

Review

General cleaning and disinfection practices used in hospitals

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Improvement in the cleaning and disinfection must be taken into account for infection prevention and control. Health care settings are engaged in a battle against healthcare associated infection (HAIs). The importance of infection prevention and control is increasingly due to rapidly developing strains of multi-drug resistant organisms (MDROs), that can result in serious illness and even death in workers and patients. There are many cleaning products which have adverse effects on human health and environment. Conventional cleaning products are complex mixture of chemical ingredients. Many of these ingredients are known or suspected to be associated with asthma and other respiratory disorders. Concerns about adverse human and environmental health effects of conventional cleaning products have led to the development of green cleaners. Some green cleaners may reduce human and environmental negative health effect as well as reduce costs.

Keywords: Disinfection, infection, resistant, conventional, green cleaner.

INTRODUCTION

Cleaning is a common activity performed to maintain a healthy, safe, and aesthetically pleasing environment. Various cleaning products have become ubiquitous parts of our everyday lives. There is increasing evidence that cleaning is related to asthma and other respiratory illnesses among those who perform cleaning tasks or spend time in recently cleaned indoor environments. Cleaning in healthcare serves the dual functions of providing surface cleanliness and infection prevention and control. Both the importance and complexity of infection prevention and control are increasing due to rapidly developing strains of multidrug-resistant organisms that can result in serious worker and patient

illness and even death. The recent decision¹ of the Center for Medicare and Medicaid Services (CMS) that it will no longer provide additional reimbursement to hospitals for specific hospital-acquired infections may add a strong economic incentive for infection prevention and control measures, including the use of more cleaners and disinfectants. More importantly the media attention to certain antibiotic-resistant organisms such as *Methicillin-resistant Staphylococcus aureus* (MRSA) or infectious agents that form spores (e.g., *Clostridium difficile*) has intensified interest in cleaning and disinfection in healthcare facilities.²

There are various cleaning and disinfection practices used in the hospitals but none of these cleaning practices gives 100% result. Health care-associated infections (HAIs) are infections that occur as a result of health care interference in any health care setting where care is

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delivered. Factors that increase the risk for the development of HAIs include:

Increased age

Greater awareness

Increasing numbers of immune-compromised clients/patients/residents

Complex treatments

Increasing use of antimicrobial agents in hospitals and institutional health care settings, creating a large reservoir of resistant microbial strains₃

Infrastructure renovations and repairs to aging hospitals and long-term care homes creating the risk of fungal diseases caused by dust and spores released during demolition and construction.^{4,5} In addition, overcrowding and pressures to move more patients through the health care system can challenge the cleaning of environment.⁶ The reduction in number of microorganisms from the health care environment is accomplished by cleaning and disinfection.

The Environment of the Health Care Setting

The environment of the health care setting has been shown to be a reservoir for infectious agents such as bacteria (e.g., methicillin resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), *Clostridium difficile*, *Acinetobacter baumannii*, *Pseudomonas* spp., *Stenotrophomonas*), viruses (e.g., influenza, respiratory syncytial virus - RSV, norovirus, rotavirus, astrovirus, sapovirus, rhinovirus – ‘common cold’) and fungi (e.g., *Aspergillus* spp., *Fusarium* spp., *Penicillium* spp., *Stachybotrys* spp., *Mucoraceae*). However, the presence of microorganisms alone on objects and items in the health care environment is not sufficient to demonstrate that they contribute to infection Table 1.

Principles of Cleaning and Disinfecting Environmental

Health care settings are complex environments that contain a large diversity of microbial flora, many of which may constitute a risk to the clients/patients/residents, staff and visitors in the environment. Transmission of microorganisms within a health care setting is intricate and very different from transmission outside health care settings and the consequences of transmission may be more severe. High-touch environmental surfaces of the health care setting hold a greater risk than do public areas of non-health care organizations. There are many ways disease can be transmitted.

Transmission Involves:

a) Presence of an infectious agent (e.g. bacterium, virus, fungus) on equipment, objects and surface in the health care environment.

b) A means for the infectious agent to transfer from patient-to-patient, patient-to-staff, staff-to-patient and staff-to-staff.

c) Presence of susceptible clients/patients/residents, staff and visitors. In the health care setting, the role of environmental cleaning is important because it reduces the number and amount of infectious agents that may be present and may also eliminate routes of transfer of Microorganisms from one person/object to another, thereby reducing the risk of infection.

Different Ways by Which Disease Spreads

There are number of different ways by which disease can be spread. These ways or areas should be considered first for the spread of disease. These areas are as follow;

Frequency of Contact with Surfaces:

All surfaces in a health care setting have the potential to harbor pathogenic microorganisms. The potential for exposure to pathogens is based on the type of activity involved in the frequency of contact with a contaminated surface. For example, a conference room table would have less potential for exposure to pathogens than the doorknob in a client/patient/room. High-touch surfaces will require more frequent cleaning regimen. Most, if not all, environmental surfaces will be adequately cleaned with soap and water or a detergent/disinfectant, depending on the nature of the surface and the type and degree of contamination.⁸

High-touch Surfaces

High-touch surfaces are those that have frequent contact with hands. Examples include doorknobs, elevator buttons, telephones, call bells, bedrails, light switches, computer keyboards, monitoring equipment, haemodialysis machines, wall areas around the toilet and edges of privacy curtains. High-touch surfaces in care areas require more frequent cleaning and disinfection than minimal contact surfaces.⁹ Cleaning and disinfection is usually done at least daily and more frequently if the risk of environmental contamination is higher (e.g., intensive care units).

Low-touch Surfaces

Low-touch surfaces are those that have minimal contact with hands. Examples include floors, walls, ceilings, mirrors and window sills. Low-touch surfaces require cleaning on a regular (but not necessarily daily) basis,

Table 1. Persistence of clinically relevant organisms on dry inanimate surfaces.⁷

Sr. No.	Micro- organisms	Duration of persistence (range)
1.	Acinetobacter spp.	3days - 5 months
2.	Clostridium dicile (spores)	5 months
3.	Escherichia coli	1.5 hours - 16 months
4.	Enterococcus spp, including VRE	5 days - 4 months
5.	Inuenza virus	1 – 2 days
6.	Norovirus and feline calici virus	8 hours – 7 days
7.	Staphylococcus aureus, including MRSA	7 days – 7 months

when soiling or spills occur, and when a client/patient/resident is discharged from the health care setting.⁹ Many low-touch surfaces may be cleaned on a periodic basis rather than a daily basis if they are also cleaned when visibly soiled.

Vulnerability

Different populations of clients/patients/residents have differing vulnerabilities based on their susceptibility to infection. In some populations, such as bone marrow transplant or burn patients, susceptibility to infection is very high and may be impacted by their environment. The frequency of cleaning may be higher in areas with vulnerable client/patient/resident populations.

More Susceptible

These are clients/patients/residents that are more susceptible to infection due to their medical condition or lack of immunity. These include those who are immune-compromised (e.g., oncology patients; those in transplant and chemotherapy units; neonates (level 2 and 3 nurseries); those who have severe burns, i.e., requiring care in a burn unit); and those undergoing invasive or operative procedures (e.g., haemodialysis).

Less Susceptible

For the purpose of risk stratification for cleaning, all other individuals are classified as less susceptible.

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 based on the activity in the area, the type of pathogens involved and the microbial load.

Heavy Contamination

An area is considered to be heavily contaminated if surfaces and/or equipment are exposed to copious

amounts of blood or other body fluids (e.g., birthing suite, autopsy suite, cardiac catheterization laboratory, burn unit, haemodialysis unit, Emergency Department, bathroom if the client/patient/resident has diarrhea or is incontinent).

Moderate Contamination

An area is considered to be moderately contaminated if surfaces and/or equipment are contaminated with blood or other body fluids as part of routine activity (e.g., patient/resident room, bathroom if client/patient/resident is continent) and the contaminated substances are contained or removed (e.g., wet sheets). All client/patient/resident rooms and bathrooms should be considered to be, as a minimum, moderately contaminated.

Light Contamination

An area is considered to be lightly contaminated or not 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, office).

Depending on cleaning, disinfection and sterilization, healthcare devices and equipment are designated as:

Critical

Semi-critical

Non-critical

Critical Items

Require sterilization

Includes items that enter sterile tissue or the vascular system

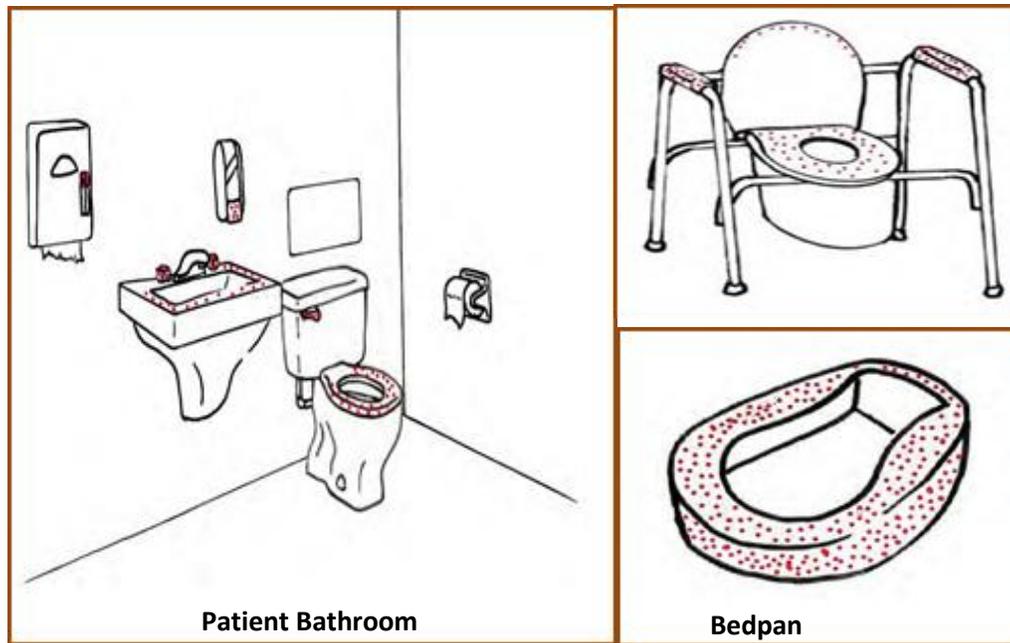
Examples include surgical instruments and accessories, biopsy forceps, cardiac and urinary catheters, implants, needles.

Semi-Critical Items

Require minimum high level disinfection (or sterilization)

Includes items in contact with non-intact skin or mucous membranes

Fig 1. Critical



Examples include respiratory therapy equipment, anesthesia equipment, flexible and laryngoscopes, bronchoscopes, GI endoscopes, cyst scopes, vaginal ultrasonic probes.

Cleaning process must precede high-level disinfection
Non-Critical Items

Require intermediate-level or low-level disinfection

Includes items in contact only with intact skin

Examples include BP cuffs, stethoscopes, durable mobile patient equipment.

High-Touch Surfaces in Health Care Settings

High-touch surfaces which may exhibit environmental contamination in health care settings can be divided into three categories

Critical fig 1

Semi-critical fig 2

Non-critical fig 3

Cleaning Agents and Disinfectants

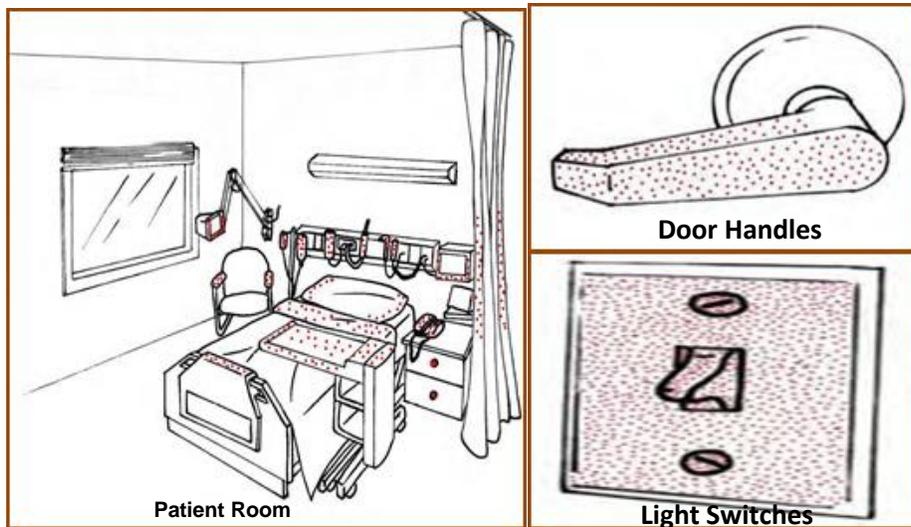
Cleaning is the removal of foreign material (e.g., dust, soil, organic material such as blood, secretions, excretions and microorganisms) from a surface or object. Cleaning physically removes rather than kills

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 a cleaner followed by a disinfectant, but is more commonly accomplished in the health care setting 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. Only sterilization will kill all forms of microbial life.

Detergents and Cleaning Agents

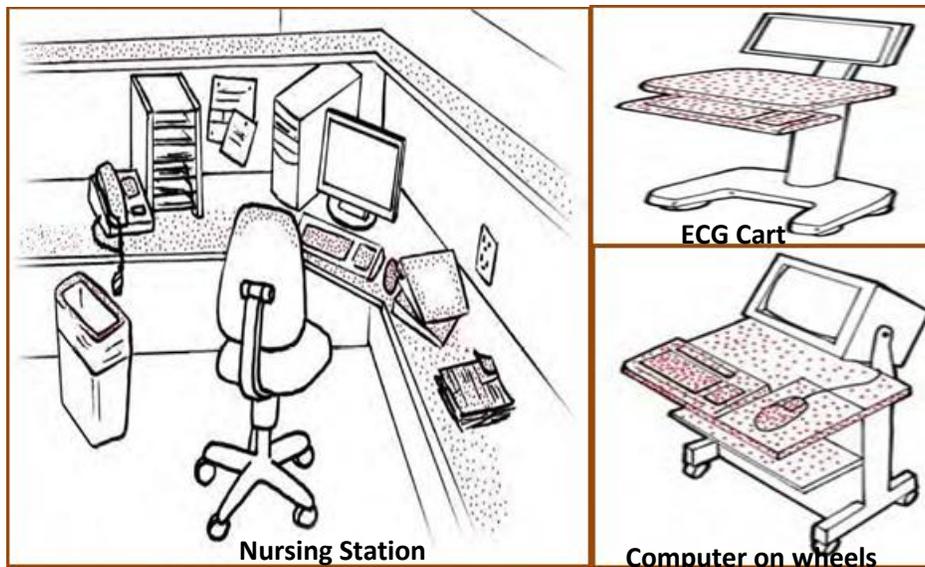
Detergents remove organic material and suspend grease or oil. Equipment and surfaces in the healthcare setting must be cleaned with approved hospital-grade cleaners and disinfectants. Equipment cleaning/disinfection should be done as soon as possible after items have been used. A variety of products from a number of suppliers can be used to achieve effective cleaning. It is important to follow the manufacturer's instructions when using cleaning agents.

Fig 2.Semi Critical.



Examples of High-touch Items and Surfaces in the Health Care Environment
(NOTE: Dots indicate areas of highest contamination and touch)

Fig 3.Non Critical.



Disinfecting products used in thehealth care setting:

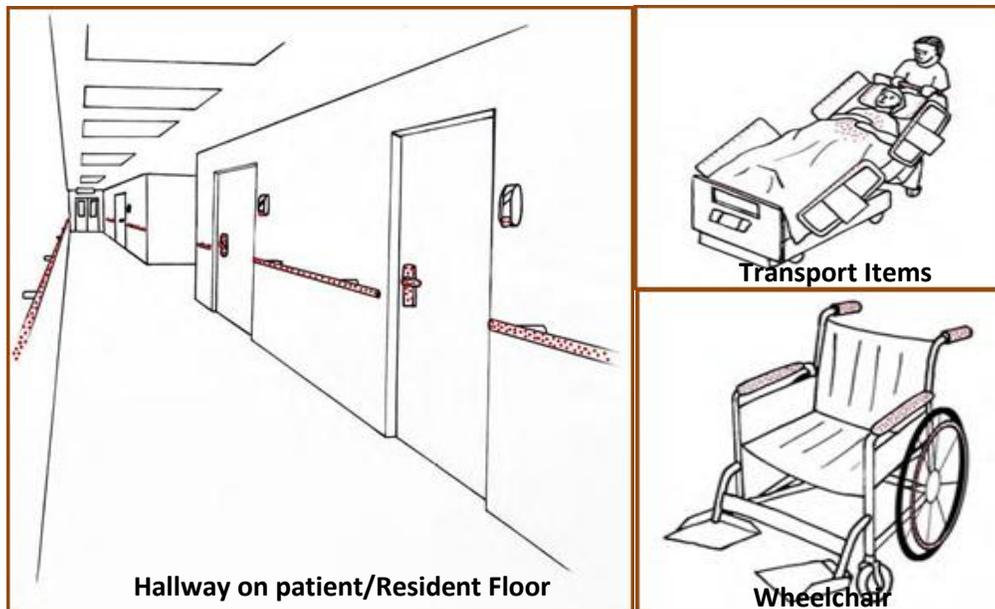
- a) Must be approved by Environmental Services, Infection Prevention and Control and Occupational Health and Safety;
- b) Must be used according to the manufacturers' recommendations for dilution, temperature, water hardness and use;

- c) Must be used according to the product's Material Safety Data Sheet (MSDS).

Disinfectants

Disinfectants rapidly kill or inactivate most infectious agents. Disinfectants are only to be used to disinfect and must not be used as general cleaning agents, unless

Fig 3. Non Critical.



Examples of High-touch Items and Surfaces in the Health Care Environment
(NOTE: Dots indicate areas of highest contamination and touch)

combined with a cleaning agent as a detergent disinfectant.

Choosing a Disinfectant

The following factors influence the choice of disinfectant¹⁶:

- a) The disinfectant must have a drug identification number (DIN) from Health Canada.
- b) The nature of the item to be disinfected;
- c) The innate resistance of expected microorganisms to the inactivating effects of the disinfectant.
- d) The amount of organic soil present.
- e) The type and concentration of disinfectant used.
- f) Duration of contact time required for efficacy at the usual room temperature of the health care setting.
- g) If using a proprietary product, other specific indications and directions for use.
- h) Occupational health considerations.
- i) Many surface disinfectants contain quaternary ammonium compounds (QUATs), phenolics, hydrogen peroxide or sodium hypochlorite's which can cause skin and respiratory irritation.
- ii. Disinfectants are one of the leading allergens affecting health care providers²⁶;
- iii. Staff will be more likely to use products that are non-toxic and not irritating.

i) Environmental protection:

- i. Consider products that are biodegradable and safe for the environment;
- ii. Many disinfectants (e.g., QUATs) may be hazardous both during manufacture and when they are discharged into the waste stream, as they are not readily biodegradable.²⁶

Using Disinfectants

When using a disinfectant:

- a) 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; most disinfectants lose their effectiveness rapidly in the presence of organic matter.
- b) A hospital-grade disinfectant may be used for equipment that only touches intact skin; examples include intravenous pumps and poles, hydraulic lifts, blood pressure cuffs, monitors and sensor pads, electrocardiogram (ECG) machine/cables and crutches;
- c) It is important that the disinfectant be used according to the manufacturer's instructions for dilution and contact time; commonly used in health care settings with their recommended concentrations and contact times.
- d) Minimize the contamination levels of the disinfectant solution and equipment used for cleaning; this can be

Table 2. At the end, the table by Premier Safety Institute clarifies bleach dilutions with household measurement terms.

Name	Examples	Physicochemical properties	Respiratory , skin, mucous membrane (eye) effects	Other health effects	Purpose of use in cleaning products
Alcohols	Examples : Benzyl alcohol C ₆ H ₅ OH Isopropyl alcohol CH ₃ CH ₂ CH ₂ OH Ethanol (ethyl alcohol) CH ₃ CH ₂ OH	Boiling point (BP): 205 °C BP: 82.5 °C	Isopropyl alcohol: Highly volatile. Irritant to eyes and the upper respiratory tract. Prolonged exposure may cause lung damage. ¹² Ethanol and isopropyl alcohol are absorbed through the skin and can irritate the skin, eyes, upper respiratory tract, and throat. ¹⁹	Benzyl alcohol has been reported as a contact allergen in cleaning products. ^{13,14}	Used as solvents and disinfectants in cleaning products. ¹²
Ammonia	NH ₃	Found in aqueous solutions in the form of ammonium hydroxide. (BP): -33.5 °C	Highly irritating. Inhalation of its vapors can irritate the nose, throat, and lungs, causing wheezing and shortness of breath. Prolonged exposure can cause bronchitis. ^{12,16}	No evidence of sensitization was found. ¹⁰	Used in glass cleaners. ¹
Ethanolamine	OH H ₂ N Ethanalamine (MEA, mono-ethanol amine, 2-aminoethanol),	BP: 170.8 °C	Breathing its vapors can irritate the nose, throat and lungs, causing coughing, wheezing and shortness of breath. ¹² It is a skin irritant and can be absorbed through the skin. ¹⁷ Can cause skin sensitization. ¹²	Exposure to ethanolamine has been associated with occupational asthma. ¹⁸	Used as surfactant in cleaning products. ¹⁰ Used in floor care products, general purpose, glass, and bathroom cleaners. ¹⁰
Ethylene glycol ethers	Examples : OH O CH ₃ 2-Butoxyethanol (2-BE, ethylene glycol monobutyl ether, butyl "Cellosolve")	2-BE (BP):168 °C	2-BE vapors are irritants to eyes and respiratory tract. ¹⁹ Class A3 : Confirmed animal carcinogen with unknown relevance to humans. ²⁰ 2-BE is a skin irritant. Absorbed in the body through skin ²¹ - an important exposure route. ²²	2-BE is a toxic chemical. ¹⁷ Ethylene glycol alkyl ethers target the central nervous system, blood and blood-forming organs, and reproductive system. ¹⁹	Used as solvent in cleaning products to dissolve fatty substances. ¹⁰ Mostly used in glass, general purpose cleaners, and floor care products

achieved by ensuring proper dilution of the disinfectant, frequently changing the disinfectant solution and by not

dipping a soiled cloth into the disinfectant solution (i.e., no 'double-dipping');

Table 2. Continued.

In organic Chlorine compounds	Examples: Bleach: 5.25 - 6.15% solution of sodium hypochlorite. ² Na-O-Cl Hydrochloric acid H-Cl	Bleach is highly toxic when mixed with ammonia or ammonium quaternary compounds, generating chloramine gas. ¹³ Can form chlorine gas when mixed/ used in conjunction with strong acids (e.g., toilet bowl cleaners). ¹³ Fire risks in contact with organic materials. ¹⁷ Store separately from other cleaning products.	Breathing a high concentration of chlorine can irritate the lungs. ¹³ Particularly dangerous for people with heart conditions or chronic respiratory problems such as asthma or emphysema. ¹³ Concentrated hypochlorite can cause corrosive damage to the skin and nails. Concentration below 5.25% not corrosive unless exposure occurs over a long period. ¹³	Strong tissue irritant. ¹⁷ Concentrated bleach can cause corrosive damage to the eyes and mucous membranes. ¹³ Chlorine bleach often manufactured using a mercury cell process, leaving contaminant mercury in the product. ¹³	Bleach is a commonly used disinfectant in medical, commercial, and household settings. ¹⁰
Oxidizers	Example: H ₂ O ₂ Hydrogen peroxide Most commercial janitorial cleaners do not contain over 10% hydrogen peroxide. ⁴	Concentrated solutions are highly reactive and have low flash points. ¹³ Explosion hazard and must be stored carefully and away from other combustible materials and other chemicals. ¹³	Corrosive to the skin over 50% concentrations, irreversible eye damage over 10% concentrations. ¹³ Ready-to-use dilutions contain less than 2% percent hydrogen peroxide - which is not irritating to the skin unless other irritating ingredients are present. At high concentrations, irritates the nose, throat, and lungs. ¹³	Classified as “mutagenic,” however, no evidence that exposure to the concentrations found in cleaning products would cause mutagenic damage in humans. ¹³	Hydrogen peroxide considered more green due to fewer toxic characteristics than, for example quaternary ammonium or chlorine compounds. ¹³
Phenols/chlorinated phenols	Ortho benzyl parachlorophenol (OBPC) Ortho phenyl phenol (OPP) And p-tert-amylphenol.	OBPC BP: 160-162 °C OPP BP: 286 °C	Irritant to eyes and respiratory tract when inhaled. ²³ Even at low concentrations is extremely irritating to the skin. Repeated skin contact can cause dryness, itching and redness. Can penetrate the skin. ¹² Skin irritant. Occupational exposures may happen mostly through dermal contact. ¹² p-tert-amylphenol can be absorbed through the skin.	Sensitivity potential reported from animal studies. ²⁴ OPP is listed as a carcinogen in California. ^{13,25}	Phenols are used as disinfectants in cleaning products – many considered effective against tuberculosis. ²⁶

e) Personal protective equipment must be worn appropriate to the product(s) used; and

f) There should be a quality monitoring system in place to ensure the efficacy of the disinfectant over time (e.g., frequent testing of product).

Table 2. Continued.

Quaternary ammonium Compounds (quats)	Examples : Di-decyl di-methyl ammonium chloride N Alkyl dimethyl benzyl ammonium chloride (benzalkonium chloride)	Quaternary ammonium compounds are salts that are soluble in water and alcohol. ¹²	Because quats are not volatile, inhalation exposures can happen through products' aerosolization. ¹⁰ Commonly used solutions can cause nose and throat irritation. Benzalkonium chloride is a severe eye irritant. ¹² Limited evidence implicates quats in the development of allergic responses and occupational asthma. ^{27,28} Exposures to benzalkonium chloride have been associated with combined respiratory and dermal hypersensitivity. ²⁹ Benzalkonium chloride is a primary skin irritant in solutions of less than 10%. Exposures to quats may cause allergic reactions to skin. ²⁹	Benzalkonium chloride suspected gastrointestinal and liver toxicant, and other quaternary ammonium compounds may have the same attributes. ¹³	Used as a low-level disinfectant. High level of disinfection is achieved if different quats and alcohols are mixed. ¹⁰ Mostly used in bathroom, floor, and general purpose cleaners
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Hazardous Ingredients in Conventional Cleaning Products

In Table 2 is a modified version published by Bello et al in Environmental Health, 2009.¹⁰

New Technologies for Cleaning and Disinfection

Before considering a change from current methods for cleaning and disinfection in a health care setting, the newer product must be weighed against current products in terms of efficacy, ease of implementation, toxicity, effects on patient care, ergonomic considerations and cost implications. Infection Prevention and Control, Environmental Services and Occupational Health and Safety must be involved in all decision-making relating to changes in cleaning and disinfection methodologies and products in the health care setting.

Air Disinfection

Disinfectant fogging techniques have been used in some countries for terminal cleaning of rooms, but aren't in

general use. Toxic gases such as formaldehyde and ethylene oxide have been used in the past, but are not currently recommended due to safety risks and long cycle times. Newer gaseous formulations, such as vapourized hydrogen peroxide (VHP), super-oxidized water and ozone gas, appear to be effective agents in comparison to standard environmental cleaning for microorganisms such as *C. difficile* and MRSA³⁰⁻³³. Disinfectant fogging is not appropriate for routine cleaning and should be restricted to terminal cleaning of isolation units and rooms involved in uncontrolled outbreaks.

Vapourized Hydrogen Peroxide (VHP)

Vapourized hydrogen peroxide (VHP) is effective against a wide range of microorganisms, including bacteria, viruses and spores, particularly those of *C. difficile*³². It has been used successfully in eradicating *Serratia marcescens* from neonatal intensive care units³¹, MRSA from surgical units^{30,35,36}, VRE³⁷ and *C. difficile*.^{32, 38, 39} VHP is relatively safe and decomposes to water and oxygen. The vapors are 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, anaeration unit in the room converts the VHP into water and oxygen. The complete decontamination process takes an average of five hours. A dry-mist hydrogen peroxide system has been used successfully in France to decrease *C.difficile* contamination by 91%, compared to a 50% reduction using sodium hypochlorite. Environmental cleaning with a detergent-disinfectant was performed prior to disinfection. The time required for the dry-mist decontamination was about 1.5 hours (dependant on room volume).³⁹

Advantages

- More effective decontamination compared to routine cleaning
- Reduced labor required
- By-products are safe for the environment
- Useful for decontaminating soft furnishings and equipment that is difficult to clean
- May be used to decontaminate entire units/wards during outbreaks

Disadvantages

- Time-consuming (average five hours to complete for VHP)
- Biological soiling reduces the efficacy of VHP
- Air ducts from the room must be sealed prior to decontamination optimal methodology (including exposure time) is still under investigation
- Expensive

Ozone Gas

Ozone is a gas that has bactericidal properties, can be generated cheaply and rapidly dissociates to oxygen. Ozone gas is widely used in water disinfection and has been used successfully to inactivate the feline calicivirus (a surrogate for norovirus)⁴⁰ and to eliminate MRSA from the home of a health care provider with eczema.⁴¹ The use of ozone gas as an antibacterial agent in recent studies shows promise for future use in health care settings.^{31,42} It is, however, toxic at high concentrations, precluding its use in populated areas. It should only be used in areas that may be completely sealed off for the duration of the treatment.

Advantages

- Effectively penetrates all areas of a room, even areas difficult to access or clean by conventional cleaning methods (e.g., fabrics, under beds, inside cracks)

- Administration of gas can be controlled from outside the room

- Easy and economical to produce

- By-products are safe for the environment

- Decontaminates surfaces even if biological material has been dried onto them

- Decontaminates a large area quickly (less than one hour for an entire room)

Disadvantages

- Toxic at high concentrations

- Area to be decontaminated must be sealed off from other areas until ozone levels return to safe limits

Super-oxidized Water

Super-oxidized water has hypochlorous acid as its principal ingredient, which is safe to use, is not harmful to the environment³³ and has a broad spectrum of activity that includes spores. Many formulations have a long shelf life and are safe for the environment.⁴³ The use of super-oxidized water as a disinfectant fog shows promise,³³ but requires more study before applying it to the health care environment.

Ultraviolet Irradiation (UVI)

The use of ultraviolet irradiation (UVI) in the health care setting is limited to destruction of airborne organisms or inactivation of microorganisms on surfaces. UVI inactivates microorganisms at wavelengths of 240 to 280 nm.⁴² Bacteria and viruses are more easily killed by UVI than are bacterial spores.

Germicidal effectiveness of UVI is influenced by^{44,45}

- a) Amount and type of organic matter present;
- b) Wavelength of ultraviolet light;
- c) Air mixing and air velocity;
- d) Temperature and relative humidity;
- e) Type of microorganisms present; and
- f) Ultraviolet light intensity, which is affected by distance and cleanliness of lamp tubes.

If UVI 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. UVI intensity should be regularly monitored.⁴⁶

UVI Disinfection of the Air

Several studies have demonstrated that UVI is effective in killing or inactivating *M. tuberculosis* and in reducing

the transmission of other infectious agents in hospitals. In the U.S., UVI is recommended as a supplement or adjunct to other TB infection control and ventilation measures in settings in which the need to kill or inactivate *M. tuberculosis* is essential, such as airborne infection isolation rooms.⁴⁵ UVI is not a substitute for HEPA filtration in airborne infection isolation rooms.⁴⁵

UVI Disinfection of Surfaces

UVI disinfection has been used successfully for final disinfection of isolation units once patients have been treated for infections.⁴⁸ Cleaning of visibly soiled surfaces is necessary before UVI disinfection, as ultraviolet light is absorbed by organic materials and its ability to penetrate is slow.⁴⁷ UVI disinfection of surfaces should not be used alone for disinfection, but may be a good addition to chemical disinfection to lower the bioburden of microorganisms in isolation units and during outbreaks.

Advantages and Disadvantages of Ultraviolet Irradiation (UVI) of Surfaces

Advantages

- Automated method – no manual labor is required
- Relatively short exposure time required (40 minutes)
- No residue left following disinfection

Disadvantages

- Destructive effect over time on plastics and vinyl's and fading of paints and fabrics
- Low penetrating effect
- Less effective in the presence of organic materials
- Disinfection does not occur in shadowed areas where the ultraviolet light cannot penetrate
- Expensive
- Rooms must be vacant during UVI disinfection and a warning sign must be posted
- Staff should avoid entry during UVI disinfection

Steam Vapour

Steam has been used effectively to sterilize medical equipment but has not been used for disinfection of environmental surfaces due to the size and immobility of equipment used to deliver the steam. Recent advancements in technology have dramatically decreased the size of steam generators, making them portable and practical. Saturated steam is composed almost entirely of water in the vapors phase and is hotter and drier than typical steam vapour, which is often laden with small droplets of liquid water. Portable steam

generators may be used to clean kitchens, bathrooms, floors, walls and other surfaces using steam delivered with a nozzle brush. Steam vapour is applied using a back and forth motion for five to ten seconds. Grease, oil, stains and dirt are easily and effectively extracted and bacteria and viruses are killed. Steam vapour effectively travels through biofilm to kill microorganisms that may be unreachable by the surface application of disinfectants. Portable steam cleaners have demonstrated bactericidal, virucidal, fungicidal and sporicidal activity against *C. difficile* spores in experimental situations.

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