phenolic compound Control rooms: C/D only Test rooms: fogging alone, or fogging then C/D *fogging procedure: a 10-20 second direct Micro-Mist spray applied to all exposed surfaces, then apparatus placed in centre of room, and fogging performed for 10-15 minutes	MS^n	Total aerobic bacteria: C/D alone: 49.5 CFU/cm^2 before, 23.2 CFU/cm^2 after◊ Fogging alone: 34.7 CFU/cm^2 before, 3.8 CFU/cm^2 after◊ Both (fogging then housekeeping): 50.5 CFU/cm^2 before, 1.3 CFU/cm^2 after◊
Jury[427]	1 H	Biomist (alcohol mist + QAC)	Control rooms: Sampling pre- and post-C/D Test rooms: Sampling pre- and post-Biomist	C/D: 10% bleach Control rooms: C/D only Test rooms: Biomist only *Use of Biomist + C/D not indicated	MS, MSG (both 100 cm^2)	MRSA: 9.4% of surfaces positive before Biomist, 2% after†. VRE: 7.4% positive for before Biomist, 0.96% after† Control rooms (10% bleach): of 40 sites that tested positive for MRSA, 0% tested positive after◊
Maclean[423]	1 PR	HINS-light (2 units installed in ceiling of 1 PR)	Sampling pre-HINS, post-HINS, and 24 hrs post-HINS	*no description of routine cleaning methods (only "according to NHS standards")	CAP ($24\ cm^2$)	Presumptive SA: In 3 separate experiments (2 with room occupied) 92%†, 65%† and 50%† reductions in mean CFU
Maclean[424]	1 PR	HINS-light (2 units installed in ceiling of 1 PR)	Sampling pre-HINS, post-HINS, and 24 hrs	*no description of routine cleaning methods (only "according to NHS	CAP ($24\ cm^2$)	In 3 separate experiments, total BPA, total BPA, and TSA CFU were reduced

Study	Setting	System	Sampling	Details	Sampling method (area)	Outcome
			post-HINS	standards")		by 67%[†], 38%[‡], and 53%[†]
Munster[426]	1 PR	Spray-fogging Bactol Micro-Mist (QAC)	Samples pre-C/D, post-C/D (pre-fogging), and post-fogging	C/D: phenolic compound *2 experiments: C/D + fogging, fogging + C/D	CAP[n]	Total aerobic bacteria: Manual cleaning increased mean CFU/sample by 293%[◊], while fogging reduced mean CFU/sample by 76%[◊]

Abbreviations: H= hospital, PR= patient room, IC= infection control, C/D= cleaning and disinfection, QAC= quaternary ammonium compound, HINS= high-intensity narrow-spectrum, M= month, PtD= patient days, MRSA= methicillin resistant *Staphylococcus aureus*, SA= *Staphylococcus aureus*, VRE= vancomycin-resistant *Enterococcus*, MS= moistened swab, MSG= moistened sterile gauze, CAP= contact agar plates, BPA= Baird-Parker agar, TSA= trypticase soy agar, CFU= colony-forming units

[†] p-value<0.05
[‡] p-value>0.05 (not statistically significant)
[◊] statistical significance not reported
[n] surface area not specified

References

1. Dillon M, Griffith C. How to audit: verifying food control systems. Grimsby, N E Lincolnshire: Manufacturing Improvement International Ltd Business; 1997.
2. Ontario. Ministry of the Environment. Guideline C-4: the management of biomedical waste in Ontario [Internet]. Toronto, ON: Queen's Printer for Ontario; 2009 [cited 2017 Nov 22]. Available from: www.ontario.ca/environment-and-energy/c-4-management-biomedical-waste-ontario
3. Health Canada. Infection control guidelines: hand washing, cleaning, disinfection and sterilization in health care. Can Commun Dis Rep. 1998;24(Suppl 8):1-55. Available from: www.collectionscanada.gc.ca/webarchives/20071115105916/http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/98pdf/cdr24s8e.pdf
4. Health Canada. Guidance document - disinfectant drugs. Ottawa, ON: Her Majesty the Queen in Right of Canada; 2014. Available from: www.hc-sc.gc.ca/dhp-mps/prodpharma/applic-demande/guide-ld/disinfect-desinfect/disin_desin-eng.php
5. Gauthier J. "Hospital clean" versus "construction clean" - is there a difference? Can J Infect Control. 2004;19(3):150-2.
6. Malik RE, Cooper RA, Griffith CJ. Use of audit tools to evaluate the efficacy of cleaning systems in hospitals. Am J Infect Control. 2003;31(3):181-7.
7. Ontario Agency for Health Protection and Promotion (Public Health Ontario). Routine practices and additional precautions in all health care settings [Internet]. 3rd ed. Toronto, ON: Queen's Printer for Ontario; 2012 [cited 2017 Dec 22]. Available from: www.publichealthontario.ca/en/eRepository/RPAP_All_HealthCare_Settings_Eng2012.pdf
8. *Workplace Hazardous Materials Information System (WHMIS)*, RRO 1990, Reg 860. Available from: www.ontario.ca/laws/regulation/900860
9. Magill SS, Edwards JR, Bamberg W, Beldavs ZG, Dumyati G, Kainer MA, et al. Multistate point-prevalence survey of health care-associated infections. N Engl J Med. 2014;370(13):1198-208. Available from: http://www.nejm.org/doi/full/10.1056/NEJMoa1306801
10. Klevens RM, Edwards JR, Richards CL, Jr., Horan TC, Gaynes RP, Pollock DA, et al. Estimating health care-associated infections and deaths in U.S. hospitals, 2002. Public Health Rep. 2007;122(2):160-6. Available from: http://journals.sagepub.com/doi/abs/10.1177/003335490712200205
11. Taylor G, Gravel D, Matlow A, Embree J, LeSaux N, Johnston L, et al. Assessing the magnitude and trends in hospital acquired infections in Canadian hospitals through sequential point prevalence surveys. Antimicrob Resist Infect Control. 2016;5(19). Available from: http://aricjournal.biomedcentral.com/articles/10.1186/s13756-016-0118-3
12. Rutledge-Taylor K, Matlow A, Gravel D, Embree J, Le Saux N, Johnston L, et al. A point prevalence survey of health care-associated infections in Canadian pediatric inpatients. Am J Infect Control. 2012;40(6):491-6.
13. Dancer SJ. Hospital cleaning in the 21st century. Eur J Clin Microbiol Infect Dis. 2011;30(12):1473-81.
14. Weber DJ, Rutala WA. Understanding and preventing transmission of healthcare-associated pathogens due to the contaminated hospital environment. Infect Control Hosp Epidemiol. 2013;34(5):449-52.

15. Leas BF, Sullivan N, Han JH, Pegues DA, Kaczmarek JL, Umscheid CA. Environmental cleaning for the prevention of healthcare-associated infections. Technical brief No. 22. (Prepared by the ECRI Institute - Penn Medicine Evidence-based Practice Center under Contract No. 290-2012-00011-I.) AHRQ Publication No. 15-EHC020-EF [Internet]. Rockville, MD: Agency for Healthcare Research and Quality; 2015 [cited 15 Dec 2017]. Available from: www.effectivehealthcare.ahrq.gov/sites/default/files/pdf/healthcare-infections_technical-brief.pdf
16. 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. Available from: http://cmr.asm.org/content/27/4/665.long
17. Brakovich B, Bonham E, VanBrackle L. War on the spore: *Clostridium difficile* disease among patients in a long-term acute care hospital. J Healthc Qual. 2013;35(3):15-21.
18. Donskey CJ. Does improving surface cleaning and disinfection reduce health care-associated infections? Am J Infect Control. 2013;41(5 Suppl):S12-9.
19. Ontario Agency for Health Protection and Promotion (Public Health Ontario). Best practices for cleaning, disinfection and sterilization of medical equipment/devices in all health care settings [Internet]. 3rd ed. Toronto, ON: Queen's Printer for Ontario; 2013 [cited 2017 Dec 22]. Available from: www.publichealthontario.ca/en/eRepository/PIDAC_Cleaning_Disinfection_and_Sterilization_2013.pdf
20. Easty A, Coakley N, Cheng R, Cividino M, Savage P, Tozer R, et al. Safe handling of cytotoxics [Internet]. Toronto, ON: Cancer Care Ontario; 2013 [cited 2015 Aug 9]. Available from: www.cancercareontario.ca/sites/ccocancercare/files/guidelines/summary/pebc16-3s_0.pdf
21. Royal College of Dental Surgeons of Ontario. Infection prevention and control in the dental office [Internet]. Toronto, ON: Royal College of Dental Surgeons of Ontario; 2010 [cited 2016 Nov 29]. Available from: www.rcdso.org/assets/documents/professional_practice/guidelines/rcdso_guidelines_infection_prevention_and_control.pdf
22. Neumann I, Santesso N, Akl EA, Rind DM, Vandvik PO, Alonso-Coello P, et al. A guide for health professionals to interpret and use recommendations in guidelines developed with the GRADE approach. J Clin Epidemiol. 2016;72:45-55.
23. Schünemann H, Brożek J, Guyatt G, Oxman A, editors. GRADE handbook [Internet]. Hamilton, ON: The GRADE Working Group; 2013 [cited 2016 Oct 24]. Available from: http://gdt.guidelinedevelopment.org/app/handbook/handbook.html
24. Muller MP, MacDougall C, Lim M; Ontario Agency for Health Protection and Promotion (Public Health Ontario) Provincial Infectious Diseases Advisory Committee on Infection Prevention and Control. Antimicrobial surfaces to prevent healthcare-associated infections: a systematic review. J Hosp Infect. 2016;92(1):7-13.
25. Alexander PE, Gionfriddo MR, Li SA, Bero L, Stoltzfus RJ, Neumann I, et al. A number of factors explain why WHO guideline developers make strong recommendations inconsistent with GRADE guidance. J Clin Epidemiol. 2016;70:111-22.
26. Murad MH, Mustafa R, Morgan R, Sultan S, Falck-Ytter Y, Dahm P. Rating the quality of evidence is by necessity a matter of judgment. J Clin Epidemiol. 2016;74:237-8.
27. Movsisyan A, Melendez-Torres GJ, Montgomery P. Users identified challenges in applying GRADE to complex interventions and suggested an extension to GRADE. J Clin Epidemiol. 2016;70:191-9.

28. Gionfriddo MR. Subjectivity is a strength: a comment on "an algorithm was developed to assign GRADE levels of evidence to comparisons within systematic reviews". J Clin Epidemiol. 2016;74:237.
29. European Centre for Disease Prevention and Control. Evidence-based methodologies for public health - how to assess the best available evidence when time is limited and there is lack of sound evidence. Stockholm, Sweden: European Centre for Disease Prevention and Control; 2011. Available from: http://ecdc.europa.eu/en/publications/publications/1109_ter_evidence_based_methods_for_public_health.pdf
30. Ontario Agency for Health Protection and Promotion (Public Health Ontario). Infection prevention and control for clinical office practice [Internet]. 1st revision. Toronto, ON: Queen's Printer for Ontario; 2015 [cited 2017 Nov 23]. Available from: www.publichealthontario.ca/en/eRepository/IPAC_Clinical_Office_Practice_2013.pdf
31. Ontario Agency for Health Protection and Promotion (Public Health Ontario). Best practices for infection prevention and control programs in Ontario in all health care settings [Internet]. 3rd ed. Toronto, ON: Queen's Printer for Ontario; 2012 [cited 2015 Mar 3]. Available from: www.publichealthontario.ca/en/eRepository/BP_IPAC_Ontario_HCSettings_2012.pdf
32. Ontario Agency for Health Protection and Promotion (Public Health Ontario). Best practices for hand hygiene in all health care settings [Internet]. 4th ed. Toronto, ON: Queen's Printer for Ontario; 2014 [cited 2015 Mar 3]. Available from: www.publichealthontario.ca/en/eRepository/2010-12%20BP%20Hand%20Hygiene.pdf
33. Ontario Agency for Health Protection and Promotion (Public Health Ontario). Just Clean Your Hands [Internet]. Toronto, ON: Queen's Printer for Ontario; 2017 [cited 2017 Dec 20]. Available from: www.publichealthontario.ca/en/BrowseByTopic/InfectiousDiseases/JustCleanYourHands/Pages/Just-Clean-Your-Hands.aspx
34. *Health Protection and Promotion Act*, RSO 1990, c H.7. Available from: www.ontario.ca/laws/statute/90h07
35. Carling PC, Huang SS. Improving healthcare environmental cleaning and disinfection: current and evolving issues. Infect Control Hosp Epidemiol. 2013;34(5):507-13.
36. Weber DJ, Anderson D, Rutala WA. The role of the surface environment in healthcare-associated infections. Curr Opin Infect Dis. 2013;26(4):338-44.
37. Mitchell BG, Dancer SJ, Anderson M, Dehn E. Risk of organism acquisition from prior room occupants: a systematic review and meta-analysis. J Hosp Infect. 2015;91(3):211-7.
38. Otter JA, Yezli S, Salkeld JA, French GL. Evidence that contaminated surfaces contribute to the transmission of hospital pathogens and an overview of strategies to address contaminated surfaces in hospital settings. Am J Infect Control. 2013;41(5 Suppl):S6-11.
39. Chemaly RF, Simmons S, Dale C, Jr., Ghantoji SS, Rodriguez M, Gubb J, et al. The role of the healthcare environment in the spread of multidrug-resistant organisms: update on current best practices for containment. Ther Adv Infect Dis. 2014;2(3-4):79-90. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/pmid/25469234/
40. Mermel LA, Jefferson J, Blanchard K, Parenteau S, Mathis B, Chapin K, et al. Reducing *Clostridium difficile* incidence, colectomies, and mortality in the hospital setting: a successful multidisciplinary approach. Jt Comm J Qual Patient Saf. 2013;39(7):298-305.
41. Nelson RE, Jones M, Leecaster M, Samore MH, Ray W, Huttner A, et al. An economic analysis of strategies to control *Clostridium difficile t*ransmission and infection using an agent-based

simulation model. PLoS One. 2016;11(3):e0152248. Available from: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0152248

42. Grabsch EA, Burrell LJ, Padiglione A, O'Keeffe JM, Ballard S, Grayson ML. Risk of environmental and healthcare worker contamination with vancomycin-resistant enterococci during outpatient procedures and hemodialysis. Infect Control Hosp Epidemiol. 2006;27(3):287-93.
43. van der Mee-Marquet N, Girard S, Lagarrigue F, Leroux I, Voyer I, Bloc D, et al. Multiresistant *Enterobacter cloacae* outbreak in an intensive care unit associated with therapeutic beds. Crit Care. 2006;10(1):405. Available from: http://ccforum.biomedcentral.com/articles/10.1186/cc4835
44. Rogers M, Weinstock DM, Eagan J, Kiehn T, Armstrong D, Sepkowitz KA. Rotavirus outbreak on a pediatric oncology floor: possible association with toys. Am J Infect Control. 2000;28(5):378-80.
45. Hota B. Contamination, disinfection, and cross-colonization: are hospital surfaces reservoirs for nosocomial infection? Clin Infect Dis. 2004;39(8):1182-9.
46. Kramer A, Schwebke I, Kampf G. How long do nosocomial pathogens persist on inanimate surfaces? A systematic review. BMC Infect Dis. 2006;6:130. Available from: http://bmcinfectdis.biomedcentral.com/articles/10.1186/1471-2334-6-130
47. Jenkins RO, Sherburn RE. Growth and survival of bacteria implicated in sudden infant death syndrome on cot mattress materials. J Appl Microbiol. 2005;99(3):573-9. Available from: http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2672.2005.02620.x/full
48. Neely AN. A survey of gram-negative bacteria survival on hospital fabrics and plastics. J Burn Care Rehabil. 2000;21(6):523-7.
49. Neely AN, Maley MP. Survival of enterococci and staphylococci on hospital fabrics and plastic. J Clin Microbiol. 2000;38(2):724-6. Available from: http://jcm.asm.org/content/38/2/724.long
50. Bonilla HF, Zervos MJ, Kauffman CA. Long-term survival of vancomycin-resistant *Enterococcus faecium* on a contaminated surface. Infect Control Hosp Epidemiol. 1996;17(12):770-2.
51. Bridges CB, Kuehnert MJ, Hall CB. Transmission of influenza: implications for control in health care settings. Clin Infect Dis. 2003;37(8):1094-101. Available from: http://academic.oup.com/cid/article/37/8/1094/2013282
52. Hirai Y. Survival of bacteria under dry conditions; from a viewpoint of nosocomial infection. J Hosp Infect. 1991;19(3):191-200.
53. Jawad A, Seifert H, Snelling AM, Heritage J, Hawkey PM. Survival of *Acinetobacter baumannii* on dry surfaces: comparison of outbreak and sporadic isolates. J Clin Microbiol. 1998;36(7):1938-41. Available from: http://jcm.asm.org/content/36/7/1938.long
54. Duckworth GJ, Jordens JZ. Adherence and survival properties of an epidemic methicillin-resistant strain of *Staphylococcus aureus* compared with those of methicillin-sensitive strains. J Med Microbiol. 1990;32(3):195-200.
55. Kundrapu S, Sunkesula V, Jury LA, Sitzlar BM, Donskey CJ. Daily disinfection of high-touch surfaces in isolation rooms to reduce contamination of healthcare workers' hands. Infect Control Hosp Epidemiol. 2012;33(10):1039-42.
56. Stiefel U, Cadnum JL, Eckstein BC, Guerrero DM, Tima MA, Donskey CJ. Contamination of hands with methicillin-resistant *Staphylococcus aureus* after contact with environmental surfaces and after contact with the skin of colonized patients. Infect Control Hosp Epidemiol. 2011;32(2):185-7.
57. Mutters R, Nonnenmacher C, Susin C, Albrecht U, Kropatsch R, Schumacher S. Quantitative detection of *Clostridium difficile* in hospital environmental samples by real-time polymerase chain reaction. J Hosp Infect. 2009;71(1):43-8.

58. Hayden MK, Blom DW, Lyle EA, Moore CG, Weinstein RA. Risk of hand or glove contamination after contact with patients colonized with vancomycin-resistant *Enterococcus* or the colonized patients' environment. Infect Control Hosp Epidemiol. 2008;29(2):149-54.
59. Duckro AN, Blom DW, Lyle EA, Weinstein RA, Hayden MK. Transfer of vancomycin-resistant enterococci via health care worker hands. Arch Intern Med. 2005;165(3):302-7.
60. Kim KH, Fekety R, Batts DH, Brown D, Cudmore M, Silva J, Jr., et al. Isolation of *Clostridium difficile* from the environment and contacts of patients with antibiotic-associated colitis. J Infect Dis. 1981;143(1):42-50.
61. Bhalla A, Pultz NJ, Gries DM, Ray AJ, Eckstein EC, Aron DC, et al. Acquisition of nosocomial pathogens on hands after contact with environmental surfaces near hospitalized patients. Infect Control Hosp Epidemiol. 2004;25(2):164-7.
62. Boyce JM, Potter-Bynoe G, Chenevert C, King T. Environmental contamination due to methicillin-resistant *Staphylococcus aureus*: possible infection control implications. Infect Control Hosp Epidemiol. 1997;18(9):622-7.
63. Samore MH, Venkataraman L, DeGirolami PC, Arbeit RD, Karchmer AW. Clinical and molecular epidemiology of sporadic and clustered cases of nosocomial *Clostridium difficile* diarrhea. Am J Med. 1996;100(1):32-40.
64. World Health Organization. WHO guidelines on hand hygiene in health care:first global patient safety challenge: clean care is safer care. Geneva: World Health Organization; 2009. Available from: http://whqlibdoc.who.int/publications/2009/9789241597906_eng.pdf?ua=1
65. Delgado Naranjo J, Villate Navarro JI, Sota Busselo M, Martinez Ruiz A, Hernández Hernández JM, Torres Garmendia MP, et al. Control of a clonal outbreak of multidrug-resistant *Acinetobacter baumannii* in a hospital of the Basque country after the introduction of environmental cleaning led by the systematic sampling from environmental objects. Interdiscip Perspect Infect Dis. 2013;2013:582831. Available from: http://www.hindawi.com/journals/ipid/2013/582831/
66. Yoon YK, Sim HS, Kim JY, Park DW, Sohn JW, Roh KH, et al. Epidemiology and control of an outbreak of vancomycin-resistant enterococci in the intensive care units. Yonsei Med J. 2009;50(5):637-43. Available from: http://www.eymj.org/DOIx.php?id=10.3349/ymj.2009.50.5.637
67. Neely AN, Maley MP, Warden GD. Computer keyboards as reservoirs for *Acinetobacter baumannii* in a burn hospital. Clin Infect Dis. 1999;29(5):1358-60. Available from: http://academic.oup.com/cid/article/29/5/1358/345517
68. de Lassence A, Hidri N, Timsit JF, Joly-Guillou ML, Thiery G, Boyer A, et al. Control and outcome of a large outbreak of colonization and infection with glycopeptide-intermediate *Staphylococcus aureus* in an intensive care unit. Clin Infect Dis. 2006;42(2):170-8. Available from: http://academic.oup.com/cid/article/42/2/170/440689
69. Rampling A, Wiseman S, Davis L, Hyett AP, Walbridge AN, Payne GC, et al. Evidence that hospital hygiene is important in the control of methicillin-resistant *Staphylococcus aureus*. J Hosp Infect. 2001;49(2):109-16.
70. Tankovic J, Legrand P, De Gatines G, Chemineau V, Brun-Buisson C, Duval J. Characterization of a hospital outbreak of imipenem-resistant *Acinetobacter baumannii* by phenotypic and genotypic typing methods. J Clin Microbiol. 1994;32(11):2677-81. Available from: http://jcm.asm.org/content/32/11/2677.long
71. Datta R, Platt R, Yokoe DS, Huang SS. Environmental cleaning intervention and risk of acquiring multidrug-resistant organisms from prior room occupants. Arch Intern Med. 2011;171(6):491-4.

72. Orenstein R, Aronhalt KC, McManus JE, Jr., Fedraw LA. A targeted strategy to wipe out *Clostridium difficile*. Infect Control Hosp Epidemiol. 2011;32(11):1137-9.
73. Hacek DM, Ogle AM, Fisher A, Robicsek A, Peterson LR. Significant impact of terminal room cleaning with bleach on reducing nosocomial *Clostridium difficile*. Am J Infect Control. 2010;38(5):350-3.
74. Dancer SJ, White LF, Lamb J, Girvan EK, Robertson C. Measuring the effect of enhanced cleaning in a UK hospital: a prospective cross-over study. BMC Med. 2009;7:28. Available from: http://bmcmedicine.biomedcentral.com/articles/10.1186/1741-7015-7-28
75. McMullen KM, Zack J, Coopersmith CM, Kollef M, Dubberke E, Warren DK. Use of hypochlorite solution to decrease rates of *Clostridium difficile*-associated diarrhea. Infect Control Hosp Epidemiol. 2007;28(2):205-7.
76. Mitchell BG, Digney W, Locket P, Dancer SJ. Controlling methicillin-resistant *Staphylococcus aureus* (MRSA) in a hospital and the role of hydrogen peroxide decontamination: an interrupted time series analysis. BMJ Open. 2014;4(4):e004522. Available from: http://bmjopen.bmj.com/content/4/4/e004522.long
77. Simmons S, Morgan M, Hopkins T, Helsabeck K, Stachowiak J, Stibich M. Impact of a multi-hospital intervention utilising screening, hand hygiene education and pulsed xenon ultraviolet (PX-UV) on the rate of hospital associated meticillin resistant *Staphylococcus aureus* infection. J Infect Prev. 2013;14(5):172-4. Available from: http://journals.sagepub.com/doi/abs/10.1177/1757177413490813
78. Barnes SL, Morgan DJ, Harris AD, Carling PC, Thom KA. Preventing the transmission of multidrug-resistant organisms: modeling the relative importance of hand hygiene and environmental cleaning interventions. Infect Control Hosp Epidemiol. 2014;35(9):1156-62. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4204209/
79. CSA Group. CSA Z8002-14: Operation and maintenance of health care facilities. Toronto, ON: CSA Group; 2014.
80. CSA Group. CSA Z8000-11: Canadian health care facilities. Toronto, Ontario: CSA Group; 2011.
81. Facility Guidelines Institute. Guidelines for design and construction of hospitals and outpatient facilities. Chicago, IL: American Society for Healthcare Engineering of the American Hospital Association; 2014.
82. Malone EB, Dellinger BA. Furniture design features and healthcare outcomes [Internet]. Concord, CA: The Centre for Health Design; 2011 [cited 2016 Feb 14]. Available from: www.healthdesign.org/chd/research/furniture-design-features-and-healthcare-outcomes
83. Malik YS, Allwood PB, Hedberg CW, Goyal SM. Disinfection of fabrics and carpets artificially contaminated with calicivirus: relevance in institutional and healthcare centres. J Hosp Infect. 2006;63(2):205-10.
84. Noskin GA, Peterson LR. Engineering infection control through facility design. Emerg Infect Dis. 2001;7(2):354-7. Available from: http://wwwnc.cdc.gov/eid/article/7/2/70-0354_article
85. Barbut F, Menuet D, Verachten M, Girou E. Comparison of the efficacy of a hydrogen peroxide dry-mist disinfection system and sodium hypochlorite solution for eradication of *Clostridium difficile* spores. Infect Control Hosp Epidemiol. 2009;30(6):507-14.
86. CSA Group. CSA Z317.13-17: Infection control during construction, renovation and maintenance of health care facilities. Toronto, ON: CSA Group; 2017.

87. Lankford MG, Collins S, Youngberg L, Rooney DM, Warren JR, Noskin GA. Limiting the spread of infection in the health care environment. Assessment of materials commonly utilized in healthcare: implications for bacterial survival and transmission. Concord, CA: Coalition for Health Environments Research (CHER) and The Center for Health Design; 2007. Available from: www.healthdesign.org/sites/default/files/limiting_the_spread_of_infection.pdf
88. Loomes S. The Journal of Infection Control Nursing. Is it safe to lie down in hospital? Nurs Times. 1988;84(49):63-5.
89. Streifel AJ, Stevens PP, Rhame FS. In-hospital source of airborne *Penicillium* species spores. J Clin Microbiol. 1987;25(1):1-4. Available from: http://jcm.asm.org/content/25/1/1.long
90. Koca O, Altoparlak U, Ayyildiz A, Kaynar H. Persistence of nosocomial pathogens on various fabrics. Eurasian J Med. 2012;44(1):28-31. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4261405/
91. Traore O, Springthorpe VS, Sattar SA. A quantitative study of the survival of two species of *Candida* on porous and non-porous environmental surfaces and hands. J Appl Microbiol. 2002;92(3):549-55. Available from: http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2672.2002.01560.x/full
92. Sehulster L, Chinn RY; CDC, HICPAC. 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. Available from: http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5210a1.htm
93. Noskin GA, Bednarz P, Suriano T, Reiner S, Peterson LR. Persistent contamination of fabric-covered furniture by vancomycin-resistant enterococci: implications for upholstery selection in hospitals. Am J Infect Control. 2000;28(4):311-3.
94. Mitchell A, Spencer M, Edmiston C, Jr. Role of healthcare apparel and other healthcare textiles in the transmission of pathogens: a review of the literature. J Hosp Infect. 2015;90(4):285-92.
95. Lankford MG, Collins S, Youngberg L, Rooney DM, Warren JR, Noskin GA. Assessment of materials commonly utilized in health care: implications for bacterial survival and transmission. Am J Infect Control. 2006;34(5):258-63.
96. NHS Estates. Infection control in the built environment: design and planning. Norwich, UK: The Stationery Office; 2002. Available from: www.md.ucl.ac.be/didac/hosp/architec/UK.Built.pdf
97. Larocque M, Carver S, Bertrand A, McGeer A, McLeod S, Borgundvaag B. Acquisition of bacteria on health care workers' hands after contact with patient privacy curtains. Am J Infect Control. 2016;44(11):1385-6.
98. Bushey MM, Lowdermilk N, Schwartz K, Taylor J, Flack L, Whiteman E, et al. Pay attention to the microbe behind the curtain. Am J Infect Control. 2015;43(6):S41-2. Available from: http://www.ajicjournal.org/article/S0196-6553(15)00348-X/pdf
99. Mahida N, Beal A, Trigg D, Vaughan N, Boswell T. Outbreak of invasive group A *Streptococcus* infection: contaminated patient curtains and cross-infection on an ear, nose and throat ward. J Hosp Infect. 2014;87(3):141-4.
100. Rutala WA, Gergen MF, Sickbert-Bennett EE, Williams DA, Weber DJ. Effectiveness of improved hydrogen peroxide in decontaminating privacy curtains contaminated with multidrug-resistant pathogens. Am J Infect Control. 2014;42(4):426-8.
101. Ohl M, Schweizer M, Graham M, Heilmann K, Boyken L, Diekema D. Hospital privacy curtains are frequently and rapidly contaminated with potentially pathogenic bacteria. Am J Infect Control. 2012;40(10):904-6.

102. Klakus J, Vaughan NL, Boswell TC. Meticillin-resistant *Staphylococcus aureus* contamination of hospital curtains. J Hosp Infect. 2008;68(2):189-90.
103. Trillis F, 3rd, Eckstein EC, Budavich R, Pultz MJ, Donskey CJ. Contamination of hospital curtains with healthcare-associated pathogens. Infect Control Hosp Epidemiol. 2008;29(11):1074-6.
104. Das I, Lambert P, Hill D, Noy M, Bion J, Elliott T. Carbapenem-resistant *Acinetobacter* and role of curtains in an outbreak in intensive care units. J Hosp Infect. 2002;50(2):110-4.
105. Sridhar SA, Ledeboer NA, Nanchal RS, Mackey T, Graham MB, VanDerSlik A, et al. Antimicrobial curtains: are they as clean as you think? Infect Control Hosp Epidemiol. 2016;37(10):1260-2.
106. Garrett R. Facility cleaning decisions: hospital curtains pose health risks. Clean Link [Internet]. Milwaukee2012 Jul 18 [cited 2016 Mar 16]. Available from: www.cleanlink.com/hs/article/Hospital-Curtains-Pose-Health-Risks--14452
107. Birchfield M. Cubicle curtains the elephant in the room. Health Facil Manage [Internet]2016 Jan 6 [cited 2017 Dec 22]. Available from: www.hfmmagazine.com/articles/1848-cubicle-curtains-the-elephant-in-the-room
108. DeAngelis DL, Khakoo R, DeAngelis DL. Hospital privacy curtains: cleaning and changing policies - are we doing enough? Am J Infect Control. 2013;41(6):S33.
109. Longtin Y, Comité sur les infections nosocomiales du Québec. Divider curtains and infection risk [Internet]. Québec, QC: Gouvernement du Québec; 2013 [cited 2016 Feb 18]. Available from: www.inspq.qc.ca/pdf/publications/1729_NoticeRecommCINQ_DividCurtainsInfectRisk.pdf
110. Anderson RL, Mackel DC, Stoler BS, Mallison GF. Carpeting in hospitals: an epidemiological evaluation. J Clin Microbiol. 1982;15(3):408-15. Available from: http://jcm.asm.org/content/15/3/408.long
111. Gerson SL, Parker P, Jacobs MR, Creger R, Lazarus HM. Aspergillosis due to carpet contamination. Infect Control Hosp Epidemiol. 1994;15(4 Pt 1):221-3.
112. Skoutelis AT, Westenfelder GO, Beckerdite M, Phair JP. Hospital carpeting and epidemiology of *Clostridium difficile*. Am J Infect Control. 1994;22(4):212-7.
113. Lueg EA, Ballagh RH, Forte V. Analysis of the recent cluster of invasive fungal sinusitis at the Toronto Hospital for Sick Children. J Otolaryngol. 1996;25(6):366-70.
114. Sessa A, Meroni M, Battini G, Pitingolo F, Giordano F, Marks M, et al. Nosocomial outbreak of *Aspergillus fumigatus* infection among patients in a renal unit? Nephrol Dial Transplant. 1996;11(7):1322-4.
115. Alvarez M, Lopez Ponga B, Rayon C, Garcia Gala J, Roson Porto MC, Gonzalez M, et al. Nosocomial outbreak caused by *Scedosporium prolificans* (*inflatum*): four fatal cases in leukemic patients. J Clin Microbiol. 1995;33(12):3290-5. Available from: http://jcm.asm.org/content/33/12/3290.long
116. Fenelon LE. Protective isolation: who needs it? J Hosp Infect. 1995;30 Suppl:218-22.
117. Tablan OC, Anderson LJ, Arden NH, Breiman RF, Butler JC, McNeil MM, et al. Guideline for prevention of nosocomial pneumonia. Infect Control Hosp Epidemiol. 1994;15(9):587-627.
118. Working party of the British Society for Antimicrobial Chemotherapy. Chemoprophylaxis for candidosis and aspergillosis in neutropenia and transplantation: a review and recommendations. J Antimicrob Chemother. 1993;32(1):5-21.
119. Weber SF, Peacock JE, Jr., Do KA, Cruz JM, Powell BL, Capizzi RL. Interaction of granulocytopenia and construction activity as risk factors for nosocomial invasive filamentous fungal disease in patients with hematologic disorders. Infect Control Hosp Epidemiol. 1990;11(5):235-42.

120. Sherertz RJ, Belani A, Kramer BS, Elfenbein GJ, Weiner RS, Sullivan ML, et al. Impact of air filtration on nosocomial *Aspergillus infections*. Unique risk of bone marrow transplant recipients. Am J Med. 1987;83(4):709-18.
121. Rotstein C, Cummings KM, Tidings J, Killion K, Powell E, Gustafson TL, et al. An outbreak of invasive aspergillosis among allogeneic bone marrow transplants: a case-control study. Infect Control. 1985;6(9):347-55.
122. Office of the Fire Marshal. OFM-TG-02-2011: safe practices for the use of alcohol-based hand rub [Internet]. Toronto, ON: Queen's Printer for Ontario; 2011 [cited 2016 Jan 11]. Available from: www.mcscs.jus.gov.on.ca/english/firemarshal/legislation/technicalguidelinesandreports/TG-2011-02.html;
123. Roberts JW, Glass G, Mickelson L. A pilot study of the measurement and control of deep dust, surface dust, and lead in 10 old carpets using the 3-spot test while vacuuming. Arch Environ Contam Toxicol. 2005;48(1):16-23.
124. Canadian Construction Association. CCA 82: 2004 mould guidelines for the Canadian construction industry. Ottawa, ON: Canadian Construction Association; 2004 [cited 2008 Dec 1]. Available from: www.cca-acc.com/wp-content/uploads/2016/10/PreviewCCA82.pdf
125. Brandt M, Brown C, Burkhart J, Burton N, Cox-Ganser J, Damon S, et al. Mold prevention strategies and possible health effects in the aftermath of hurricanes and major floods. MMWR Recomm Rep. 2006;55(RR-8):1-27. Available from: http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5508a1.htm
126. Palaty C. Mould remediation recommendations. Vancouver, BC: National Collaborating Centre for Environmental Health; 2014. Available from: www.ncceh.ca/sites/default/files/Mould_Remediation_Evidence_Review_March_2014.pdf
127. Spaulding EH. Chemical disinfection and antisepsis in the hospital. J Hosp Res. 1957;9:5-31.
128. Orr KE, Gould FK, Perry JD, Ford M, Morgan S, Sisson PR, et al. Therapeutic beds: the Trojan horses of the 1990s? Lancet. 1994;344(8914):65-6.
129. U. S. Food and Drug Administration. Damaged or worn covers for medical bed mattresses pose risk of contamination and patient infection: FDA safety communication [Internet]. Silver Spring, MD: U. S. Department of Health and Human Services; 2013 [cited 2017 Dec 22]. Available from: http://wayback.archive-it.org/7993/20170722215739/https:/www.fda.gov/MedicalDevices/Safety/AlertsandNotices/ucm348016.htm
130. Ben David D, Tal I, Barssessat A, Maor Y, Keller N, Smollan G, et al. An outbreak of Klebsiella pneumoniae carbapenemase (KPC)-producing *Klebsiella pneumoniae* associated with a damaged therapeutic mattress. Presented at: 23rd European Congress of Clinical Microbiology and Infectious Diseases; 2013 April 27-30; Berlin, Germany. Available from: http://www.escmid.org/escmid_publications/escmid_elibrary/material/?mid=8287
131. Patel S. Minimising cross-infection risks associated with beds and mattresses. Nurs Times. 2005;101(8):52-3.
132. Gerba CP, Wuollet AL, Raisanen P, Lopez GU. Bacterial contamination of computer touch screens. Am J Infect Control. 2016;44(3):358-60.
133. Pillet S, Berthelot P, Gagneux-Brunon A, Mory O, Gay C, Viallon A, et al. Contamination of healthcare workers' mobile phones by epidemic viruses. Clin Microbiol Infect. 2016;22(5):456 e1-6. Available from: http://www.sciencedirect.com/science/article/pii/S1198743X15010344

134. Achieng AA, Nkechi NN. Nosocomial infections transmitted via computers: a literature review [Internet]. Helsinki, Finland: Laurea University of Applied Sciences; 2010 [cited 2016 Feb 2]. Available from: www.theseus.fi/bitstream/handle/10024/23077/Thesis%20Final%20Version.pdf?sequence=1
135. Akinyemi Ko, Atapu AD, Adetona OO, Coker AO. The potential role of mobile phones in the spread of bacterial infections. J Infect Dev Ctries. 2009;3(8):628-32. Available from: http://jidc.org/index.php/journal/article/view/19801807
136. Cavari Y, Kaplan O, Zander A, Hazan G, Shemer-Avni Y, Borer A. Healthcare workers mobile phone usage: a potential risk for viral contamination. Surveillance pilot study. Infect Dis. 2016;48(6):432-5.
137. Kordecka A, Krajewska-Kulak E, Lukaszuk C, Kraszynska B, Kulak W. Isolation frequency of *Candida* present on the surfaces of mobile phones and hands. BMC Infect Dis. 2016;16:238. Available from: http://bmcinfectdis.biomedcentral.com/articles/10.1186/s12879-016-1577-0
138. Codish S, Toledano R, Novack V, Sherf M, Borer A. Effectiveness of stringent decontamination of computer input devices in the era of electronic medical records and bedside computing: a randomized controlled trial. Am J Infect Control. 2015;43(6):644-6.
139. Hirsch EB, Raux BR, Lancaster JW, Mann RL, Leonard SN. Surface microbiology of the iPad tablet computer and the potential to serve as a fomite in both inpatient practice settings as well as outside of the hospital environment. PLoS One. 2014;9(10):e111250. Available from: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0111250
140. Health Canada. Guidance document - safety and efficacy requirements for hard surface disinfectant drugs [Internet]. Ottawa, ON: Her Majesty the Queen in Right of Canada; 2014 [cited 2016 Feb 22]. Available from: www.hc-sc.gc.ca/dhp-mps/alt_formats/pdf/prodpharma/applic-demande/guide-ld/disinfect-desinfect/hard-surface-surfaces-dures-eng.pdf
141. Ministry of Health, New South Wales. Environmental cleaning policy [Internet]. North Sydney, NW: The Crown in right of the State of New South Wales; 2012 [cited 2016 Oct 5]. Available from: www1.health.nsw.gov.au/pds/ActivePDSDocuments/PD2012_061.pdf
142. Rutala WA, Weber DJ. Selection of the ideal disinfectant. Infect Control Hosp Epidemiol. 2014;35(7):855-65.
143. Council of State and Territorial Epidemiologists (CSTE). Position statement 11-OH: CDC and cleaning products health messages [Internet]. Atlanta, GA: Council of State and Territorial Epidemiologists (CSTE); 2011 [cited 2016 Feb 13]. Available from: http://c.ymcdn.com/sites/www.cste.org/resource/resmgr/PS/11-OH-01.pdf
144. Quirce S, Barranco P. Cleaning agents and asthma. J Investig Allergol Clin Immunol. 2010;20(7):542-50. Available from: http://www.jiaci.org/summary/vol20-issue7-num660
145. Bello A, Quinn MM, Perry MJ, Milton DK. Characterization of occupational exposures to cleaning products used for common cleaning tasks—a pilot study of hospital cleaners. Environ Health. 2009;8(11). Available from: http://ehjournal.biomedcentral.com/articles/10.1186/1476-069X-8-11
146. Zock JP, Vizcaya D, Le Moual N. Update on asthma and cleaners. Curr Opin Allergy Clin Immunol. 2010;10(2):114-20. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3125175/
147. Jaakkola JJ, Jaakkola MS. Professional cleaning and asthma. Curr Opin Allergy Clin Immunol. 2006;6(2):85-90.
148. European Agency for Safety and Health at Work. Occupational skin diseases and dermal exposure in the European Union (EU-25): policy and practice overview. Luxembourg: European Agency for Safety and Health at Work; 2008. Available from: http://osha.europa.eu/en/node/6875/file_view

149. Hawley B, Casey ML, Cox-Ganser JM, Edwards N, Fedan KB, Cummings KJ. Notes from the field. Respiratory symptoms and skin irritation among hospital workers using a new disinfectant product - Pennsylvania, 2015;. MMWR Morb Mortal Wkly Rep. 2016;65(15):400-1. Available from: http://www.cdc.gov/mmwr/volumes/65/wr/mm6515a3.htm.
150. Walters GI, Moore VC, McGrath EE, Burge PS, Henneberger PK. Agents and trends in health care workers' occupational asthma. Occup Med (Lond). 2013;63(7):513-6. Available from: http://academic.oup.com/occmed/article/63/7/513/1452683
151. Delclos GL, Gimeno D, Arif AA, Burau KD, Carson A, Lusk C, et al. Occupational risk factors and asthma among health care professionals. Am J Respir Crit Care Med. 2007;175(7):667-75. Available from: http://www.atsjournals.org/doi/abs/10.1164/rccm.200609-1331OC
152. Dettenkofer M, Wenzler S, Amthor S, Antes G, Motschall E, Daschner FD. Does disinfection of environmental surfaces influence nosocomial infection rates? A systematic review. Am J Infect Control. 2004;32(2):84-9.
153. Health Canada. Hard surface disinfectants monograph [Internet]. Ottawa, ON: Her Majesty the Queen in Right of Canada; 2015 [cited 2015 Jun 29]. Available from: www.hc-sc.gc.ca/dhp-mps/alt_formats/hpfb-dgpsa/pdf/prodpharma/applic-demande/guide-ld/disinfect-desinfect/hsd-rev-dsd-eng.pdf;
154. Rutala WA, Weber DJ, the Healthcare Infection Control Practices Advisory Committee. Guideline for disinfection and sterilization in healthcare facilities, 2008 [Internet]. Atlanta, GA: Centers for Disease Control and Prevention; 2008 [cited 2015 Aug 9]. Available from: http://www.cdc.gov/infectioncontrol/pdf/guidelines/disinfection-guidelines.pdf
155. World Health Organization. Infection prevention and control of epidemic- and pandemic-prone respiratory infections in health care. Geneva: World Health Organization; 2014. Available from: http://apps.who.int/iris/bitstream/10665/112656/1/9789241507134_eng.pdf?ua=1
156. Goldstein EJ, Johnson S, Maziade PJ, McFarland LV, Trick W, Dresser L, et al. Pathway to prevention of nosocomial *Clostridium difficile* infection. Clin Infect Dis. 2015;60 Suppl 2:S148-58. Available from: http://academic.oup.com/cid/article/60/suppl_2/S148/379746
157. Lambert RJW, Johnston MD. The effect of interfering substances on the disinfection process: a mathematical model. J Appl Microbiol. 2001;91(3):548-55. Available from: http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2672.2001.01422.x/full
158. Khanafer N, Voirin N, Barbut F, Kuijper E, Vanhems P. Hospital management of *Clostridium difficile* infection: a review of the literature. J Hosp Infect. 2015;90(2):91-101.
159. Macleod-Glover N, Sadowski C. Efficacy of cleaning products for *C. difficile*: environmental strategies to reduce the spread of *Clostridium difficile*-associated diarrhea in geriatric rehabilitation. Can Fam Physician. 2010;56(5):417-23. Available from: http://www.cfp.ca/content/56/5/417.long
160. Boyce JM, Sullivan L, Booker A, Baker J. Quaternary ammonium disinfectant issues encountered in an environmental services department. Infect Control Hosp Epidemiol. 2016;37(3):340-2.
161. Boyce JM. Modern technologies for improving cleaning and disinfection of environmental surfaces in hospitals. Antimicrob Resist Infect Control. 2016;5:10. Available from: http://aricjournal.biomedcentral.com/articles/10.1186/s13756-016-0111-x
162. Reiss I, Borkhardt A, Fussle R, Sziegoleit A, Gortner L. Disinfectant contaminated with *Klebsiella oxytoca* as a source of sepsis in babies. Lancet. 2000;356(9226):310.

163. Gavalda L, Pequeno S, Soriano A, Dominguez MA. Environmental contamination by multidrug-resistant microorganisms after daily cleaning. Am J Infect Control. 2015;43(7):776-8.
164. Boyce JM, Havill NL, Tetro J, Sattar SA. Bacterial growth in an in-use hospital-grade quaternary ammonium-based disinfectant. Presented at: 21st Annual Scientific Meeting of the Society for Healthcare Epidemiology of America; 2011 Apr 2; Dallas, TX. Available from: http://shea.confex.com/shea/2011/webprogram/Paper4711.html
165. Sattar SA, Bradley C, Kibbee R, Wesgate R, Wilkinson MA, Sharpe T, et al. Disinfectant wipes are appropriate to control microbial bioburden from surfaces: use of a new ASTM standard test protocol to demonstrate efficacy. J Hosp Infect. 2015;91(4):319-25.
166. Wiemken TL, Curran DR, Pacholski EB, Kelley RR, Abdelfattah RR, Carrico RM, et al. The value of ready-to-use disinfectant wipes: compliance, employee time, and costs. Am J Infect Control. 2014;42(3):329-30.
167. Carter Y, Barry D. Tackling *C. difficile* with environmental cleaning. Nurs Times. 2011;107(36):22-5.
168. Siani H, Cooper C, Maillard JY. Efficacy of "sporicidal" wipes against *Clostridium difficile*. Am J Infect Control. 2011;39(3):212-8.
169. Gebel J, Exner M, French G, Chartier Y, Christiansen B, Gemein S, et al. The role of surface disinfection in infection prevention. GMS Hyg Infect Control. 2013;8(1):Doc10. Available from: http://www.egms.de/static/en/journals/dgkh/2013-8/dgkh000210.shtml
170. Maillard JY. Efficacy and limitations of sporicidal wipes: the need for an appropriate test. Presented at: Federation of Infection Societies/Healthcare Infection Society 2012 Conjoint Conference; 2012 Nov 20; Liverpool, UK. Available from: http://webbertraining.com/files/library/docs/413.pdf
171. Gonzalez EA, Nandy P, Lucas AD, Hitchins VM. Ability of cleaning-disinfecting wipes to remove bacteria from medical device surfaces. Am J Infect Control. 2015;43(12):1331-5.
172. Nandy P, Lucas AD, Gonzalez EA, Hitchins VM. Efficacy of commercially available wipes for disinfection of pulse oximeter sensors. Am J Infect Control. 2016;44(3):304-10.
173. Boyce JM, Havill NL. Evaluation of a new hydrogen peroxide wipe disinfectant. Infect Control Hosp Epidemiol. 2013;34(5):521-3.
174. Howell V, Thoppil A, Mariyaselvam M, Jones R, Young H, Sharma S, et al. Disinfecting the iPad: evaluating effective methods. J Hosp Infect. 2014;87(2):77-83.
175. Subhash SS, Cavaiuolo M, Radonovich LJ, Jr., Eagan A, Lee ML, Campbell S, et al. Effectiveness of common healthcare disinfectants against H1N1 influenza virus on reusable elastomeric respirators. Infect Control Hosp Epidemiol. 2014;35(7):894-7.
176. Seenama C, Tachasirinugune P, Jintanothaitavorn D, Kachintorn K, Thamlikitkul V. Effectiveness of disinfectant wipes for decontamination of bacteria on patients' environmental and medical equipment surfaces at Siriraj Hospital. J Med Assoc Thai. 2013;96 Suppl 2:S111-6.
177. Berendt AE, Turnbull L, Spady D, Rennie R, Forgie SE. Three swipes and you're out: how many swipes are needed to decontaminate plastic with disposable wipes? Am J Infect Control. 2011;39(5):442-3.
178. Williams GJ, Denyer SP, Hosein IK, Hill DW, Maillard JY. Limitations of the efficacy of surface disinfection in the healthcare setting. Infect Control Hosp Epidemiol. 2009;30(6):570-3.
179. Albrecht UV, von Jan U, Sedlacek L, Groos S, Suerbaum S, Vonberg RP. Standardized, app-based disinfection of iPads in a clinical and nonclinical setting: comparative analysis. J Med Internet Res. 2013;15(8):e176. Available from: http://www.jmir.org/2013/8/e176/

180. Kampf G, Degenhardt S, Lackner S, Jesse K, von Baum H, Ostermeyer C. Poorly processed reusable surface disinfection tissue dispensers may be a source of infection. BMC Infect Dis. 2014;14(1):37. Available from: http://bmcinfectdis.biomedcentral.com/articles/10.1186/1471-2334-14-37
181. Kupfahl C, Walther M, Wendt C, von Baum H. Identical *Achromobacter* strain in reusable surface disinfection tissue dispensers and a clinical isolate. Infect Control Hosp Epidemiol. 2015;36(11):1362-4.
182. Bloomfield S, Exner M, Flemming HC, Goroncy-Bermes P, Hartemann P, Heeg P, et al. Lesser-known or hidden reservoirs of infection and implications for adequate prevention strategies: where to look and what to look for. GMS Hyg Infect Control. 2015;10:Doc04. Available from: http://www.egms.de/static/en/journals/dgkh/2015-10/dgkh000247.shtml
183. Mafu AA, Massicotte R, Pichette G, Lafleur S, Lemay MJ, Ahmad D. Influence of surface and cloth characteristics on mechanical removal of meticillin-resistant *Staphylococcus aureus* (MRSA) attached to inanimate environmental surfaces in hospital and healthcare facilities. Int J Infect Control. 2013;9(3). Available from: http://www.ijic.info/article/view/11588
184. United States Environmental Protection Agency. Using microfiber mops in hospitals [Internet]. San Francisco, CA: United States Environmental Protection Agency; 2002 [cited 2008 Aug 9]. Available from: www.epa.gov/region9/waste/p2/projects/hospital/mops.pdf
185. Wren MW, Rollins MS, Jeanes A, Hall TJ, Coen PG, Gant VA. Removing bacteria from hospital surfaces: a laboratory comparison of ultramicrofibre and standard cloths. J Hosp Infect. 2008;70(3):265-71.
186. Gillespie E, Wilson J, Lovegrove A, Scott C, Abernethy M, Kotsanas D, et al. Environment cleaning without chemicals in clinical settings. Am J Infect Control. 2013;41(5):461-3.
187. Race S. The microfiber manifesto: everything you need to know about microfiber towels. Boonsboro, MD: Incredibly Detailed; 2013.
188. Sustainable Hospitals Project. Case study: are microfiber mops beneficial for hospitals? [Internet]. Lowell, MA: University of Massachusetts Lowell; 2003 [cited 2016 Oct 14]. Available from: www.sustainableproduction.org/downloads/MicrofiberMopCS.pdf
189. Moore G, Griffith C. A laboratory evaluation of the decontamination properties of microfibre cloths. J Hosp Infect. 2006;64(4):379-85.
190. Trajtman AN, Manickam K, Alfa MJ. Microfiber cloths reduce the transfer of *Clostridium difficile* spores to environmental surfaces compared with cotton cloths. Am J Infect Control. 2015;43(7):686-9.
191. Gillespie E, Lovegrove A, Kotsanas D. Health care workers use disposable microfiber cloths for cleaning clinical equipment. Am J Infect Control. 2015;43(3):308-9.
192. Hamilton D, Foster A, Ballantyne L, Kingsmore P, Bedwell D, Hall TJ, et al. Performance of ultramicrofibre cleaning technology with or without addition of a novel copper-based biocide. J Hosp Infect. 2010;74(1):62-71.
193. Rutala WA, Gergen MF, Weber DJ. Microbiologic evaluation of microfiber mops for surface disinfection. Am J Infect Control. 2007;35(9):569-73.
194. Smith DL, Gillanders S, Holah JT, Gush C. Assessing the efficacy of different microfibre cloths at removing surface micro-organisms associated with healthcare-associated infections. J Hosp Infect. 2011;78(3):182-6.

195. Diab-Elschahawi M, Assadian O, Blacky A, Stadler M, Pernicka E, Berger J, et al. Evaluation of the decontamination efficacy of new and reprocessed microfiber cleaning cloth compared with other commonly used cleaning cloths in the hospital. Am J Infect Control. 2010;38(4):289-92.
196. Abernethy M, Gillespie E, Snook K, Stuart RL. Microfiber and steam for environmental cleaning during an outbreak. Am J Infect Control. 2013;41(11):1134-5.
197. Bergen LK, Meyer M, Hog M, Rubenhagen B, Andersen LP. Spread of bacteria on surfaces when cleaning with microfibre cloths. J Hosp Infect. 2009;71(2):132-7.
198. Rutala WA, Weber DJ. Monitoring and improving the effectiveness of surface cleaning and disinfection. Am J Infect Control. 2016;44(5 Suppl):e69-76.
199. Gant VA, Jeanes A, Hall TJ. Response to: Griffith CJ, Dancer SJ. 'Hospital cleaning: problems with steam cleaning and microfibre'. J Hosp Infect. 2010;74(1):82-4.
200. Griffith CJ, Dancer SJ. Hospital cleaning: problems with steam cleaning and microfibre. J Hosp Infect. 2009;72(4):360-1.
201. Marra AR, Guastelli LR, de Araujo CM, dos Santos JL, Lamblet LC, Silva M, Jr., et al. Positive deviance: a new strategy for improving hand hygiene compliance. Infect Control Hosp Epidemiol. 2010;31(1):12-20.
202. Rosenthal VD, Guzman S, Safdar N. Reduction in nosocomial infection with improved hand hygiene in intensive care units of a tertiary care hospital in Argentina. Am J Infect Control. 2005;33(7):392-7.
203. Herud T, Nilsen RM, Svendheim K, Harthug S. Association between use of hand hygiene products and rates of health care-associated infections in a large university hospital in Norway. Am J Infect Control. 2009;37(4):311-7.
204. Chen YC, Sheng WH, Wang JT, Chang SC, Lin HC, Tien KL, et al. Effectiveness and limitations of hand hygiene promotion on decreasing healthcare-associated infections. PLoS One. 2011;6(11):e27163. Available from: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0027163
205. Kirkland KB, Homa KA, Lasky RA, Ptak JA, Taylor EA, Splaine ME. Impact of a hospital-wide hand hygiene initiative on healthcare-associated infections: results of an interrupted time series. BMJ Qual Saf. 2012;21(12):1019-26.
206. Lee YT, Chen SC, Lee MC, Hung HC, Huang HJ, Lin HC, et al. Time-series analysis of the relationship of antimicrobial use and hand hygiene promotion with the incidence of healthcare-associated infections. J Antibiot (Tokyo). 2012;65(6):311-6.
207. Zerr DM, Allpress AL, Heath J, Bornemann R, Bennett E. Decreasing hospital-associated rotavirus infection: a multidisciplinary hand hygiene campaign in a children's hospital. Pediatr Infect Dis J. 2005;24(5):397-403.
208. Conly JM, Hill S, Ross J, Lertzman J, Louie TJ. Handwashing practices in an intensive care unit: the effects of an educational program and its relationship to infection rates. Am J Infect Control. 1989;17(6):330-9.
209. Swoboda SM, Earsing K, Strauss K, Lane S, Lipsett PA. Electronic monitoring and voice prompts improve hand hygiene and decrease nosocomial infections in an intermediate care unit. Crit Care Med. 2004;32(2):358-63.
210. Casewell M, Phillips I. Hands as route of transmission for Klebsiella species. Br Med J. 1977;2(6098):1315-7. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1632544/
211. Doebbeling BN, Stanley GL, Sheetz CT, Pfaller MA, Houston AK, Annis L, et al. Comparative efficacy of alternative hand-washing agents in reducing nosocomial infections in intensive care units. N Engl

J Med. 1992;327(2):88-93. Available from: http://www.nejm.org/doi/full/10.1056/nejm199207093270205

212. Reingold AL, Kane MA, Hightower AW. Failure of gloves and other protective devices to prevent transmission of hepatitis B virus to oral surgeons. JAMA. 1988;259(17):2558-60.
213. Kotilainen HR, Brinker JP, Avato JL, Gantz NM. Latex and vinyl examination gloves. Quality control procedures and implications for health care workers. Arch Intern Med. 1989;149(12):2749-53.
214. Boyce JM, Pittet D, Healthcare Infection Control Practices Advisory Committee. HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Guideline for hand hygiene in health-care settings: recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. MMWR Recomm Rep. 2002;51(RR-16):1-45. Available from: http://www.cdc.gov/mmwr/PDF/rr/rr5116.pdf
215. Girou E, Loyeau S, Legrand P, Oppein F, Brun-Buisson C. Efficacy of handrubbing with alcohol based solution versus standard handwashing with antiseptic soap: randomised clinical trial. BMJ. 2002;325(7360):362. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC117885/
216. Public Health Agency of Canada. Hand hygiene practices in healthcare settings. Ottawa, ON: Her Majesty the Queen in Right of Canada; 2012. Available from: http://publications.gc.ca/collections/collection_2012/aspc-phac/HP40-74-2012-eng.pdf
217. *Control of Exposure to Biological or Chemical Agents*, RRO 1990, Reg 833. Available from: www.ontario.ca/laws/regulation/900833
218. Public Health Agency of Canada. Routine practices and additional precautions for preventing the transmission of infection in health care. Ottawa, ON: Her Majesty the Queen in Right of Canada; 2012. Available from: http://publications.gc.ca/collections/collection_2013/aspc-phac/HP40-83-2013-eng.pdf
219. *Health Care and Residential Facilities*, O Reg 67/93. Available from: www.ontario.ca/laws/regulation/930067
220. *Industrial Establishments*, RRO 1990, Reg 851. Available from: www.ontario.ca/laws/regulation/900851
221. CSA Group. CAN/CSA-Z94.4-11: Selection, use and care of respirators. Toronto, ON: CSA Group; 2011.
222. European Agency for Safety and Health at Work. Literature review - the occupational safety and health of cleaning workers. Luxembourg: European Agency for Safety and Health at Work; 2009. Available from: http://osha.europa.eu/en/tools-and-publications/publications/literature_reviews/cleaning_workers_and_OSH
223. Kampf G, Loffler H. Prevention of irritant contact dermatitis among health care workers by using evidence-based hand hygiene practices: a review. Ind Health. 2007;45(5):645-52. Available from: http://www.jstage.jst.go.jp/article/indhealth/45/5/45_5_645/_article
224. Poutanen SM, Vearncombe M, McGeer AJ, Gardam M, Large G, Simor AE. Nosocomial acquisition of methicillin-resistant *Staphylococcus aureus* during an outbreak of severe acute respiratory syndrome. Infect Control Hosp Epidemiol. 2005;26(2):134-7.
225. Patterson JE, Vecchio J, Pantelick EL, Farrel P, Mazon D, Zervos MJ, et al. Association of contaminated gloves with transmission of *Acinetobacter calcoaceticus* var. anitratus in an intensive care unit. Am J Med. 1991;91(5):479-83.

226. Doebbeling BN, Pfaller MA, Houston AK, Wenzel RP. Removal of nosocomial pathogens from the contaminated glove. Implications for glove reuse and handwashing. Ann Intern Med. 1988;109(5):394-8.
227. Hagos B, Kibwage IO, Mwongera M, Muthotho JN, Githiga IM, Mukindia GG. The microbial and physical quality of recycled gloves. East Afr Med J. 1997;74(4):224-6.
228. Olsen RJ, Lynch P, Coyle MB, Cummings J, Bokete T, Stamm WE. Examination gloves as barriers to hand contamination in clinical practice. JAMA. 1993;270(3):350-3.
229. *Occupational Health and Safety Act*, RSO 1990, c. O.1. Available from: http://www.ontario.ca/laws/statute/90o01
230. Hayden MK, Bonten MJ, Blom DW, Lyle EA, van de Vijver DA, Weinstein RA. Reduction in acquisition of vancomycin-resistant *Enterococcus* after enforcement of routine environmental cleaning measures. Clin Infect Dis. 2006;42(11):1552-60. Available from: http://academic.oup.com/cid/article/42/11/1552/282558
231. Dancer SJ. Importance of the environment in meticillin-resistant Staphylococcus aureus acquisition: the case for hospital cleaning. Lancet Infect Dis. 2008;8(2):101-13.
232. Canadian Centre for Occupational Health and Safety. Workplace housekeeping - basic guide [Internet]. Hamilton, ON: Canadian Centre for Occupational Health & Safety; 2008 [cited 2016 Feb 2]. Available from: www.ccohs.ca/oshanswers/hsprograms/house.html
233. Shaughnessy MK, Micielli RL, DePestel DD, Arndt J, Strachan CL, Welch KB, et al. Evaluation of hospital room assignment and acquisition of *Clostridium difficile* infection. Infect Control Hosp Epidemiol. 2011;32(3):201-6.
234. Denton M, Wilcox MH, Parnell P, Green D, Keer V, Hawkey PM, et al. Role of environmental cleaning in controlling an outbreak of *Acinetobacter baumannii* on a neurosurgical intensive care unit. J Hosp Infect. 2004;56(2):106-10.
235. Jha AK, Orav EJ, Zheng J, Epstein AM. Patients' perception of hospital care in the United States. N Engl J Med. 2008;359(18):1921-31. Available from: http://www.nejm.org/doi/full/10.1056/NEJMsa0804116
236. Department of Health. An integrated approach to hospital cleaning: microfibre cloth and steam cleaning technology [Internet]. London, UK: Crown Copyright; 2008 [cited 2016 Oct 14]. Available from: www.gov.uk/government/uploads/system/uploads/attachment_data/file/143264/Microfibre_report_revised_Mar_08.pdf
237. Public Health Agency of Canada. Essential resources for effective infection prevention and control programs: A matter of patient safety - a discussion paper [Internet]. Ottawa, ON: Her Majesty the Queen in Right of Canada; 2010 [cited 2016 Mar 15]. Available from: www.phac-aspc.gc.ca/nois-sinp/guide/ps-sp/index-eng.php
238. Zuberi D. Cleaning up; how hospital outsourcing is hurting workers and endangering patients. Ithaca, NY: Cornell University Press; 2013.
239. Lethbridge J. Empty promises. The impact of outsourcing on the delivery of NHS services [Internet]. London, UK: UNISON; 2012 [cited 2016 Nov 30]. Available from: www.psiru.org/sites/default/files/2012-04-H%20UNISONEmptyPromisesOutsourcing_0.pdf
240. Zuberi D. Contracting out hospital support jobs: the effects of poverty wages, excessive workload, and job insecurity on work and family life. Am Behav Sci. 2011;55(7):920-40.

241. Stinson J, Pollak N, Cohen M. The pains of privatization: how contracting out hurts health support workers, their families, and health care [Internet]. Vancouver, BC: Canadian Centre for Policy Alternatives, BC Office; 2005 [cited 2016 Oct 25]. Available from: www.nnewh.org/images/upload/attach/8593pains_privatization.pdf
242. Auditor General for Scotland. A clean bill of health? A review of domestic services in Scottish hospitals [Internet]. Edinburgh, Scotland: Audit Scotland; 2000 [cited 2017 Dec 22]. Available from: www.audit-scotland.gov.uk/docs/health/2000/nr_000407_domestic_services_hospitals.pdf
243. Ontario Hospital Association. Communicable disease surveillance protocols [Internet]. Toronto, ON: Ontario Hospital Association; 2013 [cited 2016 Jan 29]. Available from: http://www.oha.com/labour-relations-and-human-resources/health-and-safety/communicable-diseases-surveillance-protocols
244. Wilson AP, Smyth D, Moore G, Singleton J, Jackson R, Gant V, et al. The impact of enhanced cleaning within the intensive care unit on contamination of the near-patient environment with hospital pathogens: a randomized crossover study in critical care units in two hospitals. Crit Care Med. 2011;39(4):651-8.
245. Zoutman DE, Ford BD, Sopha K. Working relationships of infection prevention and control programs and environmental services and associations with antibiotic-resistant organisms in Canadian acute care hospitals. Am J Infect Control. 2014;42(4):349-52.
246. Zoutman DE, Ford BD, Sopha K. Environmental cleaning resources and activities in Canadian acute care hospitals. Am J Infect Control. 2014;42(5):490-4.
247. Healthcare Insurance Reciprocal of Canada. Risk reference sheet: Infection control - healthcare acquired infections [Internet]. Toronto, ON: Healthcare Insurance Reciprocal of Canada; 2012 [cited 2016 Mar 17]. Available from: www.hiroc.com/getmedia/2d56acfe-568e-4844-93e4-b0e0fa507680/11-Healthcare-Acquired-Infections-Risk-Reference-Sheet.pdf.aspx?ext=.pdf
248. Powell N, Walters J. Infection-control gaps at hospital highlight report. Toronto Star [Internet]2008 Sep 26 [cited 2017 Jan 27]; Life/Health & Wellness. Available from: www.thestar.com/life/health_wellness/2008/09/26/infectioncontrol_gaps_at_hospital_highlight_report.html
249. Zoutman D, Ford BD, Sopha K, Wylie B. The influence of patient room type, cleaning procedure, and isolation precautions on room cleaning times in Canadian acute care hospitals. Can J Infect Control. 2015;30(4):213-7.
250. Walker B. 612 Cleaning times. Northbrook, IL: International Sanitary Supply Association; 2014.
251. International Sanitary Supply Association. InfoClean 2.0 easy workloading [software]. Version 2.0. Northbrook, IL: International Sanitary Supply Association; 2016.
252. Rupp ME, Adler A, Schellen M, Cassling K, Fitzgerald T, Sholtz L, et al. The time spent cleaning a hospital room does not correlate with the thoroughness of cleaning. Infect Control Hosp Epidemiol. 2013;34(1):100-2.
253. Guerrero DM, Carling PC, Jury LA, Ponnada S, Nerandzic MM, Donskey CJ. Beyond the Hawthorne effect: reduction of *Clostridium difficile* environmental contamination through active intervention to improve cleaning practices. Infect Control Hosp Epidemiol. 2013;34(5):524-6.
254. Sitzlar B, Deshpande A, Fertelli D, Kundrapu S, Sethi AK, Donskey CJ. An environmental disinfection odyssey: evaluation of sequential interventions to improve disinfection of *Clostridium difficile* isolation rooms. Infect Control Hosp Epidemiol. 2013;34(5):459-65.

255. Smith A, Taggart LR, Lebovic G, Zeynalova N, Khan A, Muller MP. *Clostridium difficile* infection incidence: impact of audit and feedback programme to improve room cleaning. J Hosp Infect. 2016;92(2):161-6.
256. Bryce E, Grant J, Scharf S, Dempster L, Lau TT, Laing F, et al. Horizontal infection prevention measures and a risk-managed approach to vancomycin-resistant enterococci: an evaluation. Am J Infect Control. 2015;43(11):1238-43.
257. Koll BS, Ruiz RE, Calfee DP, Jalon HS, Stricof RL, Adams A, et al. Prevention of hospital-onset *Clostridium difficile* infection in the New York metropolitan region using a collaborative intervention model. J Healthc Qual. 2014;36(3):35-45.
258. Cohen MJ, Block C, Levin PD, Schwartz C, Gross I, Weiss Y, et al. Institutional control measures to curtail the epidemic spread of carbapenem-resistant *Klebsiella pneumoniae*: a 4-year perspective. Infect Control Hosp Epidemiol. 2011;32(7):673-8.
259. Walker J, International Sanitary Supply Association. The official ISSA 447 cleaning times. Walker J, editor. Northbrook, IL: International Sanitary Supply Association; 2003.
260. Kundrapu S, Sunkesula V, Sitzlar BM, Fertelli D, Deshpande A, Donskey CJ. More cleaning, less screening: evaluation of the time required for monitoring versus performing environmental cleaning. Infect Control Hosp Epidemiol. 2014;35(2):202-4.
261. Borer A, Eskira S, Nativ R, Saidel-Odes L, Riesenberg K, Livshiz-Riven I, et al. A multifaceted intervention strategy for eradication of a hospital-wide outbreak caused by carbapenem-resistant *Klebsiella pneumoniae* in Southern Israel. Infect Control Hosp Epidemiol. 2011;32(12):1158-65.
262. Ontario. Ministry of Health and Long-Term Care. Ebola virus disease directive #2 for paramedic services (land and air ambulance) [Internet]. Toronto, ON: Queen's Printer for Ontario; 2015 [cited 2016 Feb 2]. Available from: www.health.gov.on.ca/en/public/programs/emu/ebola/docs/evd_directive_2_paramedic.pdf
263. Ontario. Ministry of Health and Long-Term Care. Ebola virus disease directive #3 for primary care settings [Internet]. Toronto, ON: Queen's Printer for Ontario; 2015 [cited 2016 Feb 2]. Available from: www.health.gov.on.ca/en/public/programs/emu/ebola/docs/evd_directive_3.pdf
264. Ontario. Ministry of Health and Long-Term Care. Ebola virus disease directive #4 regarding waste management for designated hospitals and all paramedic services [Internet]. Toronto, ON: Queen's Printer for Ontario; 2015 [cited 2016 Feb 2]. Available from: www.health.gov.on.ca/en/public/programs/emu/ebola/docs/evd_directive_4_hosp_para.pdf
265. Falk PS, Winnike J, Woodmansee C, Desai M, Mayhall CG. Outbreak of vancomycin-resistant enterococci in a burn unit. Infect Control Hosp Epidemiol. 2000;21(9):575-82.
266. Ontario. Ministry of Labour. Workplace Hazardous Materials Information System (WHMIS): A guide to the legislation [Internet]. Toronto, ON: Queen's Printer for Ontario; 2008 [cited 2017 Dec 17]. Available from: http://files.ontario.ca/books/mol_whmis_guide_english.pdf
267. *Transportation of Dangerous Goods Act*, 1992, SC 1992, c. 34. Available from: http://laws-lois.justice.gc.ca/eng/acts/T-19.01/
268. *Food Premises*, RRO 1990, Reg 562. Available from: www.ontario.ca/laws/regulation/900562
269. *General*, O Reg 63/09. Available from: www.ontario.ca/laws/regulation/090063
270. *General*, O Reg 79/10. Available from: www.ontario.ca/laws/regulation/100079
271. Noble WC. Dispersal of skin microorganisms. Br J Dermatol. 1975;93(4):477-85.

272. Bonten MJ, Hayden MK, Nathan C, van Voorhis J, Matushek M, Slaughter S, et al. Epidemiology of colonisation of patients and environment with vancomycin-resistant enterococci. Lancet. 1996;348(9042):1615-9.
273. Vernon MO, Hayden MK, Trick WE, Hayes RA, Blom DW, Weinstein RA, et al. Chlorhexidine gluconate to cleanse patients in a medical intensive care unit: the effectiveness of source control to reduce the bioburden of vancomycin-resistant enterococci. Arch Intern Med. 2006;166(3):306-12. Available from: http://jamanetwork.com/journals/jamainternalmedicine/fullarticle/409730
274. Munoz-Price LS, Namias N, Cleary T, Fajardo-Aquino Y, Depascale D, Arheart KL, et al. *Acinetobacter baumannii:* association between environmental contamination of patient rooms and occupant status. Infect Control Hosp Epidemiol. 2013;34(5):517-20.
275. Lerner A, Adler A, Abu-Hanna J, Meitus I, Navon-Venezia S, Carmeli Y. Environmental contamination by carbapenem-resistant Enterobacteriaceae. J Clin Microbiol. 2013;51(1):177-81. Available from: http://jcm.asm.org/content/51/1/177.full
276. Smith SJ, Young V, Robertson C, Dancer SJ. Where do hands go? An audit of sequential hand-touch events on a hospital ward. J Hosp Infect. 2012;80(3):206-11.
277. Cheng VC, Chau PH, Lee WM, Ho SK, Lee DW, So SY, et al. Hand-touch contact assessment of high-touch and mutual-touch surfaces among healthcare workers, patients, and visitors. J Hosp Infect. 2015;90(3):220-5.
278. Huslage K, Rutala WA, Sickbert-Bennett E, Weber DJ. A quantitative approach to defining "high-touch" surfaces in hospitals. Infect Control Hosp Epidemiol. 2010;31(8):850-3.
279. Adams CE, Smith J, Watson V, Robertson C, Dancer SJ. Examining the association between surface bioburden and frequently touched sites in intensive care. J Hosp Infect. 2017;95(1):76-80.
280. Moore G, Muzslay M, Wilson AP. The type, level, and distribution of microorganisms within the ward environment: a zonal analysis of an intensive care unit and a gastrointestinal surgical ward. Infect Control Hosp Epidemiol. 2013;34(5):500-6.
281. Verani M, Bigazzi R, Carducci A. Viral contamination of aerosol and surfaces through toilet use in health care and other settings. Am J Infect Control. 2014;42(7):758-62.
282. Morter S, Bennet G, Fish J, Richards J, Allen DJ, Nawaz S, et al. Norovirus in the hospital setting: virus introduction and spread within the hospital environment. J Hosp Infect. 2011;77(2):106-12.
283. Russotto V, Cortegiani A, Raineri SM, Giarratano A. Bacterial contamination of inanimate surfaces and equipment in the intensive care unit. J Intensive Care. 2015;3:54. Available from: http://jintensivecare.biomedcentral.com/articles/10.1186/s40560-015-0120-5
284. Seki M, Machida H, Yamagishi Y, Yoshida H, Tomono K. Nosocomial outbreak of multidrug-resistant *Pseudomonas aeruginosa* caused by damaged transesophageal echocardiogram probe used in cardiovascular surgical operations. J Infect Chemother. 2013;19(4):677-81.
285. Russotto V, Cortegiani A, Raineri SM, Iozzo P, Gregoretti C, Giarratano A. What is the risk of acquiring bacteria from prior intensive care unit bed occupants? Crit Care. 2017;21(1):55-017-1652-y. Available from: http://ccforum.biomedcentral.com/articles/10.1186/s13054-017-1652-y
286. Levin PD, Shatz O, Sviri S, Moriah D, Or-Barbash A, Sprung CL, et al. Contamination of portable radiograph equipment with resistant bacteria in the ICU. Chest. 2009;136(2):426-32.
287. Matsuo M, Oie S, Furukawa H. Contamination of blood pressure cuffs by methicillin-resistant *Staphylococcus aureus* and preventive measures. Ir J Med Sci. 2013;182(4):707-9. Available from: http://link.springer.com/article/10.1007%2Fs11845-013-0961-7

288. O'Flaherty N, Fenelon L. The stethoscope and healthcare-associated infection: a snake in the grass or innocent bystander? J Hosp Infect. 2015;91(1):1-7.
289. Livshiz-Riven I, Borer A, Nativ R, Eskira S, Larson E. Relationship between shared patient care items and healthcare-associated infections: a systematic review. Int J Nurs Stud. 2015;52(1):380-92.
290. Grewal H, Varshney K, Thomas LC, Kok J, Shetty A. Blood pressure cuffs as a vector for transmission of multi-resistant organisms: colonisation rates and effects of disinfection. Emerg Med Australas. 2013;25(3):222-6.
291. Ramphal L, Suzuki S, McCracken IM, Addai A. Improving hospital staff compliance with environmental cleaning behavior. Proc (Bayl Univ Med Cent). 2014;27(2):88-91. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3954653/
292. Smith PW, Beam E, Sayles H, Rupp ME, Cavalieri RJ, Gibbs S, et al. Impact of adenosine triphosphate detection and feedback on hospital room cleaning. Infect Control Hosp Epidemiol. 2014;35(5):564-9.
293. Grabsch EA, Mahony AA, Cameron DR, Martin RD, Heland M, Davey P, et al. Significant reduction in vancomycin-resistant enterococcus colonization and bacteraemia after introduction of a bleach-based cleaning-disinfection programme. J Hosp Infect. 2012;82(4):234-42.
294. *Occupational Health and Safety Awareness and Training*, O Reg 297/13. Available from: www.ontario.ca/laws/regulation/130297
295. CSA Group. CAN/CSA-Z1000-14: Occupational health and safety management. Toronto, ON: CSA Group; 2014.
296. CSA Group. CSA Z317.10-15: Handling of health care waste materials. Toronto, ON: CSA Group; 2015.
297. Lee SJ, Nam B, Harrison R, Hong O. Acute symptoms associated with chemical exposures and safe work practices among hospital and campus cleaning workers: a pilot study. Am J Ind Med. 2014;57(11):1216-26.
298. Lee SJ, Nam B, Harrison R, Hong O. Erratum to "acute symptoms associated with chemical exposures and safe work practices among hospital and campus cleaning workers: a pilot study". Am J Ind Med. 2015;58(8):914. Available from: http://onlinelibrary.wiley.com/doi/10.1002/ajim.22474/full
299. Salwe K, Kumar S, Hood J. Nonfatal occupational injury rates and musculoskeletal symptoms among housekeeping employees of a hospital in Texas. J Environ Public Health. 2011;2011:382510. Available from: http://www.hindawi.com/journals/jeph/2011/382510/
300. Sherman HA, Karakis I, Heimer D, Arzt M, Goldstein W, Bouhnik L, et al. Housekeeping health care workers have the highest risk for tuberculin skin test conversion. Int J Tuberc Lung Dis. 2011;15(8):1050-5. Available from: http://www.ingentaconnect.com/content/iuatld/ijtld/2011/00000015/00000008/art00008
301. Alamgir H, Yu S. Epidemiology of occupational injury among cleaners in the healthcare sector. Occup Med. 2008;58(6):393-9. Available from: http://academic.oup.com/occmed/article/58/6/393/1373884
302. Jungbauer FH, Van Der Harst JJ, Schuttelaar ML, Groothoff JW, Coenraads PJ. Characteristics of wet work in the cleaning industry. Contact Dermatitis. 2004;51(3):131-4.
303. Bauer A. Contact dermatitis in the cleaning industry. Curr Opin Allergy Clin Immunol. 2013;13(5):521-4.

304. CSA Group. CSA Z314.10.2-15: Laundering, maintenance, and preparation of multiple-use gowns, drapes, and wrappers in health care facilities. Toronto, ON: CSA Group; 2015.
305. Smith PW, Bennett G, Bradley S, Drinka P, Lautenbach E, Marx J, et al. SHEA/APIC Guideline: infection prevention and control in the long-term-care facility. Am J Infect Control. 2008;36(7):504-35.
306. Public Health Agency of Canada. Canadian immunization guide [Internet]. Ottawa, ON: Government of Canada; 2016 [cited 2016 Dec 26]. Available from: http://healthycanadians.gc.ca/healthy-living-vie-saine/immunization-immunisation/canadian-immunization-guide-canadien-immunisation/index-eng.php
307. Rashid H, Yin JK, Ward K, King C, Seale H, Booy R. Assessing interventions to improve influenza vaccine uptake among health care workers. Health Aff (Millwood). 2016;35(2):284-92.
308. Hofmann F, Ferracin C, Marsh G, Dumas R. Influenza vaccination of healthcare workers: a literature review of attitudes and beliefs. Infection. 2006;34(3):142-7.
309. Sartor C, Tissot-Dupont H, Zandotti C, Martin F, Roques P, Drancourt M. Use of a mobile cart influenza program for vaccination of hospital employees. Infect Control Hosp Epidemiol. 2004;25(11):918-22.
310. Ontario Hospital Association; Ontario Medical Association Joint Communicable Disease Surveillance Protocols Committee; Ontario. Ministry of Health and Long-Term Care. Influenza surveillance protocol for Ontario hospitals [Internet]. Toronto, ON: Ontario Hospital Association; 2017 [cited 2017 Dec 20]. Available from: www.oha.com/Documents/Influenza%20Protocol%20Revised%20May%202017.pdf
311. Ontario Hospital Association; Ontario Medical Association Joint Communicable Disease Surveillance Protocols Committee; Ontario. Ministry of Health and Long-Term Care. Measles surveillance protocol for Ontario hospitals [Internet]. Toronto, ON: Ontario Hospital Association; 2017 [cited 2017 Dec 20]. Available from: www.oha.com/Documents/Measles%20Protocol%20revised%20%20May%202017.pdf
312. Ontario Hospital Association; Ontario Medical Association Joint Communicable Disease Surveillance Protocols Committee; Ontario. Ministry of Health and Long-Term Care. Mumps surveillance protocol for Ontario hospitals [Internet]. Toronto, ON: Ontario Hospital Association; 2017 [cited 2017 Dec 20]. Available from: www.oha.com/Documents/Mumps%20Protocol%20Revised%20May%202017.pdf
313. Ontario Hospital Association; Ontario Medical Association Joint Communicable Disease Surveillance Protocols Committee; Ontario. Ministry of Health and Long-Term Care. Rubella surveillance protocol for Ontario hospitals [Internet]. Toronto, ON: Ontario Hospital Association; 2017 [cited 2017 Dec 22]. Available from: www.oha.com/Documents/Rubella%20Protocol%20Revised%20May%202017.pdf
314. Ontario Hospital Association; Ontario Medical Association Joint Communicable Disease Surveillance Protocols Committee; Ontario. Ministry of Health and Long-Term Care. Varicella/zoster (chickenpox/shingles) surveillance protocol for Ontario hospitals [Internet]. Toronto, ON: Ontario Hospital Association; 2016 [cited 2017 Dec 22]. Available from: www.oha.com/Documents/Varicella%20Zoster%20Protocol%20Reviewed%20and%20Revised%20May%202016.pdf
315. Ontario Hospital Association; Ontario Medical Association Joint Communicable Disease Surveillance Protocols Committee; Ontario. Ministry of Health and Long-Term Care. Blood-borne diseases surveillance protocol for Ontario hospitals [Internet]. Toronto, ON: Ontario Hospital Association;

2016 [cited 2017 Dec 22]. Available from: www.oha.com/Documents/Blood%20Borne%20Diseases%20Protocol%20-%20Reviewed%20and%20Revised%20Dec%202016.pdf

316. Ontario Hospital Association; Ontario Medical Association Joint Communicable Disease Surveillance Protocols Committee; Ontario. Ministry of Health and Long-Term Care. Pertussis surveillance protocol for Ontario hospitals [Internet]. Toronto, ON: Ontario Hospital Association; 2017 [cited 2017 Dec 22]. Available from: www.oha.com/Documents/Pertussis%20Protocol%20October%202017%20(last%20reviewed%20and%20revised%20on%20October%202017).pdf
317. Medina-Ramon M, Zock JP, Kogevinas M, Sunyer J, Torralba Y, Borrell A, et al. Asthma, chronic bronchitis, and exposure to irritant agents in occupational domestic cleaning: a nested case-control study. Occup Environ Med. 2005;62(9):598-606. Available from: http://oem.bmj.com/content/62/9/598.full
318. Quinn MM, Henneberger PK, Braun B, Delclos GL, Fagan K, Huang V, et al. Cleaning and disinfecting environmental surfaces in health care: toward an integrated framework for infection and occupational illness prevention. Am J Infect Control. 2015;43(5):424-34. Available from: http://www.sciencedirect.com/science/article/pii/S0196655315000759
319. LeBouf RF, Virji MA, Saito R, Henneberger PK, Simcox N, Stefaniak AB. Exposure to volatile organic compounds in healthcare settings. Occup Environ Med. 2014;71(9):642-50. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4591534/
320. Centers for Disease Control and Prevention (CDC). Acute antimicrobial pesticide-related illnesses among workers in health-care facilities - California, Louisiana, Michigan, and Texas, 2002-2007. MMWR Morb Mort Wkly Rep. 2010;59(18):551-6. Available from: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5918a2.htm
321. Arif AA, Delclos GL, Serra C. Occupational exposures and asthma among nursing professionals. Occup Environ Med. 2009;66(4):274-8.
322. CSA Group. CSA Z314.0-13: Medical device reprocessing - general requirements. Toronto, ON: CSA Group; 2013.
323. Folletti I, Zock JP, Moscato G, Siracusa A. Asthma and rhinitis in cleaning workers: a systematic review of epidemiological studies. J Asthma. 2014;51(1):18-28.
324. Siracusa A, De Blay F, Folletti I, Moscato G, Olivieri M, Quirce S, et al. Asthma and exposure to cleaning products - a European Academy of Allergy and Clinical Immunology task force consensus statement. Allergy. 2013;68(12):1532-45.
325. Le Moual N, Varraso R, Siroux V, Dumas O, Nadif R, Pin I, et al. Domestic use of cleaning sprays and asthma activity in females. Eur Respir J. 2012;40(6):1381-9. Available from: http://erj.ersjournals.com/content/40/6/1381.long
326. Dumas O, Donnay C, Heederik DJ, Hery M, Choudat D, Kauffmann F, et al. Occupational exposure to cleaning products and asthma in hospital workers. Occup Environ Med. 2012;69(12):883-9.
327. Mirabelli MC, Zock JP, Plana E, Anto JM, Benke G, Blanc PD, et al. Occupational risk factors for asthma among nurses and related healthcare professionals in an international study. Occup Environ Med. 2007;64(7):474-9. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2078479/
328. Zock JP, Kogevinas M, Sunyer J, Almar E, Muniozguren N, Payo F, et al. Asthma risk, cleaning activities and use of specific cleaning products among Spanish indoor cleaners. Scand J Work Environ Health. 2001;27(1):76-81.

329. Zock JP, Plana E, Jarvis D, Anto JM, Kromhout H, Kennedy SM, et al. The use of household cleaning sprays and adult asthma: an international longitudinal study. Am J Respir Crit Care Med. 2007;176(8):735-41. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2020829/
330. Nielsen J, Bach E. Work-related eye symptoms and respiratory symptoms in female cleaners. Occup Med (Lond). 1999;49(5):291-7.
331. Medina-Ramon M, Zock JP, Kogevinas M, Sunyer J, Basagana X, Schwartz J, et al. Short-term respiratory effects of cleaning exposures in female domestic cleaners. Eur Respir J. 2006;27(6):1196-203. Available from: http://erj.ersjournals.com/content/27/6/1196.long
332. Lasrado OE, Mollerlokken OJ, Moen BE, Van den Bergh G. Musculoskeletal symptoms among hospital cleaners. Arch Environ Occup Health. 2017;72(2):87-92.
333. Woods V, Buckle P. An investigation into the design and use of workplace cleaning equipment. Int J Ind Ergon. 2005;35(3):247-66.
334. Kumar R, Kumar S. Musculoskeletal risk factors in cleaning occupation — a literature review. Int J Ind Ergon. 2008;38(2):158-70.
335. Woods V, Buckle P. Musculoskeletal ill health amongst cleaners and recommendations for work organisational change. Int J Ind Ergon. 2006;36(1):61-72.
336. Robens Centre for Health Ergonomics, European Institute for Health and Medical Sciences, University of Surrey. Musculoskeletal health of cleaners: Contract Research Report 215/1999. Norwich, UK: Crown copyright; 1999. Available from: www.hse.gov.uk/research/crr_pdf/1999/crr99215.pdf
337. Wallius MA, Rissanen SM, Bragge T, Vartiainen P, Karjalainen PA, Rasanen K, et al. Effects of mop handle height on shoulder muscle activity and perceived exertion during floor mopping using a figure eight method. Ind Health. 2016;54(1):58-67. Available from: http://www.jstage.jst.go.jp/article/indhealth/54/1/54_2015-0108/_article
338. Missar VJ, Metcalfe D, Gilmore G. Transforming a hospital safety and ergonomics program: a four year journey of change. Work. 2012;41 Suppl 1:5912-6.
339. Carrivick PJ, Lee AH, Yau KK, Stevenson MR. Evaluating the effectiveness of a participatory ergonomics approach in reducing the risk and severity of injuries from manual handling. Ergonomics. 2005;48(8):907-14.
340. Ontario. Ministry of Health and Long-Term Care. Long-term care home design manual 2015 [Internet]. Toronto, ON: Queen's Printer for Ontario; 2015 [cited 2016 Oct 27]. Available from: www.health.gov.on.ca/en/public/programs/ltc/docs/home_design_manual.pdf
341. Department of Health. Core elements. Health building note 00-03: clinical and clinical support spaces. Surrey, UK: Crown copyright; 2013 [cited 2016 Mar 29]. Available from: www.gov.uk/government/uploads/system/uploads/attachment_data/file/147845/HBN_00-03_Final.pdf
342. CSA Group. CAN/CSA Z317.2-15: Special requirements for heating, ventilation, and air conditioning (HVAC) systems in health care facilities. Toronto, ON: CSA Group; 2015.
343. Mollenkamp B. Custodial closet. CleanLink [Internet]2008 Jul 1 [cited 2016 Dec 15]. Available from: www.cleanlink.com/hs/article/Custodial-Closet--8936
344. Public Health Agency of Canada. Construction-related nosocomial infections in patients in health care facilities. Decreasing the risk of *Aspergillus*, *Legionella* and other infections. Can Comm Dis Rep. 2001;27 Suppl 2:i,x, 1-42, i-x, 1-6. Available from:

http://www.collectionscanada.gc.ca/webarchives/20071124025823/http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/01vol27/27s2/index.html

345. Bar V. Categories for water, flood or sewage damage - 3 types of categories for your insurance claim. EzineArticles [Internet]2008 Apr 1 [cited 2012 Apr 20]. Available from: http://ezinearticles.com/?Categories-For-Water,-Flood-Or-Sewage-Damage---3-Types-Of-Categories-For-Your-Insurance-Claim&id=1082761
346. Teal LJ, Schultz KM, Weber DJ, Gergen MF, Miller MB, DiBiase LM, et al. Invasive cutaneous *Rhizopus* infections in an immunocompromised patient population associated with hospital laundry carts. Infect Control Hosp Epidemiol. 2016;37(10):1251-3.
347. Sehulster LM. Healthcare laundry and textiles in the United States: review and commentary on contemporary infection prevention issues. Infect Control Hosp Epidemiol. 2015;36(9):1073-88.
348. Duffy J, Harris J, Gade L, Sehulster L, Newhouse E, O'Connell H, et al. Mucormycosis outbreak associated with hospital linens. Pediatr Infect Dis J. 2014;33(5):472-6.
349. Cheng VC, Chen JH, Wong SC, Leung SS, So SY, Lung DC, et al. Hospital outbreak of pulmonary and cutaneous zygomycosis due to contaminated linen items from substandard laundry. Clin Infect Dis. 2016;62(6):714-21. Available from: http://academic.oup.com/cid/article/62/6/714/2462724
350. Sooklal S, Khan A, Kannangara S. Hospital *Clostridium difficile* outbreak linked to laundry machine malfunction. Am J Infect Control. 2014;42(6):674-5.
351. Thomas MC, Giedinghagen DH, Hoff GL. An outbreak of scabies among employees in a hospital-associated commercial laundry. Infect Control. 1987;8(10):427-9.
352. Standaert SM, Hutcheson RH, Schaffner W. Nosocomial transmission of *Salmonella gastroenteritis* to laundry workers in a nursing home. Infect Control Hosp Epidemiol. 1994;15(1):22-6.
353. Borg MA, Portelli A. Hospital laundry workers--an at-risk group for hepatitis A? Occup Med. 1999;49(7):448-50. Available from: http://academic.oup.com/occmed/article/49/7/448/1467500
354. Weinstein SA, Gantz NM, Pelletier C, Hibert D. Bacterial surface contamination of patients' linen: isolation precautions versus standard care. Am J Infect Control. 1989;17(5):264-7.
355. Shiomori T, Miyamoto H, Makishima K, Yoshida M, Fujiyoshi T, Udaka T, et al. Evaluation of bedmaking-related airborne and surface methicillin-resistant *Staphylococcus aureus* contamination. J Hosp Infect. 2002;50(1):30-5.
356. England T, Beeching B. Management of used and infected linen policy, Version 2 [Internet]. Southampton, Scotland: Southern Health NHS Foundation Trust; 2016 [cited 2016 May 18]. Available from: www.southernhealth.nhs.uk/EasysiteWeb/getresource.axd?AssetID=83283&type=full&servicetype=Inline&filename=/Management_of_Used_and_Infected_Linen_V2.pdf
357. Department of Health. Choice framework for local policy and procedures 01-04: decontamination of linen for health and social care: management and provision [Internet]. London: Crown Copyright; 2013 [cited 2016 May 18]. Available from: www.gov.uk/government/uploads/system/uploads/attachment_data/file/148536/CFPP_01-04_Mgmt_and_provision_Final.pdf
358. Pugliese G. Isolating and double-bagging laundry: is it really necessary? Health Facil Manage. 1989;2(2):16, 8-21.
359. Centers for Medicare & Medicaid Services. Clarification of interpretive guidance at F Tag 441-Laundry and infection control [Internet]. Baltimore, MD: Centers for Medicare & Medicaid Services;

2013 [cited 2016 May 20]. Available from: www.cms.gov/Medicare/Provider-Enrollment-and-Certification/SurveyCertificationGenInfo/Downloads/Survey-and-Cert-Letter-13-09.pdf

360. Association for Advancement of Medical Instrumentation. AAMI ST65:2008/(R2013). Processing of reusable surgical textiles for use in health care facilities. Arlington, VA: Association for Advancement of Medical Instrumentation; 2013.
361. Ontario Hospital Association. Greening health care sector report: waste management [Internet]. Toronto, ON: Ontario Hospital Association; 2015 [cited 2016 May 24]. Available from: www.oha.com/KnowledgeCentre/Library/Documents/Waste%20Management.pdf
362. Windfeld ES, Brooks MS. Medical waste management - a review. J Environ Manage. 2015;163:98-108.
363. CSA Group, Fallis P. Infection prevention and control in office-based health care and allied systems. 2nd ed. Toronto, ON: CSA Group; 2004.
364. Public Health Agency of Canada. Canadian biosafety standard (CBS) [Internet]. 2nd ed. Ottawa, ON: Her Majesty the Queen in Right of Canada; 2015 [cited 2016 Dec 11]. Available from: http://canadianbiosafetystandards.collaboration.gc.ca/cbs-ncb/index-eng.php
365. Garvey MI, Bradley CR, Bradley CW. Evaluating the risks of wash hand basin tap disinfection. J Hosp Infect. 2016;94(1):21-2.
366. Kanamori H, Weber DJ, Rutala WA. Healthcare outbreaks associated with a water reservoir and infection prevention strategies. Clin Infect Dis. 2016;62(11):1423-35. Available from: http://academic.oup.com/cid/article/62/11/1423/1745014
367. Leitner E, Zarfel G, Luxner J, Herzog K, Pekard-Amenitsch S, Hoenigl M, et al. Contaminated handwashing sinks as the source of a clonal outbreak of KPC-2-producing *Klebsiella oxytoca* on a hematology ward. Antimicrob Agents Chemother. 2015;59(1):714-6. Available from: http://aac.asm.org/content/59/1/714.full
368. Kotsanas D, Wijesooriya WR, Korman TM, Gillespie EE, Wright L, Snook K, et al. "Down the drain": carbapenem-resistant bacteria in intensive care unit patients and handwashing sinks. Med J Aust. 2013;198(5):267-9.
369. Lowe C, Willey B, O'Shaughnessy A, Lee W, Lum M, Pike K, et al. Outbreak of extended-spectrum beta-lactamase-producing *Klebsiella oxytoca* infections associated with contaminated handwashing sinks. Emerg Infect Dis. 2012;18(8):1242-7. Available from: http://wwwnc.cdc.gov/eid/article/18/8/11-1268_article
370. Public Services Health & Safety Association. Planning guide to the implementation of safety engineered medical sharps: resource manual [Internet]. Toronto, ON: Public Services Health & Safety Association; 2012 [cited 2016 May 2]. Available from: www.pshsa.ca/wp-content/uploads/2013/02/ISHMNAEN0412-A-Planning-Guide-to-the-Implementation-of-Safety-Engineered-Medical-Sharps-low-res-protected.pdf
371. Centers for Disease Control and Prevention (CDC). Workbook for designing, implementing and evaluating a sharps injury prevention program [Internet]. Atlanta, GA: Centers for Disease Control and Prevention; 2015 [cited 2016 May 26]. Available from: www.cdc.gov/sharpssafety/pdf/sharpsworkbook_2008.pdf
372. Toraman AR, Battal F, Ozturk K, Akcin B. Sharps injury prevention for hospital workers. Int J Occup Saf Ergon. 2011;17(4):455-61.
373. *Needle Safety*, O Reg. 474/07. Available from: www.ontario.ca/laws/regulation/070474

374. Transport Canada. Transportation of dangerous goods. TDG bulletin: shipping infectious substances [Internet]. Ottawa, ON: Government of Canada; 2016 [cited 2017 Dec 20]. Available from: http://www.tc.gc.ca/media/documents/tdg-eng/Shipping_Infectious_Substances_NEW.pdf
375. Chartier Y, Emmanuel J, Pieper U, Pruss A, Rushbrook P, Stringer R, et al. Safe management of wastes from health-care activities. 2nd ed. Geneva, Switzerland: World Health Organization; 2014. Available from: www.who.int/iris/bitstream/10665/85349/1/9789241548564_eng.pdf?ua=1
376. Han JH, Sullivan N, Leas BF, Pegues DA, Kaczmarek JL, Umscheid CA. Cleaning hospital room surfaces to prevent health care-associated infections: a technical brief. Ann Intern Med. 2015;163(8):598-607. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4812669/
377. Hasan J, Chatterjee K. Recent advances in engineering topography mediated antibacterial surfaces. Nanoscale. 2015;7(38):15568-75. Available from: http://pubs.rsc.org/en/content/articlehtml/2015/nr/c5nr04156b
378. Mann EE, Manna D, Mettetal MR, May RM, Dannemiller EM, Chung KK, et al. Surface micropattern limits bacterial contamination. Antimicrob Resist Infect Control. 2014;3(28):28. Available from: http://aricjournal.biomedcentral.com/articles/10.1186/2047-2994-3-28
379. Casey AL, Adams D, Karpanen TJ, Lambert PA, Cookson BD, Nightingale P, et al. Role of copper in reducing hospital environment contamination. J Hosp Infect. 2010;74(1):72-7.
380. Salgado CD, Sepkowitz KA, John JF, Cantey JR, Attaway HH, Freeman KD, 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.
381. Karpanen TJ, Casey AL, Lambert PA, Cookson BD, Nightingale P, Miruszenko L, et al. The antimicrobial efficacy of copper alloy furnishing in the clinical environment: a crossover study. Infect Control Hosp Epidemiol. 2012;33(1):3-9.
382. Mikolay A, Huggett S, Tikana L, Grass G, Braun J, Nies DH. Survival of bacteria on metallic copper surfaces in a hospital trial. Appl Microbiol Biotechnol. 2010;87(5):1875-9.
383. Schmidt MG, Attaway Iii HH, Fairey SE, Steed LL, Michels HT, Salgado CD. Copper continuously limits the concentration of bacteria resident on bed rails within the intensive care unit. Infect Control Hosp Epidemiol. 2013;34(5):530-3.
384. Schmidt MG, Attaway HH, Sharpe PA, John J, Jr., Sepkowitz KA, Morgan A, et al. Sustained reduction of microbial burden on common hospital surfaces through introduction of copper. J Clin Microbiol. 2012;50(7):2217-23. Available from: http://jcm.asm.org/content/50/7/2217.long
385. Lazary A, Weinberg I, Vatine JJ, Jefidoff A, Bardenstein R, Borkow G, et al. Reduction of healthcare-associated infections in a long-term care brain injury ward by replacing regular linens with biocidal copper oxide impregnated linens. Int J Infect Dis. 2014;24:23-9. Available from: http://www.sciencedirect.com/science/article/pii/S1201971214000599
386. Gerba CP, Sifuentes LY, Lopez GU, Abd-Elmaksoud S, Calabrese J, Tanner B. Wide-spectrum activity of a silver-impregnated fabric. Am J Infect Control. 2016;44(6):689-90.
387. Kotsanas D, Wijesooriya WR, Sloane T, Stuart RL, Gillespie EE. The silver lining of disposable sporicidal privacy curtains in an intensive care unit. Am J Infect Control. 2014;42(4):366-70.
388. Phillips P, Taylor L, Hastings R. Silver ion antimicrobial technology: decontamination in a nursing home. Br J Community Nurs. 2009;14(6):S25-9.
389. Chung CJ, Lin HI, Tsou HK, Shi ZY, He JL. An antimicrobial TiO2 coating for reducing hospital-acquired infection. J Biomed Mater Res B Appl Biomater. 2008;85(1):220-4.

390. Copello GJ, Teves S, Degrossi J, D'Aquino M, Desimone MF, Diaz LE. Antimicrobial activity on glass materials subject to disinfectant xerogel coating. J Ind Microbiol Biotechnol. 2006;33(5):343-8.
391. Rutala WA, Weber DJ. New disinfection and sterilization methods. Emerg Infect Dis. 2001;7(2):348-53. Available from: http://wwwnc.cdc.gov/eid/article/7/2/70-0348_article
392. Boyce JM, Havill NL, Guercia KA, Schweon SJ, Moore BA. Evaluation of two organosilane products for sustained antimicrobial activity on high-touch surfaces in patient rooms. Am J Infect Control. 2014;42(3):326-8.
393. Tamimi AH, Carlino S, Gerba CP. Long-term efficacy of a self-disinfecting coating in an intensive care unit. Am J Infect Control. 2014;42(11):1178-81.
394. Schmidt MG, von Dessauer B, Benavente C, Benadof D, Cifuentes P, Elgueta A, et al. Copper surfaces are associated with significantly lower concentrations of bacteria on selected surfaces within a pediatric intensive care unit. Am J Infect Control. 2016;44(2):203-9. Available from: http://www.sciencedirect.com/science/article/pii/S0196655315009815
395. Hinsa-Leasure SM, Nartey Q, Vaverka J, Schmidt MG. Copper alloy surfaces sustain terminal cleaning levels in a rural hospital. Am J Infect Control. 2016;44(11):e195-e203. Available from: http://www.sciencedirect.com/science/article/pii/S0196655316307519
396. CSA Group. EXP06-2015: Evaluating emerging materials and technologies for infection prevention and control. Toronto, ON: CSA Group; 2015.
397. Rutala WA, Weber DJ. Disinfectants used for environmental disinfection and new room decontamination technology. Am J Infect Control. 2013;41(5 Suppl):S36-41.
398. Ali S, Muzslay M, Bruce M, Jeanes A, Moore G, Wilson AP. Efficacy of two hydrogen peroxide vapour aerial decontamination systems for enhanced disinfection of meticillin-resistant *Staphylococcus aureus*, *Klebsiella pneumoniae* and *Clostridium difficile* in single isolation rooms. J Hosp Infect. 2016;93(1):70-7.
399. Blazejewski C, Wallet F, Rouze A, Le Guern R, Ponthieux S, Salleron J, et al. Efficiency of hydrogen peroxide in improving disinfection of ICU rooms. Crit Care. 2015;19:30. Available from: http://ccforum.biomedcentral.com/articles/10.1186/s13054-015-0752-9
400. Horn K, Otter JA. Hydrogen peroxide vapor room disinfection and hand hygiene improvements reduce *Clostridium difficile* infection, methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant enterococci, and extended-spectrum beta-lactamase. Am J Infect Control. 2015;43(12):1354-6.
401. Best EL, Parnell P, Thirkell G, Verity P, Copland M, Else P, et al. Effectiveness of deep cleaning followed by hydrogen peroxide decontamination during high *Clostridium difficile* infection incidence. J Hosp Infect. 2014;87(1):25-33.
402. Barbut F, Yezli S, Mimoun M, Pham J, Chaouat M, Otter JA. Reducing the spread of *Acinetobacter baumannii* and methicillin-resistant *Staphylococcus aureus* on a burns unit through the intervention of an infection control bundle. Burns. 2013;39(3):395-403.
403. Manian FA, Griesnauer S, Bryant A. Implementation of hospital-wide enhanced terminal cleaning of targeted patient rooms and its impact on endemic *Clostridium difficile* infection rates. Am J Infect Control. 2013;41(6):537-41.
404. Passaretti CL, Otter JA, Reich NG, Myers J, Shepard J, Ross T, et al. An evaluation of environmental decontamination with hydrogen peroxide vapor for reducing the risk of patient acquisition of multidrug-resistant organisms. Clin Infect Dis. 2013;56(1):27-35. Available from: http://academic.oup.com/cid/article/56/1/27/417496

405. Chmielarczyk A, Higgins PG, Wojkowska-Mach J, Synowiec E, Zander E, Romaniszyn D, et al. Control of an outbreak of *Acinetobacter baumannii* infections using vaporized hydrogen peroxide. J Hosp Infect. 2012;81(4):239-45.
406. Havill NL, Moore BA, Boyce JM. Comparison of the microbiological efficacy of hydrogen peroxide vapor and ultraviolet light processes for room decontamination. Infect Control Hosp Epidemiol. 2012;33(5):507-12.
407. Taneja N, Biswal M, Kumar A, Edwin A, Sunita T, Emmanuel R, et al. Hydrogen peroxide vapour for decontaminating air-conditioning ducts and rooms of an emergency complex in northern India: time to move on. J Hosp Infect. 2011;78(3):200-3.
408. Chan HT, White P, Sheorey H, Cocks J, Waters MJ. Evaluation of the biological efficacy of hydrogen peroxide vapour decontamination in wards of an Australian hospital. J Hosp Infect. 2011;79(2):125-8.
409. Otter JA, Yezli S, Schouten MA, van Zanten AR, Houmes-Zielman G, Nohlmans-Paulssen MK. Hydrogen peroxide vapor decontamination of an intensive care unit to remove environmental reservoirs of multidrug-resistant gram-negative rods during an outbreak. Am J Infect Control. 2010;38(9):754-6.
410. Ray A, Perez F, Beltramini AM, Jakubowycz M, Dimick P, Jacobs MR, et al. Use of vaporized hydrogen peroxide decontamination during an outbreak of multidrug-resistant *Acinetobacter baumannii* infection at a long-term acute care hospital. Infect Control Hosp Epidemiol. 2010;31(12):1236-41. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3731999/
411. Boyce JM, Havill NL, Otter JA, McDonald LC, Adams NM, Cooper T, et al. Impact of hydrogen peroxide vapor room decontamination on *Clostridium difficile* environmental contamination and transmission in a healthcare setting. Infect Control Hosp Epidemiol. 2008;29(8):723-9.
412. Shapey S, Machin K, Levi K, Boswell TC. Activity of a dry mist hydrogen peroxide system against environmental *Clostridium difficile* contamination in elderly care wards. J Hosp Infect. 2008;70(2):136-41.
413. Otter JA, Cummins M, Ahmad F, van Tonder C, Drabu YJ. Assessing the biological efficacy and rate of recontamination following hydrogen peroxide vapour decontamination. J Hosp Infect. 2007;67(2):182-8.
414. Hardy KJ, Gossain S, Henderson N, Drugan C, Oppenheim BA, Gao F, et al. Rapid recontamination with MRSA of the environment of an intensive care unit after decontamination with hydrogen peroxide vapour. J Hosp Infect. 2007;66(4):360-8.
415. French GL, Otter JA, Shannon KP, Adams NM, Watling D, Parks MJ. Tackling contamination of the hospital environment by methicillin-resistant *Staphylococcus aureus* (MRSA): a comparison between conventional terminal cleaning and hydrogen peroxide vapour decontamination. J Hosp Infect. 2004;57(1):31-7.
416. Haas JP, Menz J, Dusza S, Montecalvo MA. Implementation and impact of ultraviolet environmental disinfection in an acute care setting. Am J Infect Control. 2014;42(6):586-90.
417. Jinadatha C, Quezada R, Huber TW, Williams JB, Zeber JE, Copeland LA. Evaluation of a pulsed-xenon ultraviolet room disinfection device for impact on contamination levels of methicillin-resistant *Staphylococcus aureus*. BMC Infect Dis. 2014;14:187. Available from: http://bmcinfectdis.biomedcentral.com/articles/10.1186/1471-2334-14-187
418. Boyce JM, Havill NL, Moore BA. Terminal decontamination of patient rooms using an automated mobile UV light unit. Infect Control Hosp Epidemiol. 2011;32(8):737-42.

419. Stibich M, Stachowiak J, Tanner B, Berkheiser M, Moore L, Raad I, et al. Evaluation of a pulsed-xenon ultraviolet room disinfection device for impact on hospital operations and microbial reduction. Infect Control Hosp Epidemiol. 2011;32(3):286-8.
420. Nerandzic MM, Cadnum JL, Pultz MJ, Donskey CJ. Evaluation of an automated ultraviolet radiation device for decontamination of *Clostridium difficile* and other healthcare-associated pathogens in hospital rooms. BMC Infect Dis. 2010;10:197. Available from: http://bmcinfectdis.biomedcentral.com/articles/10.1186/1471-2334-10-197
421. Andersen BM, Banrud H, Boe E, Bjordal O, Drangsholt F. Comparison of UV C light and chemicals for disinfection of surfaces in hospital isolation units. Infect Control Hosp Epidemiol. 2006;27(7):729-34.
422. Bache SE, Maclean M, MacGregor SJ, Anderson JG, Gettinby G, Coia JE, et al. Clinical studies of the High-Intensity Narrow-Spectrum light Environmental Decontamination System (HINS-light EDS), for continuous disinfection in the burn unit inpatient and outpatient settings. Burns. 2012;38(1):69-76.
423. Maclean M, Macgregor SJ, Anderson JG, Woolsey GA, Coia JE, Hamilton K, et al. Environmental decontamination of a hospital isolation room using high-intensity narrow-spectrum light. J Hosp Infect. 2010;76(3):247-51.
424. Maclean M, Booth MG, Anderson JG, MacGregor SJ, Woolsey GA, Coia JE, et al. Continuous decontamination of an intensive care isolation room during patient occupancy using 405 nm light technology. J Infect Prev. 2013;14(5):176-81. Available from: http://journals.sagepub.com/doi/abs/10.1177/1757177413483646
425. Friedman H, Volin E, Laumann D. Terminal disinfection in hospitals with quaternary ammonium compounds by use of a spray-fog technique. Appl Microbiol. 1968;16(2):223-7. Available from: http://aem.asm.org/content/16/2/223.full.pdf
426. Munster AM, Ostrander WE. Terminal disinfection of contaminated patient care areas: to fog or not to fog? Am Surg. 1974;40(12):713-5.
427. Jury LA, Cadnum JL, Jennings-Sanders A, Eckstein EC, Chang S, Donskey CJ. Evaluation of an alcohol-based power sanitizing system for decontamination of hospital rooms of patients with methicillin-resistant *Staphylococcus aureus* carriage. Am J Infect Control. 2010;38(3):234-6.
428. Park GW, Vinje J, Kim JH, Cho M. Comparison of inactivation profiles of surrogate strains of human norovirus and *Clostridium difficile* against gaseous ozone. Presented at: APIC 37th Annual Educational Conference and International Meeting; 2010 Jul 14; New Orleans, LA.
429. Sharma M, Hudson JB. Ozone gas is an effective and practical antibacterial agent. Am J Infect Control. 2008;36(8):559-63.
430. de Boer HE, van Elzelingen-Dekker CM, van Rheenen-Verberg CM, Spanjaard L. Use of gaseous ozone for eradication of methicillin-resistant *Staphylococcus aureus* from the home environment of a colonized hospital employee. Infect Control Hosp Epidemiol. 2006;27(10):1120-2.
431. Berrington AW, Pedler SJ. Investigation of gaseous ozone for MRSA decontamination of hospital side-rooms. J Hosp Infect. 1998;40(1):61-5.
432. Clark J, Barrett SP, Rogers M, Stapleton R. Efficacy of super-oxidized water fogging in environmental decontamination. J Hosp Infect. 2006;64(4):386-90.
433. Sexton JD, Tanner BD, Maxwell SL, Gerba CP. Reduction in the microbial load on high-touch surfaces in hospital rooms by treatment with a portable saturated steam vapor disinfection system. Am J Infect Control. 2011;39(8):655-62.

434. Tanner BD. Reduction in infection risk through treatment of microbially contaminated surfaces with a novel, portable, saturated steam vapor disinfection system. Am J Infect Control. 2009;37(1):20-7.
435. Weber DJ, Kanamori H, Rutala WA. 'No touch' technologies for environmental decontamination: focus on ultraviolet devices and hydrogen peroxide systems. Curr Opin Infect Dis. 2016;29(4):424-31.
436. Dancer SJ. Floor wars: the battle for 'clean' surfaces. J Hosp Infect. 2013;84(4):339-40.
437. Otter JA, Puchowicz M, Ryan D, Salkeld JA, Cooper TA, Havill NL, et al. Feasibility of routinely using hydrogen peroxide vapor to decontaminate rooms in a busy United States hospital. Infect Control Hosp Epidemiol. 2009;30(6):574-7.
438. Jensen PA, Lambert LA, Iademarco MF, Ridzon R, CDC. Guidelines for preventing the transmission of *Mycobacterium tuberculosis* in health-care settings, 2005. MMWR Recomm Rep. 2005;54(RR-17):1-141. Available from: http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5417a1.htm
439. Schafer MP, Kujundzic E, Moss CE, Miller SL. Method for estimating ultraviolet germicidal fluence rates in a hospital room. Infect Control Hosp Epidemiol. 2008;29(11):1042-7.
440. Wong T, Woznow T, Petrie M, Murzello E, Muniak A, Kadora A, et al. Postdischarge decontamination of MRSA, VRE, and *Clostridium difficile* isolation rooms using 2 commercially available automated ultraviolet-C-emitting devices. Am J Infect Control. 2016;44(4):416-20.
441. Napolitano NA, Mahapatra T, Tang W. The effectiveness of UV-C radiation for facility-wide environmental disinfection to reduce health care-acquired infections. Am J Infect Control. 2015;43(12):1342-6.
442. Vianna PG, Dale CR, Jr., Simmons S, Stibich M, Licitra CM. Impact of pulsed xenon ultraviolet light on hospital-acquired infection rates in a community hospital. Am J Infect Control. 2016;44(3):299-303. Available from: http://www.sciencedirect.com/science/article/pii/S0196655315010640
443. Nagaraja A, Visintainer P, Haas JP, Menz J, Wormser GP, Montecalvo MA. *Clostridium difficile* infections before and during use of ultraviolet disinfection. Am J Infect Control. 2015;43(9):940-5.
444. Miller R, Simmons S, Dale C, Stachowiak J, Stibich M. Utilization and impact of a pulsed-xenon ultraviolet room disinfection system and multidisciplinary care team on *Clostridium difficile* in a long-term acute care facility. Am J Infect Control. 2015;43(12):1350-3. Available from: http://www.sciencedirect.com/science/article/pii/S0196655315008020
445. Levin J, Riley LS, Parrish C, English D, Ahn S. The effect of portable pulsed xenon ultraviolet light after terminal cleaning on hospital-associated *Clostridium difficile* infection in a community hospital. Am J Infect Control. 2013;41(8):746-8.
446. Zoutman D, Shannon M, Mandel A. Effectiveness of a novel ozone-based system for the rapid high-level disinfection of health care spaces and surfaces. Am J Infect Control. 2011;39(10):873-9.
447. Hudson JB, Sharma M, Petric M. Inactivation of Norovirus by ozone gas in conditions relevant to healthcare. J Hosp Infect. 2007;66(1):40-5.
448. Davies A, Pottage T, Bennett A, Walker J. Gaseous and air decontamination technologies for *Clostridium difficile* in the healthcare environment. J Hosp Infect. 2011;77(3):199-203.
449. Accreditation Canada. Qmentum quarterly: quality in health care [Internet]. Ottawa, ON: Accreditation Canada; 2013 [cited 2016 Oct 26]. Available from: http://accreditation.ca/sites/default/files/qq-spring-2013.pdf
450. Office of the Auditor General of Ontario. Special report: prevention and control of hospital-acquired infections. Toronto, ON: Queen's Printer for Ontario; 2008. Available from: www.auditor.on.ca/en/content/specialreports/specialreports/hai_en.pdf

451. Fisher D, Pang L, Salmon S, Lin RT, Teo C, Tambyah P, et al. A successful vancomycin-resistant enterococci reduction bundle at a Singapore hospital. Infect Control Hosp Epidemiol. 2016;37(1):107-9.
452. Public Health Agency of Canada. The Chief Public Health Officer's report on the state of public health in Canada, 2013. Infectious disease—the never-ending threat [Internet]. Ottawa, ON: Government of Canada; 2013 [cited 2016 Oct 25]. Available from: www.phac-aspc.gc.ca/cphorsphc-respcacsp/2013/infections-eng.php
453. Snyder GM, Holyoak AD, Leary KE, Sullivan BF, Davis RB, Wright SB. Effectiveness of visual inspection compared with non-microbiologic methods to determine the thoroughness of post-discharge cleaning. Antimicrob Resist Infect Control. 2013;2(1):26. Available from: http://aricjournal.biomedcentral.com/articles/10.1186/2047-2994-2-26
454. National Patient Safety Agency. The revised healthcare cleaning manual [Internet]. Redditch, UK: National Health Service England; 2009 [cited 2009 Aug 5]. Available from: www.nrls.npsa.nhs.uk/EasySiteWeb/getresource.axd?AssetID=61814
455. National Facilities Scotland, Health Care Associated Infection Task Force. The NHS Scotland national cleaning services specification. Version 4.0 June 2016 [Internet]. Glasgow: Health Facilities Scotland; 2016 [cited 2016 Dec 10]. Available from: www.hfs.scot.nhs.uk/publications/1479818599-The%20NHSScotland%20National%20Cleaning%20Services%20Specification%20%20-%20June%202016.pdf
456. Ontario Healthcare Housekeepers Association. Cleaning standards for health care facilities. Bath, ON: Ontario Healthcare Housekeepers' Association Inc; 2000.
457. Griffith CJ, Cooper RA, Gilmore J, Davies C, Lewis M. An evaluation of hospital cleaning regimes and standards. J Hosp Infect. 2000;45(1):19-28.
458. Cooper RA, Griffith CJ, Malik RE, Obee P, Looker N. Monitoring the effectiveness of cleaning in four British hospitals. Am J Infect Control. 2007;35(5):338-41.
459. Sherlock O, O'Connell N, Creamer E, Humphreys H. Is it really clean? An evaluation of the efficacy of four methods for determining hospital cleanliness. J Hosp Infect. 2009;72(2):140-6.
460. Guh A, Carling P, Environmental Evaluation Working Group. Options for evaluating environmental cleaning [Internet]. Atlanta, GA: Centers for Disease Control and Prevention; 2010 [cited 2016 Sep 24]. Available from: www.cdc.gov/HAI/pdfs/toolkits/Environ-Cleaning-Eval-toolkit12-2-2010.pdf
461. Isaac T, Zaslavsky AM, Cleary PD, Landon BE. The relationship between patients' perception of care and measures of hospital quality and safety. Health Serv Res. 2010;45(4):1024-40. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2910567/
462. Carling PC, Bartley JM. Evaluating hygienic cleaning in health care settings: what you do not know can harm your patients. Am J Infect Control. 2010;38(5 Suppl 1):S41-50.
463. Omidbakhsh N, Ahmadpour F, Kenny N. How reliable are ATP bioluminescence meters in assessing decontamination of environmental surfaces in healthcare settings? PLoS One. 2014;9(6):e99951. Available from: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0099951
464. Association for Professionals in Infection Control and Epidemiology. APIC Practice Guidelines Committee (PGC) position statement on adenosine triphosphate (ATP) testing of reusable textiles in healthcare facilities [Internet]. Arlington, VA: Association for Professionals in Infection Control and Epidemiology; 2012 [cited 2016 Sep 24]. Available from: www.apic.org/Resource_/TinyMceFileManager/Position_Statements/APIC_position_ATP_and_reusable_textiles_082012.pdf

465. Professional and Technical Services. Adenosine triphosphate (ATP) bioluminescence and its usefulness in monitoring the effectiveness of environmental cleaning and disinfection: technical bulletin [Internet]. Oakville, ON: Professional and Technical Services; 2012 [cited 2016 Sep 25]. Available from: www.infectionpreventionresource.com/files/PTS%20Technical%20Bulletin%20-%20Use%20of%20ATP%20for%20Evaluating%20Cleaning%20%20Disinfection%20Effectiveness%20Oct%202012%20_2_.pdf
466. Green TA, Russell SM, Fletcher DL. Effect of chemical sanitizing agents on ATP bioluminescence measurements. J Food Prot. 1998;61(8):1013-7.
467. Velazquez M, Feirtag JM. Quenching and enhancement effects of ATP extractants, cleansers, and sanitizers on the detection of the ATP bioluminescence signal. J Food Protect. 1997;60(7):799-803. Available from: http://www.jfoodprotection.org/doi/pdf/10.4315/0362-028X-60.7.799
468. Brown E, Eder AR, Thompson KM. Do surface and cleaning chemistries interfere with ATP measurement systems for monitoring patient room hygiene? J Hosp Infect. 2010;74(2):193-5.
469. Carling PC, Parry MF, Von Beheren SM, Healthcare Environmental Hygiene Study Group. Identifying opportunities to enhance environmental cleaning in 23 acute care hospitals. Infect Control Hosp Epidemiol. 2008;29(1):1-7.
470. Carling PC, Von Beheren S, Kim P, Woods C, Healthcare Environmental Hygiene Study Group. Intensive care unit environmental cleaning: an evaluation in sixteen hospitals using a novel assessment tool. J Hosp Infect. 2008;68(1):39-44.
471. Fattorini M, Ceriale E, Nante N, Lenzi D, Manzi P, Basagni C, et al. Use of a fluorescent marker for assessing hospital bathroom cleanliness. Am J Infect Control. 2016;44(9):1066-8.
472. Carling PC, Parry MF, Bruno-Murtha LA, Dick B. Improving environmental hygiene in 27 intensive care units to decrease multidrug-resistant bacterial transmission. Crit Care Med. 2010;38(4):1054-9.
473. Goodman ER, Platt R, Bass R, Onderdonk AB, Yokoe DS, Huang SS. Impact of an environmental cleaning intervention on the presence of methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant enterococci on surfaces in intensive care unit rooms. Infect Control Hosp Epidemiol. 2008;29(7):593-9. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2670228/
474. Munoz-Price LS, Ariza-Heredia E, Adams S, Olivier M, Francois L, Socarras M, et al. Use of UV powder for surveillance to improve environmental cleaning. Infect Control Hosp Epidemiol. 2011;32(3):283-5.
475. Ragan K, Khan A, Zeynalova N, McKernan P, Baser K, Muller MP. Use of audit and feedback with fluorescent targeting to achieve rapid improvements in room cleaning in the intensive care unit and ward settings. Am J Infect Control. 2012;40(3):284-6.
476. Anderson RE, Young V, Stewart M, Robertson C, Dancer SJ. Cleanliness audit of clinical surfaces and equipment: who cleans what? J Hosp Infect. 2011;78(3):178-81.
477. Knelson LP, Ramadanovic G, Chen LF, Moehring RW, Lewis SS, Rutala W, et al. Self-monitoring of hospital room cleaning by environmental services may not accurately measure cleanliness. Presented at: ID Week 2015; 2015 Oct 9; San Diego, CA. Available from: http://academic.oup.com/ofid/article/doi/10.1093/ofid/ofv131.85/2633996/Self-Monitoring-of-Hospital-Room-Cleaning-by
478. Lewis T, Griffith C, Gallo M, Weinbren M. A modified ATP benchmark for evaluating the cleaning of some hospital environmental surfaces. J Hosp Infect. 2008;69(2):156-63.

479. Mulvey D, Redding P, Robertson C, Woodall C, Kingsmore P, Bedwell D, et al. Finding a benchmark for monitoring hospital cleanliness. J Hosp Infect. 2011;77(1):25-30.
480. Huang Y, Chen YC, Chen ML, Cheng A, Hung IC, Wang JT, et al. Comparing visual inspection, aerobic colony counts, and adenosine triphosphate bioluminescence assay for evaluating surface cleanliness at a medical center. Am J Infect Control. 2015;43(8):882-6.
481. Amodio E, Dino C. Use of ATP bioluminescence for assessing the cleanliness of hospital surfaces: a review of the published literature (1990-2012). J Infect Public Health. 2014;7(2):92-8. Available from: http://www.sciencedirect.com/science/article/pii/S1876034113001330
482. Health Facilities Scotland. Use of ATP as a tool for monitoring cleanliness. Report on visit to North Tees Hospital Trust. March 2011 [Internet]. Glasgow, Scotland: Health Facilities Scotland; 2011 [cited 2018 Feb 26]. Available from: http://encrypted.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwjgk_eVssLZAhUK74MKHayHC5oQFggmMAA&url=http%3A%2F%2Fwww.hfs.scot.nhs.uk%2Fdownloads%2F1302166663-North%252BTees%252Bfinal%252Breport%252B.pdf&usg=AOvVaw1oIXFEU6LN5fmZDD0mu6KI
483. Boyce JM, Havill NL, Dumigan DG, Golebiewski M, Balogun O, Rizvani R. Monitoring the effectiveness of hospital cleaning practices by use of an adenosine triphosphate bioluminescence assay. Infect Control Hosp Epidemiol. 2009;30(7):678-84.
484. Simpson WJ, Hammond JR. The effect of detergents on firefly luciferase reactions. J Biolumin Chemilumin. 1991;6(2):97-106.
485. Shimoda T, Yano R, Nakamura S, Yoshida M, Matsuo J, Yoshimura S, et al. ATP bioluminescence values are significantly different depending upon material surface properties of the sampling location in hospitals. BMC Res Notes. 2015;8(1):807. Available from: http://bmcresnotes.biomedcentral.com/articles/10.1186/s13104-015-1757-9
486. Boyce JM, Havill NL, Havill HL, Mangione E, Dumigan DG, Moore BA. Comparison of fluorescent marker systems with 2 quantitative methods of assessing terminal cleaning practices. Infect Control Hosp Epidemiol. 2011;32(12):1187-93.
487. Whiteley GS, Derry C, Glasbey T. Reliability testing for portable adenosine triphosphate bioluminometers. Infect Control Hosp Epidemiol. 2013;34(5):538-40.
488. Loveday HP, Wilson JA, Pratt RJ, Golsorkhi M, Tingle A, Bak A, et al. epic3: national evidence-based guidelines for preventing healthcare-associated infections in NHS hospitals in England. J Hosp Infect. 2014;86 Suppl 1:S1-70.
489. International Sanitary Supply Association. Using an ATP monitoring system in health care settings. ISSA Today [Internet]. Washington, DC: International Sanitary Supply Association; [cited 2016 Dec 10]. Available from: http://fmlink.com/articles/using-an-atp-monitoring-system-in-health-care-settings/
490. Huslage K, Rutala WA, Gergen MF, Sickbert-Bennett EE, Weber DJ. Microbial assessment of high-, medium-, and low-touch hospital room surfaces. Infect Control Hosp Epidemiol. 2013;34(2):211-2.
491. Dancer SJ. How do we assess hospital cleaning? A proposal for microbiological standards for surface hygiene in hospitals. J Hosp Infect. 2004;56(1):10-5.
492. Mitchell BG, Wilson F, Dancer SJ, McGregor A. Methods to evaluate environmental cleanliness in healthcare facilities. Healthcare infection. 2013;18(1):23-30.
493. Whiteley GS, Derry C, Glasbey T. Failure analysis in the identification of synergies between cleaning monitoring methods. Am J Infect Control. 2015;43(2):147-53.

494. Luick L, Thompson PA, Loock MH, Vetter SL, Cook J, Guerrero DM. Diagnostic assessment of different environmental cleaning monitoring methods. Am J Infect Control. 2013;41(8):751-2.
495. Willis C, Morley R, Westbury J, Greenwood M, Pallett A. Evaluation of ATP bioluminescence swabbing as a monitoring and training tool for effective hospital cleaning. Br J Infect Contr. 2016;8(5):17-21.
496. Speight S, Moy A, Macken S, Chitnis R, Hoffman PN, Davies A, et al. Evaluation of the sporicidal activity of different chemical disinfectants used in hospitals against *Clostridium difficile*. J Hosp Infect. 2011;79(1):18-22.
497. Nanwa N, Sander B, Krahn M, Daneman N, Lu H, Austin PC, et al. A population-based matched cohort study examining the mortality and costs of patients with community-onset *Clostridium difficile* infection identified using emergency department visits and hospital admissions. PLoS One. 2017;12(3):e0172410. Available from: http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0172410
498. Pant C, Sferra TJ, Olyaee M, Gilroy R, Anderson MP, Rastogi A, et al. Emergency department visits related to *Clostridium difficile* infection: results from the nationwide emergency department sample, 2006 through 2010. Acad Emerg Med. 2015;22(1):117-9. Available from: http://onlinelibrary.wiley.com/doi/10.1111/acem.12552/full
499. Smith AM, Wuerth BA, Wiemken TL, Arnold FW. Prevalence of *Clostridium difficile* infection presenting to US EDs. Am J Emerg Med. 2015;33(2):238-43.
500. Abrahamian FM, Talan DA, Krishnadasan A, Citron DM, Paulick AL, Anderson LJ, et al. *Clostridium difficile* infection among US emergency department patients with diarrhea and no vomiting. Ann Emerg Med. 2017;70(1):19-27.
501. Gupta A, Khanna S. Community-acquired *Clostridium difficile* infection: an increasing public health threat. Infect Drug Resist. 2014;7:63-72. Available from: http://www.dovepress.com/community-acquired-clostridium-difficile-infection-an-increasing-publi-peer-reviewed-fulltext-article-IDR
502. Danforth D, Nicolle LE, Hume K, Alfieri N, Sims H. Nosocomial infections on nursing units with floors cleaned with a disinfectant compared with detergent. J Hosp Infect. 1987;10(3):229-35.
503. Rutala WA, Weber DJ. Surface disinfection: should we do it? J Hosp Infect. 2001;48 Suppl A:S64-8.
504. Daschner FD, Schuster A, Dettenkofer M, Kummerer K. No routine surface disinfection. Am J Infect Control. 2004;32(8):513-5.
505. Dharan S, Mourouga P, Copin P, Bessmer G, Tschanz B, Pittet D. Routine disinfection of patients' environmental surfaces. Myth or reality? J Hosp Infect. 1999;42(2):113-7.
506. U. S. Food and Drug Administration. Public health notification from FDA, CDC, EPA and OSHA: avoiding hazards with using cleaners and disinfectants on electronic medical equipment [Internet]. Silver Spring, MD: U. S. Food and Drug Administration; 2007 [cited 2018 Feb 26]. Available from: http://wayback.archive-it.org/7993/20170111190527/http://www.fda.gov/MedicalDevices/Safety/AlertsandNotices/PublicHealthNotifications/ucm062052.htm
507. Li LM, Wong T, Rose E, Wickham G, Bryce E. Evaluation of an ultraviolet C light-emitting device for disinfection of electronic devices. Am J Infect Control. 2016;44(12):1554-7.
508. Mathew JI, Cadnum JL, Sankar T, Jencson AL, Kundrapu S, Donskey CJ. Evaluation of an enclosed ultraviolet-C radiation device for decontamination of mobile handheld devices. Am J Infect Control. 2016;44(6):724-6. Available from: http://www.sciencedirect.com/science/article/pii/S0196655316000389

509. Gostine A, Gostine D, Donohue C, Carlstrom L. Evaluating the effectiveness of ultraviolet-C lamps for reducing keyboard contamination in the intensive care unit: a longitudinal analysis. Am J Infect Control. 2016;44(10):1089-94. Available from: http://www.sciencedirect.com/science/article/pii/S019665531630579X
510. Shaikh AA, Ely D, Cadnum JL, Koganti S, Alhmidi H, Sankar CT, et al. Evaluation of a low-intensity ultraviolet-C radiation device for decontamination of computer keyboards. Am J Infect Control. 2016;44(6):705-7. Available from: http://www.sciencedirect.com/science/article/pii/S0196655315012183
511. Schuetz AN, Hughes RL, Howard RM, Williams TC, Nolte FS, Jackson D, et al. Pseudo-outbreak of *Legionella pneumophila* serogroup 8 infection associated with a contaminated ice machine in a bronchoscopy suite. Infect Control Hosp Epidemiol. 2009;30(5):461-6.
512. Labombardi VJ, O'Brien AM, Kislak JW. Pseudo-outbreak of *Mycobacterium fortuitum* due to contaminated ice machines. Am J Infect Control. 2002;30(3):184-6.
513. Wilson IG, Hogg GM, Barr JG. Microbiological quality of ice in hospital and community. J Hosp Infect. 1997;36(3):171-80.
514. Anson JJ, Allen KD. Hospital ice machines. J Hosp Infect. 1997;37(4):335-6.
515. Graman PS, Quinlan GA, Rank JA. Nosocomial legionellosis traced to a contaminated ice machine. Infect Control Hosp Epidemiol. 1997;18(9):637-40.
516. Gallimore CI, Taylor C, Gennery AR, Cant AJ, Galloway A, Xerry J, et al. Contamination of the hospital environment with gastroenteric viruses: comparison of two pediatric wards over a winter season. J Clin Microbiol. 2008;46(9):3112-5. Available from: http://jcm.asm.org/content/46/9/3112.full
517. Randle J, Fleming K. The risk of infection from toys in the intensive care setting. Nurs Stand. 2006;20(40):50-4.
518. Fleming K, Randle J. Toys-friend or foe? A study of infection risk in a paediatric intensive care unit. Paediatr Nurs. 2006;18(4):14-8.
519. Avila-Aguero Ml, German G, Paris MM, Herrera JF, Safe Toys Study Group. Toys in a pediatric hospital: are they a bacterial source? Am J Infect Control. 2004;32(5):287-90.
520. Akhter J, al-Hajjar S, Myint S, Qadri SM. Viral contamination of environmental surfaces on a general paediatric ward and playroom in a major referral centre in Riyadh. Eur J Epidemiol. 1995;11(5):587-90.
521. Kamhuka LN, Rees G, Ward L, Carson J, Church D, Baggott S, et al. Successful control of a vancomycin resistant enterococci (VRE) outbreak on a pediatric ward – do not forget the toys. Presented at: 40th Annual Conference, APIC 2013; 2013 Jun 7-10; Ft Lauderdale, FL. Available from: www.ajicjournal.org/article/S0196-6553(13)00296-4/abstract
522. Buttery JP, Alabaster SJ, Heine RG, Scott SM, Crutchfield RA, Bigham A, et al. Multiresistant *Pseudomonas aeruginosa* outbreak in a pediatric oncology ward related to bath toys. Pediatr Infect Dis J. 1998;17(6):509-13.
523. Pappas DE, Hendley JO, Schwartz RH. Respiratory viral RNA on toys in pediatric office waiting rooms. Pediatr Infect Dis J. 2010;29(2):102-4.
524. IPAC Canada's Paediatric and Neonatal Interest Group. IPAC Canada practice recommendations: toys [Internet]. Winnipeg, MB: Infection Prevention and Control Canada; 2016 [cited 2017 Dec 22]. Available from: www.ipac-

canada.org/photos/custom/Members/pdf/Toys%20Practice%20Recommendations_%202016_final_Jan2017%20-%20FINAL%20FINAL%20ENGLISH.pdf

525. Yu Y, Cheng AS, Wang L, Dunne WM, Bayliss SJ. Hot tub folliculitis or hot hand-foot syndrome caused by *Pseudomonas aeruginosa*. J Am Acad Dermatol. 2007;57(4):596-600.
526. Glazer CS, Martyny JW, Lee B, Sanchez TL, Sells TM, Newman LS, et al. Nontuberculous mycobacteria in aerosol droplets and bulk water samples from therapy pools and hot tubs. J Occup Environ Hyg. 2007;4(11):831-40.
527. Berrouane YF, McNutt LA, Buschelman BJ, Rhomberg PR, Sanford MD, Hollis RJ, et al. Outbreak of severe *Pseudomonas aeruginosa* infections caused by a contaminated drain in a whirlpool bathtub. Clin Infect Dis. 2000;31(6):1331-7. Available from: http://academic.oup.com/cid/article/31/6/1331/366312
528. Hollyoak V, Allison D, Summers J. *Pseudomonas aeruginosa* wound infection associated with a nursing home's whirlpool bath. Commun Dis Rep CDR Rev. 1995;5(7):R100-2.
529. Tredget EE, Shankowsky HA, Joffe AM, Inkson TI, Volpel K, Paranchych W, et al. Epidemiology of infections with *Pseudomonas aeruginosa* in burn patients: the role of hydrotherapy. Clin Infect Dis. 1992;15(6):941-9.
530. Schlech WF, 3rd, Simonsen N, Sumarah R, Martin RS. Nosocomial outbreak of *Pseudomonas aeruginosa* folliculitis associated with a physiotherapy pool. CMAJ. 1986;134(8):909-13. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1490981/
531. McGuckin MB, Thorpe RJ, Abrutyn E. Hydrotherapy: an outbreak of *Pseudomonas aeruginosa* wound infections related to Hubbard tank treatments. Arch Phys Med Rehabil. 1981;62(6):283-5.
532. Dickey L. Water systems issues and prevention of waterborne infectious diseases in healthcare facilities. In: Grota P, Allen V, Boston KM, Bumsted AC, Conway LJ, Fine LS, et al., editors. APIC text online. Washington DC: Association for Professionals in Infection Control and Epidemiology (APIC); 2014.
533. Ontario Agency for Health Protection and Promotion (Public Health Ontario). Annex C-testing, surveillance and management of *Clostridium difficile*. Annexed to: Routine practices and additional precautions in all health care settings [Internet]. 4th ed. Toronto, ON: Queen's Printer for Ontario; 2013 [cited 2015 Mar 3]. Available from: www.publichealthontario.ca/en/eRepository/PIDAC-IPC_Annex_C_Testing_SurveillanceManage_C_difficile_2013.pdf
534. Ontario Agency for Health Protection and Promotion (Public Health Ontario). Annex A-screening, testing and surveillance for antibiotic-resistant organisms (AROs) in all health care settings. Annexed to: Routine practices and additional precautions in all health care settings [Internet]. 4th ed. Toronto, ON: Queen's Printer for Ontario; 2013 [cited 2015 Mar 3]. Available from: www.publichealthontario.ca/en/eRepository/PIDAC-IPC_Annex_A_Screening_Testing_Surveillance_AROs_2013.pdf
535. Sharma S, Kaur N, Malhotra S, Madan P, Hans C. Control of an outbreak of *Acinetobacter baumannii* in burn unit in a tertiary care hospital of North India. Advances in Public Health. 2014;2014:3. Available from: http://www.hindawi.com/journals/aph/2014/896289/
536. Lin H, Ng S, Chan S, Chan WM, Lee KC, Ho SC, et al. Institutional risk factors for norovirus outbreaks in Hong Kong elderly homes: a retrospective cohort study. BMC Public Health. 2011;11:297. Available from: http://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-11-297
537. Wepler M, Stahl W, von Baum H, Wildermuth S, Dirks B, Georgieff M, et al. Prevalence of nosocomial pathogens in German ambulances: the SEKURE study. Emerg Med J. 2015;32(5):409-11.

538. Peretz A, Koiefman A, Dinisman E, Brodsky D, Labay K. Do wheelchairs spread pathogenic bacteria within hospital walls? World J Microbiol Biotechnol. 2014;30(2):385-7.
539. Noh H, Shin SD, Kim NJ, Ro YS, Oh HS, Joo SI, et al. Risk stratification-based surveillance of bacterial contamination in metropolitan ambulances. J Korean Med Sci. 2011;26(1):124-30. Available from: http://jkms.org/DOIx.php?id=10.3346/jkms.2011.26.1.124
540. Alves DW, Bissell RA. Bacterial pathogens in ambulances: results of unannounced sample collection. Prehosp Emerg Care. 2008;12(2):218-24.
541. Gardner P, Muller MP, Prior B, So K, Tooze J, Eum L, et al. Wheelchair cleaning and disinfection in Canadian health care facilities: "That's wheelie gross!". Am J Infect Control. 2014;42(11):1173-7.
542. Ontario. Ministry of Health and Long-Term Care, Emergency Health Services Branch. Infection prevention and control best practices manual for land ambulance paramedics [Internet]. Version 1.0. Toronto, ON: Queen's Printer for Ontario; 2007 [cited 2008 Dec 1]. Available from: www.health.gov.on.ca/en/public/programs/ehs/edu/practice_documents.aspx
543. Ambrogi V, Cavalie L, Mantion B, Ghiglia MJ, Cointault O, Dubois D, et al. Transmission of metallo-beta-lactamase-producing *Pseudomonas aeruginosa* in a nephrology-transplant intensive care unit with potential link to the environment. J Hosp Infect. 2016;92(1):27-9.
544. Garvey MI, Bradley CW, Tracey J, Oppenheim B. Continued transmission of *Pseudomonas aeruginosa* from a wash hand basin tap in a critical care unit. J Hosp Infect. 2016;94(1):8-12.
545. Roux D, Aubier B, Cochard H, Quentin R, van der Mee-Marquet N, H. A. I. Prevention Group of the Reseau des Hygienistes du Centre. Contaminated sinks in intensive care units: an underestimated source of extended-spectrum beta-lactamase-producing Enterobacteriaceae in the patient environment. J Hosp Infect. 2013;85(2):106-11.
546. Stjarne AA, Sjostrom K, Olsson LB, Morgelin M, Melander E, Pahlman LI. Acetic acid as a decontamination method for sink drains in a nosocomial outbreak of metallo-beta-lactamase—producing *Pseudomonas aeruginosa*. J Hosp Infect. 2016;94(1):13-20.
547. Walker JT, Jhutty A, Parks S, Willis C, Copley V, Turton JF, et al. Investigation of healthcare-acquired infections associated with *Pseudomonas aeruginosa* biofilms in taps in neonatal units in Northern Ireland. J Hosp Infect. 2014;86(1):16-23.
548. Breathnach AS, Cubbon MD, Karunaharan RN, Pope CF, Planche TD. Multidrug-resistant *Pseudomonas aeruginosa* outbreaks in two hospitals: association with contaminated hospital waste-water systems. J Hosp Infect. 2012;82(1):19-24.
549. Balm MN, Salmon S, Jureen R, Teo C, Mahdi R, Seetoh T, et al. Bad design, bad practices, bad bugs: frustrations in controlling an outbreak of *Elizabethkingia meningoseptica* in intensive care units. J Hosp Infect. 2013;85(2):134-40.
550. Lucero CA, Cohen AL, Trevino I, Rupp AH, Harris M, Forkan-Kelly S, et al. Outbreak of *Burkholderia cepacia* complex among ventilated pediatric patients linked to hospital sinks. Am J Infect Control. 2011;39(9):775-8.
551. Swan JS, Deasy EC, Boyle MA, Russell RJ, O'Donnell MJ, Coleman DC. Elimination of biofilm and microbial contamination reservoirs in hospital washbasin U-bends by automated cleaning and disinfection with electrochemically activated solutions. J Hosp Infect. 2016;94(2):169-74. Available from: http://www.sciencedirect.com/science/article/pii/S0195670116302560
552. Wendel AF, Kolbe-Busch S, Ressina S, Schulze-Robbecke R, Kindgen-Milles D, Lorenz C, et al. Detection and termination of an extended low-frequency hospital outbreak of GIM-1-producing *Pseudomonas aeruginosa* ST111 in Germany. Am J Infect Control. 2015;43(6):635-9.

553. Wendel AF, Ressina S, Kolbe-Busch S, Pfeffer K, MacKenzie CR. Species diversity of environmental GIM-1-producing bacteria collected during a long-term outbreak. Appl Environ Microbiol. 2016;82(12):3605-10. Available from: http://aem.asm.org/content/82/12/3605.long

554. Xue Z, Seo Y. Impact of chlorine disinfection on redistribution of cell clusters from biofilms. Environ Sci Technol. 2013;47(3):1365-72.

555. Chapuis A, Amoureux L, Bador J, Gavalas A, Siebor E, Chretien ML, et al. Outbreak of extended-spectrum beta-lactamase producing *Enterobacter cloacae* with high MICs of quaternary ammonium compounds in a hematology ward associated with contaminated sinks. Front Microbiol. 2016;7:1070. Available from: http://www.frontiersin.org/articles/10.3389/fmicb.2016.01070/full

556. Walker J, Moore G. *Pseudomonas aeruginosa* in hospital water systems: biofilms, guidelines, and practicalities. J Hosp Infect. 2015;89(4):324-7.

557. Fusch C, Pogorzelski D, Main C, Meyer CL, El Helou S, Mertz D. Self-disinfecting sink drains reduce the *Pseudomonas aeruginosa* bioburden in a neonatal intensive care unit. Acta Paediatr. 2015;104(8):e344-9.

558. Wolf I, Bergervoet PW, Sebens FW, van den Oever HL, Savelkoul PH, van der Zwet WC. The sink as a correctable source of extended-spectrum beta-lactamase contamination for patients in the intensive care unit. J Hosp Infect. 2014;87(2):126-30.

559. Schneider H, Geginat G, Hogardt M, Kramer A, Durken M, Schroten H, et al. *Pseudomonas aeruginosa* outbreak in a pediatric oncology care unit caused by an errant water jet into contaminated siphons. Pediatr Infect Dis J. 2012;31(6):648-50.

560. Ling ML, How KB. *Pseudomonas aeruginosa* outbreak linked to sink drainage design. Healthcare Infection. 2013;18(4):143-6.

561. Starlander G MA. 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.

562. Vergara-López S, Domínguez MC, Conejo MC, Pascual Á, Rodriguez-Baño J. Wastewater drainage system as an occult reservoir in a protracted clonal outbreak due to metallo-beta-lactamase-producing *Klebsiella oxytoca*. Clin Microbiol Infect. 2013;19(11):E490-8.

563. Department of Health, Estates & Facilities. Health technical memorandum 04-01: addendum: *Pseudomonas aeruginosa* - advice for augmented care units [Internet]. Quarry Hill, UK: Crown Copyright; 2013 [cited 2016 Sep 6]. Available from: www.gov.uk/government/uploads/system/uploads/attachment_data/file/140105/Health_Technical_Memorandum_04-01_Addendum.pdf

564. Operating Room Nurses Association of Canada (ORNAC). The ORNAC Standards, guidelines, and position statements for perioperative registered nurses. 13th ed. Kingston, ON: Operating Room Nurses Association of Canada; 2017.

565. Shimokura G, Chai F, Weber DJ, Samsa GP, Xia GL, Nainan OV, et al. Patient-care practices associated with an increased prevalence of hepatitis C virus infection among chronic hemodialysis patients. Infect Control Hosp Epidemiol. 2011;32(5):415-24. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3147181/

566. Kallen AJ, Arduino MJ, Patel PR. Preventing infections in patients undergoing hemodialysis. Expert Rev Anti Infect Ther. 2010;8(6):643-55.

567. Aho-Glele LS, Giraudon H, Astruc K, Soltani Z, Lefebvre A, Pothier P, et al. Investigation of a case of genotype 5a hepatitis C virus transmission in a French hemodialysis unit using epidemiologic data and deep sequencing. Infect Control Hosp Epidemiol. 2016;37(2):134-9.

568. Weber DJ, Rutala WA, Fried MW. Hepatitis C virus outbreaks in hemodialysis centers: a continuing problem. Infect Control Hosp Epidemiol. 2016;37(2):140-2.

569. Nguyen DB, Gutowski J, Ghiselli M, Cheng T, Bel Hamdounia S, Suryaprasad A, et al. A large outbreak of hepatitis C virus infections in a hemodialysis clinic. Infect Control Hosp Epidemiol. 2016;37(2):125-33. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4824294/

570. Centers for Disease Control and Prevention (CDC). Healthcare-associated hepatitis B and C outbreaks (≥ 2 cases) Reported to the Centers for Disease Control and Prevention (CDC) 2008-2016 [Internet]. Atlanta, GA: US Department of Health and Human Services; 2017 [cited 2017 Dec 17]. Available from: www.cdc.gov/hepatitis/outbreaks/healthcarehepoutbreaktable.htm

571. Fabrizi F, Messa P. Transmission of hepatitis C virus in dialysis units: a systematic review of reports on outbreaks. Int J Artif Organs. 2015;38(9):471-80.

572. Girou E, Chevaliez S, Challine D, Thiessart M, Morice Y, Lesprit P, et al. Determinant roles of environmental contamination and noncompliance with standard precautions in the risk of hepatitis C virus transmission in a hemodialysis unit. Clin Infect Dis. 2008;47(5):627-33. Available from: http://academic.oup.com/cid/article/47/5/627/295818

573. Centers for Disease Control and Prevention (CDC). Environmental surfaces disinfection in dialysis facilities: notes for clinical managers [Internet]. Atlanta, GA: Centers for Disease Control and Prevention; 2015 [cited 2016 May 17]. Available from: www.cdc.gov/dialysis/PDFs/collaborative/Env_notes_Feb13.pdf

574. Centers for Disease Control and Prevention (CDC). Recommendations for preventing transmission of infections among chronic hemodialysis patients. MMWR Recomm Rep. 2001;50(RR-5):1-43. Available from: http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5005a1.htm

575. Bushey P, Hess S. CDC trial: station disinfection. Presented at: Presented at: Infection prevention: improving outcomes, saving lives; 2013 Nov 21; Uncasville, CT. Available from: http://networkofnewengland.org/wp-content/uploads/2013/02/2013-Network-1-November-21-talk.pdf

576. Public Health Agency of Canada, Canadian Lung Association Canadian Thoracic Society,. Canadian tuberculosis standards [Internet]. 7th ed. Ottawa, ON: Her Majesty the Queen in Right of Canada; 2014 [cited 2017 Dec 17]. Available from: http://cts.lung.ca/sites/default/files/documents/cts/Canadian%20Tuberculosis%20Standards_7th%20edition_Complete.pdf

577. Friedman ND, Walton AL, Boyd S, Tremonti C, Low J, Styles K, et al. The effectiveness of a single-stage versus traditional three-staged protocol of hospital disinfection at eradicating vancomycin-resistant Enterococci from frequently touched surfaces. Am J Infect Control. 2013;41(3):227-31.

578. Rossini FA, Fagnani R, Leichsenring ML, Dantas SR, Cardoso LG, Levy CE, et al. Successful prevention of the transmission of vancomycin-resistant enterococci in a Brazilian public teaching hospital. Rev Soc Bras Med Trop. 2012;45(2):184-8. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0037-86822012000200009&lng=en&nrm=iso&tlng=en

579. Weber DJ, Anderson DJ, Sexton DJ, Rutala WA. Role of the environment in the transmission of *Clostridium difficile* in health care facilities. Am J Infect Control. 2013;41(5 Suppl):S105-10. Available from: http://www.sciencedirect.com/science/article/pii/S0196655313000205

580. Arias A, Emmott E, Vashist S, Goodfellow I. Progress towards the prevention and treatment of norovirus infections. Future Microbiol. 2013;8(11):1475-87. Available from: http://www.futuremedicine.com/doi/10.2217/fmb.13.109

581. MacCannell T, Umscheid CA, Agarwal RK, Lee I, Kuntz G, Stevenson KB, et al. Guideline for the prevention and control of norovirus gastroenteritis outbreaks in healthcare settings [Internet]. Atlanta, GA: Department of Health and Human Services; 2011 [cited 2018 Feb 25]. Available from: http://www.cdc.gov/infectioncontrol/guidelines/norovirus/index.html
582. Johnston CP, Qiu H, Ticehurst JR, Dickson C, Rosenbaum P, Lawson P, et al. Outbreak management and implications of a nosocomial norovirus outbreak. Clin Infect Dis. 2007;45(5):534-40. Available from: http://academic.oup.com/cid/article/45/5/534/273747
583. Zoutman DE, Ford BD, Sopha K, Wylie B. The influence of patient room type, cleaning procedure and isolation conditions on room cleaning times in Canadian acute care hospitals. Can J Infect Control. 2015;30(4):213-7. Available from: http://ipac-canada.org/photos/custom/OldSite/cjic/vol30no4.pdf
584. Enfield KB, Huq NN, Gosseling MF, Low DJ, Hazen KC, Toney DM, et al. Control of simultaneous outbreaks of carbapenemase-producing Enterobacteriaceae and extensively drug-resistant *Acinetobacter baumannii* infection in an intensive care unit using interventions promoted in the Centers for Disease Control and Prevention 2012 carbapenemase-resistant Enterobacteriaceae tool kit. Infect Control Hosp Epidemiol. 2014;35(7):810-7.
585. French CE, Coope C, Conway L, Higgins JP, McCulloch J, Okoli G, et al. Control of carbapenemase-producing Enterobacteriaceae outbreaks in acute settings: an evidence review. J Hosp Infect. 2017;95(1):3-45.
586. Ciobotaro P, Oved M, Nadir E, Bardenstein R, Zimhony O. An effective intervention to limit the spread of an epidemic carbapenem-resistant *Klebsiella pneumoniae* strain in an acute care setting: from theory to practice. Am J Infect Control. 2011;39(8):671-7.
587. Robilotti E, Deresinski S, Pinsky BA. Norovirus. Clin Microbiol Rev. 2015;28(1):134-64. Available from: http://cmr.asm.org/content/28/1/134.long
588. Sample ML, Gravel D, Oxley C, Toye B, Garber G, Ramotar K. An outbreak of vancomycin-resistant enterococci in a hematology-oncology unit: control by patient cohorting and terminal cleaning of the environment. Infect Control Hosp Epidemiol. 2002;23(8):468-70.
589. Byers KE, Durbin LJ, Simonton BM, Anglim AM, Adal KA, Farr BM. Disinfection of hospital rooms contaminated with vancomycin-resistant *Enterococcus faecium*. Infect Control Hosp Epidemiol. 1998;19(4):261-4.
590. Abreu AC, Tavares RR, Borges A, Mergulhão F, Simões M. Current and emergent strategies for disinfection of hospital environments. J Antimicrob Chemother. 2013;68(12):2718-32. Available from: http://academic.oup.com/jac/article/68/12/2718/698356
591. Fawley WN, Wilcox MH. Molecular epidemiology of endemic *Clostridium difficile* infection. Epidemiol Infect. 2001;126(3):343-50. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2869701/
592. Doan L, Forrest H, Fakis A, Craig J, Claxton L, Khare M. Clinical and cost effectiveness of eight disinfection methods for terminal disinfection of hospital isolation rooms contaminated with *Clostridium difficile* 027. J Hosp Infect. 2012;82(2):114-21.
593. Surawicz CM, Brandt LJ, Binion DG, Ananthakrishnan AN, Curry SR, Gilligan PH, et al. Guidelines for diagnosis, treatment, and prevention of *Clostridium difficile* infections. Am J Gastroenterol. 2013;108(4):478-98; quiz 99.
594. Vonberg RP, Kuijper EJ, Wilcox MH, Barbut F, Tull P, Gastmeier P, et al. Infection control measures to limit the spread of *Clostridium difficile*. Clin Microbiol Infect. 2008;14 Suppl 5:2-20. Available from: http://onlinelibrary.wiley.com/doi/10.1111/j.1469-0691.2008.01992.x/full

595. Wilcox MH, Fawley WN, Wigglesworth N, Parnell P, Verity P, Freeman J. Comparison of the effect of detergent versus hypochlorite cleaning on environmental contamination and incidence of *Clostridium difficile* infection. J Hosp Infect. 2003;54(2):109-14.

596. Rutala WA, Weber DJ. Uses of inorganic hypochlorite (bleach) in health-care facilities. Clin Microbiol Rev. 1997;10(4):597-610. Available from: http://cmr.asm.org/content/10/4/597.full.pdf

597. Perez J, Springthorpe VS, Sattar SA. Activity of selected oxidizing microbicides against the spores of *Clostridium difficile*: relevance to environmental control. Am J Infect Control. 2005;33(6):320-5.

598. Wullt M, Odenholt I, Walder M. Activity of three disinfectants and acidified nitrite against *Clostridium difficile* spores. Infect Control Hosp Epidemiol. 2003;24(10):765-8.

599. Dubberke ER, Reske KA, Noble-Wang J, Thompson A, Killgore G, Mayfield J, et al. Prevalence of *Clostridium difficile* environmental contamination and strain variability in multiple health care facilities. Am J Infect Control. 2007;35(5):315-8.

600. Dumford DM, 3rd, Nerandzic MM, Eckstein BC, Donskey CJ. What is on that keyboard? Detecting hidden environmental reservoirs of *Clostridium difficile* during an outbreak associated with North American pulsed-field gel electrophoresis type 1 strains. Am J Infect Control. 2009;37(1):15-9.

601. Galdys AL, Curry SR, Harrison LH. Asymptomatic *Clostridium difficile* colonization as a reservoir for *Clostridium difficile* infection. Expert Rev Anti Infect Ther. 2014;12(8):967-80.

602. International Infection Control Council. Global consensus conference on infection prevention and control practice for *Clostridium difficile* associated disease (CDAD) [Internet]. Winnipeg: Infection Prevention and Control Canada; 2008 [cited 2018 Feb 25]. Available from: http://ipac-canada.org/photos/custom/OldSite/pdf/2008_C_DIFF_RECOMM.pdf

603. Dubberke ER, Carling P, Carrico R, Donskey CJ, Loo VG, McDonald LC, et al. SHEA/IDSA practice recommendation. Strategies to prevent *Clostridium difficile* infections in acute care hospitals: 2014 update. Infect Control Hosp Epidemiol. 2014;35(6):628-45.

604. Public Health Agency of Canada. Clostridium difficile infection: infection prevention and control guidance for management in acute care settings [Internet]. Ottawa, ON: Her Majesty the Queen in Right of Canada; 2013 [cited 2016 Aug 30]. Available from: www.phac-aspc.gc.ca/nois-sinp/guide/c-dif-acs-esa/index-eng.php

605. Public Health Agency of Canada. Clostridium difficile infection: infection prevention and control guidance for management in long-term care facilities. Ottawa, ON: Her Majesty the Queen in Right of Canada; 2013 [cited 2016 Aug 30]. Available from: www.phac-aspc.gc.ca/nois-sinp/guide/c-dif-ltc-sld/index-eng.php

606. Nenonen NP, Hannoun C, Svensson L, Toren K, Andersson LM, Westin J, et al. Norovirus GII.4 detection in environmental samples from patient rooms during nosocomial outbreaks. J Clin Microbiol. 2014;52(7):2352-8. Available from: http://jcm.asm.org/content/52/7/2352.full

607. La Rosa G, Fratini M, Della Libera S, Iaconelli M, Muscillo M. Viral infections acquired indoors through airborne, droplet or contact transmission. Ann Ist Super Sanita. 2013;49(2):124-32.

608. Centers for Disease Control and Prevention (CDC). Norovirus in healthcare facilities fact sheet [Internet]. Atlanta, GA: Centers for Disease Control and Prevention; 2011 [cited 2016 Dec 10]. Available from: www.cdc.gov/hai/pdfs/norovirus/229110-ANoroCaseFactSheet508.pdf

609. Cheesbrough JS, Green J, Gallimore CI, Wright PA, Brown DW. Widespread environmental contamination with Norwalk-like viruses (NLV) detected in a prolonged hotel outbreak of gastroenteritis. Epidemiol Infect. 2000;125(1):93-8. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2869574/

610. Teunis PF, Sukhrie FH, Vennema H, Bogerman J, Beersma MF, Koopmans MP. Shedding of norovirus in symptomatic and asymptomatic infections. Epidemiol Infect. 2015;143(8):1710-7.
611. Kambhampati A, Koopmans M, Lopman BA. Burden of norovirus in healthcare facilities and strategies for outbreak control. J Hosp Infect. 2015;89(4):296-301. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4668703/
612. Wu HM, Fornek M, Schwab KJ, Chapin AR, Gibson K, Schwab E, et al. A norovirus outbreak at a long-term-care facility: the role of environmental surface contamination. Infect Control Hosp Epidemiol. 2005;26(10):802-10.
613. Chadwick PR, Beards G, Brown D, Caul EO, Cheesbrough J, Clarke I, et al. Management of hospital outbreaks of gastro-enteritis due to small roundstructured viruses. J Hosp Infect. 2000;45(1):1-10.
614. Division of Viral Diseases, National Center for Immunization and Respiratory Diseases, Centers for Disease Control and Prevention. Updated norovirus outbreak management and disease prevention guidelines. MMWR Recomm Rep. 2011;60(RR-3):1-18. Available from: http://www.cdc.gov/mmwr/preview/mmwrhtml/rr6003a1.htm
615. Greig JD, Lee MB. A review of nosocomial norovirus outbreaks: infection control interventions found effective. Epidemiol Infect. 2012;140(7):1151-60.
616. Doultree JC, Druce JD, Birch CJ, Bowden DS, Marshall JA. Inactivation of feline calicivirus, a Norwalk virus surrogate. J Hosp Infect. 1999;41(1):51-7.
617. Nakamura A, Osonoi T, Terauchi Y. Relationship between urinary sodium excretion and pioglitazone-induced edema. J Diabetes Investig. 2010;1(5):208-11. Available from: http://onlinelibrary.wiley.com/doi/10.1111/j.2040-1124.2010.00046.x/full
618. Virox Technologies Inc. Our technology: FAQ's [Internet]. Oakville, ON: Virox Technologies Inc; 2015 [cited 2016 Oct 4]. Available from: www.virox.com/index_en.php?page=faq
619. Virox Technologies Inc. Technical bulletin: material compatibility of common disinfectants [Internet]. Oakville, ON: Virox Technologies Inc; 2007 [cited 2016 Oct 4]. Available from: www.acceleratedhydrogenperoxide.com/files_docs/content/pdf/en/download/Technical%20Bulletin%20on%20Compatibility%20Dec%202007-%20New%20Format.pdf
620. Weber DJ, Rutala WA, Sickbert-Bennett EE. Outbreaks associated with contaminated antiseptics and disinfectants. Antimicrob Agents Chemother. 2007;51(12):4217-24. Available from: http://aac.asm.org/content/51/12/4217.full

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