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In this article...

- Why environmental cleaning and disinfection is important
- How environmental cleaning and disinfection is performed in healthcare environments
- Innovations in environmental cleaning and disinfection techniques

Environmental decontamination 1: what is it and why is it important?

Key points

Cleaning and disinfection in the clinical environment is a multiprofessional responsibility

Contaminated environment plays a key role in the transmission of some pathogens

Patients may acquire healthcare-associated infection from being in a room previously occupied by a patient with a pathogen

Cleaning and disinfection does not always eradicate pathogens from surfaces and failure is usually related to the procedure used

Ensuring that surfaces are clean and adequately disinfected is a legal requirement

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Abstract Contamination of the environment plays a key role in the transmission of some pathogens that cause healthcare-associated infection. This article is the first in a three-part series looking at cleaning and disinfection in healthcare settings. It describes the process of environmental decontamination, which includes cleaning and disinfection and focuses on the nurse's role in ensuring the environment is safe for patients.

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Environmental decontamination refers to the process by which environmental contamination is reduced to a level that is not harmful to health. Decontamination of the environment can be achieved through:

- Cleaning;
- Disinfection;
- A combination of the two.

Box 1 defines these terms, as well as others that are relevant.

Cleaning and disinfection

For many years, the healthcare environment was not thought to contribute significantly to the transmission of microbes (including bacteria, fungi and viruses) that cause healthcare-associated infections (HCAIs) (Otter et al, 2011). However, recent evidence has prompted a re-evaluation of this, and it is generally accepted that the contaminated environment plays a key role in the transmission of some pathogens that cause HCAIs in hospitals, care homes and in the community.

Perhaps the most powerful evidence of the role of the contaminated environment is the finding that admission to a hospital room previously occupied by a patient with a pathogen – for example *Clostridium difficile*, meticillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE) or *Acinetobacter baumannii* – increases the risk of acquisition for the incoming occupant (Mitchell et al, 2015). This implies that we are not effectively decontaminating the environment, especially at patient discharge. Other studies show that improving the quality of cleaning and disinfection reduces the risk of infection linked to previous occupants of a room (Anderson et al, 2017; Passaretti et al, 2013).

The spread of pathogens

A range of pathogens are shed into the environment and can cause widespread contamination. For example, a study performed almost 15 years ago in London found high levels of contamination: more than three-quarters of the sites in rooms occupied by patients known to be infected or colonised with MRSA were contaminated with it (French et al, 2004). These pathogens can survive for long periods on

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Box 1. **Glossary of terms**

- **Healthcare-associated infection (HCAI)** – infection that occurs as a result of contact with the healthcare system
- **Environmental decontamination** – process by which the healthcare environment is made free from a harmful level of contamination that may result in the transfer of pathogens that can cause HCAIs
- **Cleaning** – removal of 'dirt' from surfaces, which may include microbial (for example, bacteria) and non-microbial (for example, body fluids) contamination
- **Disinfection** – killing of microbes on surfaces, via chemicals, heat, or another process
- **Non-critical surfaces** – surfaces that only come into contact with intact skin, such as bedrails and floors
- **Semi-critical surfaces** – surfaces that come into contact with mucous membranes or non-intact skin (for example, endoscopes)
- **Critical surfaces** – surfaces that enter usually sterile parts of the body (for example, scalpels)
- **Terminal decontamination** – decontamination performed at the time of discharge

dry surfaces (Table 1); VRE has remarkable survival properties, remaining alive on a dry laboratory surface for in excess of *four years* in one study (Wagenvoort et al, 2011).

Cleaning and disinfection rarely eliminates pathogens from the hospital environment – typically, only about half of pathogens are removed when terminal decontamination is performed (Otter et al, 2011). This could be at least in part because not all surfaces in a room are actually cleaned or disinfected by manual processes: a well-known US study found that only half of the surfaces in patient rooms were cleaned or disinfected at patient discharge (Carling et al, 2008).

There is frequent transfer of contamination present on dry surfaces to the hands of healthcare workers, which can then colonise the patient's skin and other body sites (Fig 1). This was demonstrated by a study undertaken almost 20 years ago, in which a telephone in one pod of a neonatal intensive care unit was seeded with marker DNA. Within hours the DNA marker had spread to healthcare worker hands and environmental surfaces around the unit (Oelberg et al, 2000).

Environmental decontamination

The Health and Social Care Act (Department of Health, 2008) requires that healthcare facilities maintain a clean, appropriate environment that facilitates the prevention and control of infection. Effective environmental decontamination is an essential part of meeting this requirement. Cleaning and disinfection in the NHS is performed to meet standards outlined in the *Healthcare Cleaning Manual* – this is currently being revised by NHS Improvement.

The structures around the provision of environmental decontamination services vary from hospital to hospital, but cleaning and disinfection in the clinical environment is always multiprofessional. Specifically trained non-clinical staff (cleaners or 'domestics') typically provide daily and terminal cleaning and disinfection of non-critical surfaces. Semi-critical surfaces are typically disinfected by nursing staff at the point of care or sent for decontamination in a reprocessing unit. Critical surfaces are usually single-patient use or sent for decontamination in a reprocessing unit using validated processes.

A particular challenge is mobile equipment (for example, blood-pressure cuffs and stethoscopes) that move from patient to patient. While the availability of disinfectant wipes at the point of care provides a good way of disinfecting these items, it is not always clear who is responsible for doing so.

The decontamination strategy will be influenced by the microbiological scenario. For example, *Clostridium difficile* spores are resistant to many disinfectants, so a sporicidal disinfectant (such as a chlorine-releasing disinfectant, hydrogen peroxide, or peracetic acid) must be used. Enhanced decontamination using a disinfectant is usually performed for environmental decontamination where contamination with key antibiotic-resistant bacteria is likely – for example, carbapenemase-producing Enterobacteriaceae, MRSA and VRE (Otter et al, 2011).

Nurses play a key role in environmental decontamination. As well as bearing direct responsibility for decontaminating some items, they collaborate with environmental decontamination services to develop policies and training schedules, deliver training and education, audit the cleaning process, inform purchasing decisions and escalate cleaning issues day-to-day (Bellemy et al, 2012). This will be covered in more detail in Part 2 of this series.

A range of materials and tools are required for effective decontamination of the environment. Typically in the NHS, detergent is used for cleaning most non-critical surfaces. However, detergent cleaning:

- Does not eliminate microbial contamination;
- May spread contamination from surface to surface;
- Requires a drying step to avoid leaving a surface wet and prone to biofilm development.

Biofilms are communities of microbes encased in proteins that are difficult to remove through cleaning and resist disinfection. As a result, these surfaces are increasingly cleaned using disinfectant wipes. Approaches for the decontamination of semi-critical and critical devices will be covered in Part 2.

Table 1. **Pathogen survival times on dry surfaces**

Organism	Survival time
Clostridium difficile (spores)	5 months
Acinetobacter spp	3 days to 5 months
Enterococcus spp including vancomycin-resistant *Enterococci*	5 days to 4 years (Wagenvoort et al, 2011)
Pseudomonas aeruginosa	6 hours to 16 months
Klebsiella spp	2 hours to > 30 months
Staphylococcus aureus, including meticillin-resistant *Staphylococcus aureus*	7 days to 7 months
Norovirus (and feline calicivirus)	8 hours to > 2 weeks
Severe acute respiratory syndrome Coronavirus (SARS-CoV)	72 hours to >28 days
Influenza	Hours to several days

Source: Adapted from Kramer et al (2006)

The approach to disinfection of a patient environment known to be infected or colonised with a pathogen associated with HCAI varies, but often includes the use of a disinfectant (commonly chlorine-containing agents and quaternary ammonium compound formulations, and increasingly the peroxygens such as peracetic acid and hydrogen peroxide).

Limitations

Micro-organisms vary in their level of susceptibility to disinfectants, so agents must be chosen carefully for their effectiveness, particularly for *C. difficile* spores and norovirus (Otter et al, 2011).

Furthermore, the healthcare environment is complex and often difficult to clean, and the use of a cleaning agent that is not effective against the target organism can spread pathogens to other surfaces. Selection of disinfectants should always be based on efficacy data from independent, accredited laboratories.

Some liquid disinfectants may damage equipment, and chlorine-containing materials may corrode metals (Otter et al, 2011). Certain disinfectants can potentially harm users and the discharge of waste biocides into the environment may encourage the development of both biocide and antibiotic resistance, as well as having more general environmentally damaging effects. However, disinfectants with improved safety and efficacy profiles are being developed.

Cleaning and disinfection does not always eradicate pathogens from surfaces. The frequent finding of contamination in empty rooms and rooms occupied by patients unaffected by pathogens suggests residual contamination from previous occupants (Otter et al, 2011). There are several drivers of failures of environmental decontamination, including:

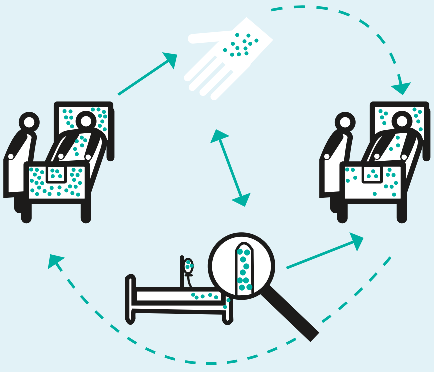
- Disinfectant efficacy and related issues;
- Healthcare environments being intricate and challenging;
- Biofilms on surfaces increasing bacterial resistance to decontamination.

However, the main reason for failures in environmental decontamination relate to the procedure rather than the product: an effective manual decontamination process relies on a human being for the correct formulation, distribution and contact time of a cleaning or disinfecting agent.

Innovation and new technology

Innovation and new technology can help to improve the effectiveness of cleaning and disinfection. For example, the Design Bugs Out initiative aims to design hospital furniture and equipment that is easier and quicker to clean (Bit.ly/BugsDesign). In addition, new and advanced formulations of liquid disinfectants boast improved efficacy and practicability, reducing the risk of human error during use.

Fig 1. **Contamination transfer**



The emergence of wipes impregnated with disinfectants – such as quaternary ammonium compounds, hydrogen peroxide, chlorine and others – are also promising developments. These wipes are:

- Better tolerated by nurses and cleaners;
- Effective for surface disinfection;
- Manufactured to provide optimal disinfectant concentration;
- Available at the point of care.

Also, they do not require reconstitution and whereas detergent wipes require a drying step, this is not necessary with disinfectant wipes, whose efficacy depends on achieving an appropriate contact time.

Emerging new disinfectants, which can be applied as a liquid or via a wipe, include reformulated hydrogen peroxide solutions (sometimes called 'activated' or 'improved' hydrogen peroxide) and electrolysed water.

There has also been development in automated room decontamination (ARD) systems, which remove or reduce reliance on the operator to ensure distribution, contact time and process repeatability (Otter et al, 2013). Both hydrogen peroxide-based systems and ultraviolet systems have been shown to reduce the transmission of pathogens associated with HCAI (Anderson et al, 2017; Passaretti et al, 2013). The choice of ARD system should be influenced by the intended application, the evidence base for effectiveness, practicalities of implementation and cost constraints.

Conclusion

Published evidence now demonstrates the key role of environmental contamination in healthcare settings in relation to the transmission of pathogens associated with HCAIs. Ensuring that surfaces are clean and adequately disinfected is a vital part of patient safety – and a legal requirement. Processes for maintaining a clean, safe environment vary from setting to setting but are always multiprofessional and nurses always have a crucial role. **NT**

● Disclosure: Jonathan Otter is a consultant to GAMA Healthcare and has been a consultant to Pfizer

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