Abstract

Effective decontamination is a vital aspect of infection prevention and control, and has a crucial role in reducing healthcare-associated infections (HCAs). Various decontamination methods can be used in healthcare settings to ensure that medical devices, equipment and the clinical environment are safe. It is essential for nurses and other healthcare staff to have adequate knowledge of the decontamination methods and infection prevention and control practices required to prevent HCAs. This article discusses the most common HCAs, decontamination methods that can be used, and relevant UK legislation, policies and guidance. It also outlines nurses’ responsibilities in relation to infection prevention and control and the importance of education and training in this area, with a particular focus on integrating human factors.

Why you should read this article:

- To refresh your knowledge of the most common healthcare-associated infections and major sources of contamination
- To consider how effective decontamination forms a vital aspect of infection prevention and control
- To update your understanding of the benefits of applying human factors to nursing procedures to reduce human error

The role of decontamination in reducing healthcare-associated infections

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In the UK, the NHS continues to work towards reducing the incidence and prevalence of healthcare-associated infections (HCAs). Also known as iatrogenic or nosocomial infections, HCAs occur as an adverse consequence of treatment and care interventions that patients receive while under the care of healthcare services. HCAs can be defined in various ways: as infections that were not previously present (incubating) in patients before hospitalisation (Kollef et al 2021); as infections resulting from interventions that occurred at the point of admission or within 48 hours of admission (Health Protection Agency 2012); or as infections confirmed within three days of discharge or within 30 days of undergoing an operation or discharge following inpatient care (Revelas 2012).

There are numerous pathogenic multi-drug resistant microorganisms implicated in causing HCAs, including various bacteria (Gram positive and Gram negative), viruses and fungi. Box 1 lists the most common types of healthcare-associated and medical device-associated infections.

HCAs remain responsible for high rates of mortality and morbidity worldwide. According to the World Health Organization (WHO) (2021), 8.9 million HCAs occur every year in acute and long-term care facilities in the European Union and European Economic Area (EU/EEA). In 2021, there were an estimated 53,985 severe antibiotic-resistant infections and 2,213 associated deaths in England (UK Health Security Agency 2022). Around one in 10 patients affected by an HCAI will die from it (WHO 2022a), with mortality rates increasing up to threefold when infections are resistant to antimicrobials (WHO 2022b). Furthermore, HCAs can lead to sepsis, and it is estimated that more than 24% of patients affected by healthcare-associated sepsis will die from it (WHO 2022b).

The ubiquitous presence of pathogenic microorganisms poses significant risk for patients, particularly when items such as medical devices and shared patient equipment are inadequately decontaminated between each use (Otter et al 2011). There has also been an emergence of hypervirulent microbial strains.
that are not easily treatable with available antibiotics (National Institutes of Health 2023), meaning that effective decontamination is vital to address the presence and persistence of these resistant species.

The term decontamination refers to a combination of physical processes that are employed to remove harmful substances from an environment, object or person (Oxford Reference 2024). This includes the removal and destruction of pathogenic microorganisms. The risks of harm occurring from such sources are minimised significantly when they are controlled using appropriate decontamination methods. Decontamination is crucial to prevent viable infectious agents from reaching susceptible sites on the body in quantities sufficient to initiate infection (Health and Safety Executive 2002). These susceptible sites can include breaches in intact skin, for example surgical wound sites and peripheral and central cannulation sites.

Legislation, policies and guidance
In the UK, the Health and Social Care Act 2008, and its supplementary (Regulated Activities) Regulations 2014, legislate a code of practice for health and adult social care on the prevention and control of infections (Department of Health 2010, Department of Health and Social Care 2022a). This code of practice provides guidance on infection prevention and control practice to all health and social care providers, and it was updated in 2022 to include antimicrobial stewardship and antimicrobial resistance (Department of Health and Social Care 2022a). Antimicrobial stewardship refers to a collection of coordinated, interprofessional, focused strategies to ensure antibiotic use only when clinically indicated, with the primary aim of reducing antimicrobial resistance (Manning et al 2016, Courtenay and Chater 2021). The code of practice does not replace other legislation such as the Health and Safety at Work etc. Act 1974, The Personal Protective Equipment (PPE) at Work (Amendment) Regulations 2022 and The Control of Substances Hazardous to Health Regulations 2002, but provides further unification of statutory governance.

The code of practice is further exemplified by the work of the Care Quality Commission (CQC), established in 2009 as the independent regulator for health and adult social care in England (Health and Social Care Act 2008). The CQC and the equivalent regulators for Scotland (Care Inspectorate), Wales (Healthcare Inspectorate Wales) and Northern Ireland (The Regulation and Quality Improvement Authority) have legal authority to ensure the standards for quality and safety are being met by all healthcare organisations and professionals. This includes oversight for all aspects of decontamination. Additionally, health technical memoranda provide specific guidance on decontamination, for example in relation to surgical instruments and flexible endoscopes (NHS England 2024a, 2024b).

National decontamination policy and standards were significantly revised following the emergence of variant Creutzfeldt-Jakob disease (vCJD) in humans in 1996, which was scientifically linked during the bovine spongiform encephalopathy (BSE) epidemic during the late 1980s and early 1990s (Hill et al 1997). The disease is caused by a prion (irregular protein) leading to a rare but fatal type of transmissible spongiform encephalopathy that affects the central nervous system. Although prions are not contagious pathogens, they are transmissible via inoculation (Department of Health and Social Care 2021). Prions have been found to be highly resistant microorganisms that are capable of surviving routine sterilisation methods (Department of Health and Social Care 2021). As a result, strict tracking, tracing and quantifying of individual instruments and medical devices used on patients with diagnosed or suspected vCJD was necessary to minimise the risk of inadvertent secondary use on other patients (National Institute for Health and Care Excellence 2020, NHS England 2021a).

Decontamination methods
Decontamination methods are broadly categorised into three levels aligned with whether the physical removal, reduction or eradication of microorganisms is required: cleaning, disinfection and sterilisation, respectively. Table 1 shows the susceptibility of different types of microorganisms to decontamination.

Cleaning enables the physical removal of organic contaminants that are visibly present on the skin or inanimate surfaces, using neutral detergent solutions or wipes. It is regarded as the first and most crucial step in the decontamination process, because the efficacy of disinfection or sterilisation are compromised if cleaning is not performed correctly (HSE 2002, WHO 2020). Disinfection aims to significantly reduce and remove the presence of viable pathogenic microorganisms that are not visible, to levels that are not harmful. It can range from bacteriostatic activity, which causes the inactivation of pathogenic microorganisms and thereby prevents their replication, to bactericidal activity, which destroys pathogenic microorganisms and effectively makes an item or surface

**Box 1. Most common types of healthcare-associated and medical device-associated infections**

*Most frequent microorganisms reported in healthcare-associated infections in Europe (2016-17)*
- **Escherichia coli** (31%)
- **Staphylococcus aureus** (12%)
- **Klebsiella pneumoniae** (10%)
- **Proteus mirabilis** (10%)
- **Pseudomonas aeruginosa** (7%)
- **Enterococcus spp.** (5%)

*Six most common types of healthcare-associated infections in England (2012)*
- **Respiratory infections (including pneumonia and lower respiratory tract infections)** (23%)
- **Urinary tract infections** (7%)
- **Surgical site infections** (16%)
- **Clinical sepsis** (1%)
- **Gastrointestinal infections** (9%)
- **Bloodstream infections** (7%)

*Medical device-associated infections in the US (2015-17)*
- **Surgical site infections** (43%)
- **Central line-associated bloodstream infections** (25%)
- **Catheter-associated urinary tract infections** (29%)
- **Ventilator-associated pneumonia** (3%)

sterile. In UK healthcare settings, commonly used disinfectants include chlorine, chlorine-based compounds (such as sodium hypochlorite (bleach) and chlorine dioxide) (NHS National Services Scotland 2024), and peroxides such as hydrogen peroxide for environmental fogging systems (these use a low-pressure mist applied mechanically to distribute chemicals in gaseous form and disinfect surfaces) (Antimicrobial Resistance and Healthcare Associated Infection Scotland 2022). However, a range of factors can limit or nullify the efficacy of disinfectants, including the base chemical properties, concentration, shelf life and contact time (WHO 2020). When using disinfectants, The Control of Substances Hazardous to Health Regulations 2002 must be adhered to, and guidance must be provided on use of products, handling, storage and any other safety concerns.

Sterilisation causes the absolute destruction of all living microorganisms except for prions (HSE 2002). Sterilisation can be achieved via heat or chemical methods. The most common heat process involves the use of autoclaves (pressure steam sterilisers); evidence has demonstrated that this method is reliable, effective and efficient in destroying the vast range of microorganisms (HSE 2002, NHS England 2024a). Other heat methods include dry heat ovens and boiling, but these are considered less reliable because they lack the necessary level of heat delivery and treatment control provided by steam sterilisers (HSE 2002). Chemical methods used for sterilisation or high-level disinfection depend on their efficacy at inactivating pathogenic microorganisms, particularly endospores. These methods are chosen to reprocess medical equipment that cannot be reprocessed using heat, such as flexible endoscopes or bronchoscopes. Chemical methods are used less commonly than heat processes and are favoured for more specific purposes, such as for use in laboratories and environmental fogging (WHO 2020).

Local decontamination policies and procedural guidance on decontamination are a vital reference point for clinical staff, underpinning standardised practice. However, these are only beneficial if they are readily accessible and easy to understand (Davies 2009, Dancer 2011).

**Risk assessment and classification**

Decontamination risk assessments are an integral component of patient safety and must take place for every individual patient treatment or care intervention that involves the use of shared patient equipment, reprocessable medical devices or repeated use of equipment or medical devices with a single patient (Department of Health and Social Care 2022b). This is to enable staff to select the most appropriate decontamination method depending on the clinical procedure and type of equipment or medical device used.

Spaulding’s (1957) risk classification system is a well-known framework designed to assist in the selection of decontamination methods. The risk categories are determined by how medical devices interface with the body; that is, whether they are invasive or non-invasive. Invasive medical devices and procedures carry the highest risk of contamination and require high-level disinfection or sterilisation (Spaulding 1957). Although developed more than 65 years ago, advantages of Spaulding’s system include its logical design and simple interpretation, hence its longevity (Rowan et al 2023). However, it has also been suggested that the system would benefit from being updated to meet the current challenges posed by the complex design of some modern medical devices and the emergence of resistant pathogens with high resilience to disinfection processes. Given these complexities, inadequate cleaning and inappropriate disinfection is a concern, since outbreaks of infection have resulted from these issues (Rowan et al 2023).

Table 2 shows an adapted version of Spaulding’s classification system, outlining risk categories, applications, decontamination methods and examples of medical devices and inanimate surfaces.

**Infection prevention and control**

According to the WHO (2024), infection prevention and control is a unique area of patient safety and quality of care, since it is universally relevant to every healthcare professional and patient.

### Key points

- There are numerous pathogenic multi-drug resistant microorganisms implicated in causing healthcare-associated infections (HCAIs), including various bacteria, viruses and fungi
- HCAIs remain responsible for high rates of mortality and morbidity worldwide
- Antimicrobial stewardship refers to a collection of coordinated, interprofessional, focused strategies to optimise antibiotic use only when clinically indicated, with the primary aim of reducing antimicrobial resistance
- Infection prevention and control is a practical, evidence-based approach that uses proven methods to prevent HCAIs
- Nurses have direct responsibility for ensuring that the clinical environment is safe to deliver care

### Table I. Susceptibility of different types of microorganisms to decontamination

<table>
<thead>
<tr>
<th>Decreasing level of resistance to disinfection or sterilisation</th>
<th>Microorganism</th>
</tr>
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<tbody>
<tr>
<td>Very resistant</td>
<td>Prions</td>
</tr>
<tr>
<td></td>
<td>Bacterial spores</td>
</tr>
<tr>
<td></td>
<td>Mycobacteria</td>
</tr>
<tr>
<td></td>
<td>Protozoal cysts</td>
</tr>
<tr>
<td></td>
<td>Non-enveloped viruses, for example polio and hepatitis A</td>
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<tr>
<td>Susceptible</td>
<td>Vegetative bacteria</td>
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<tr>
<td></td>
<td>Enveloped viruses, for example human immunodeficiency virus (HIV), respiratory syncytial virus and hepatitis B</td>
</tr>
<tr>
<td></td>
<td>Fungi and their spores</td>
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<tr>
<td></td>
<td>Non-encysted protozoa</td>
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(Walker 2019)
at every healthcare interaction. Infection prevention and control is a practical, evidence-based approach that uses proven methods to prevent HCAIs (Loveday et al 2014). The mantra ‘infection control is everyone’s business’ (Weaving and Cooper 2006) embraces the concept that a unified approach from all healthcare staff is required to ensure effectiveness and asserts that staff must be diligent and responsible for their individual practice.

It has been suggested that up to 30% of HCAIs could be prevented with improved infection prevention and control practices (Siani and Maillard 2015). For example, it has been identified that healthcare workers’ hands are a significant factor in the transmission and transference of microorganisms after contact with contaminated surfaces or patients with infections (Kampf and Kramer 2004, Landelle et al 2014). Therefore, it is important to improve adherence to hand hygiene practices, and this requires constant vigilance.

Kramer et al (2006) reviewed the data on how long various nosocomial pathogens persist on inanimate surfaces. For example, they found that the bacteria *Staphylococcus aureus* (including methicillin-resistant *S. aureus*) can survive for up to seven months, *Clostridium difficile* (formerly *Clostridium difficile*) up to five months and noroviruses have lesser longevity of up to seven days. The highest environmental bioburden of nosocomial microorganisms is carried by high-touch surfaces that are nearest to the patient such as bed rails and call-buttons, as well as fixtures and fittings such as light switches and door handles in close proximity (Otter et al 2011, Loveday et al 2014, Rutała et al 2019). Furthermore, mobile shared equipment such as commodes, blood pressure cuffs and tourniquets are major sources of biological contamination because they frequently become soiled with blood and body fluids (Davis 2009, Bucior et al 2019). Furthermore, mobile shared equipment such as commodes, blood pressure cuffs and tourniquets are major sources of biological contamination because they frequently become soiled with blood and body fluids (Davis 2009, Bucior et al 2019). Therefore, infection prevention and control practice requires the practical upskilling of nurses and other front-line healthcare staff as a necessary starting point. Therefore, infection prevention and control education and training is crucial to enhance the development of healthcare staff and should not only include standard practical aspects, but also behaviour modification – a facet of human factors science (Storr et al 2013). Human factors, also known as ergonomics, is a scientific discipline that aims to understand the interplay between the dynamics of human behaviour and multiple external factors that people encounter during their day-to-day work activities (Clinical Human Factors Group 2024). It focuses on how people interact with external systems around them, such as the physical work environment, equipment, devices and processes of care. Healthcare is a complex sociotechnical system that encompasses many challenges for its workforce, which can lead to heightened incidences of human error (Carayon et al 2006, Clinical Human Factors Group 2024).

For example, staff shortages, high workloads, a lack of resources and unfamiliar or new equipment can lead to increased tiredness, a propensity to ‘cut corners’, lapses in focus or attention to detail and errors in using equipment. Human factors has been used in the wider healthcare sector and has contributed to improvements in service quality, patient outcomes and patient safety (Chartered Institute of Ergonomics and Human Factors and Health Education England 2019, The Health Foundation 2024). Infection prevention and control is viewed as an area that

<table>
<thead>
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<th>Table 2. Risk classification system</th>
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<tr>
<td><strong>Risk category</strong></td>
</tr>
<tr>
<td>High (critical)</td>
</tr>
<tr>
<td>Medium/intermediate (semi-critical)</td>
</tr>
<tr>
<td>Low (non-critical)</td>
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<tr>
<td>Minimal</td>
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(Adapted from Spaulding 1957, Harrogate and District NHS Foundation Trust 2016)
would benefit from human factors training for healthcare staff (Storr et al 2013). There is limited evidence of successful integration of human factors training specifically relating to infection prevention and control (Jacob et al 2018); however, examples of its effective application in practice include (Drews et al 2019):

» Hand hygiene – for example a human factors approach was used to conceptualise appropriate hand hygiene based on the moments at which transmission of an infectious organism can occur.

» Personal protective equipment (PPE) – consideration of human factors may improve adherence to donning and doffing procedures, as well as appropriate PPE use.

» Central line-related activities – a human factors-based central line maintenance kit improved procedural adherence and led to a significant reduction in the number of central line-associated bloodstream infections. These examples suggest there is potential for wider integration of human factors in infection prevention and control education and training.

Conclusion

Effective decontamination remains a continual challenge for healthcare organisations and professionals in the UK, as well as globally. Despite legislation, stringent national regulations and guidance being in place, HCAIs continue to occur due to substandard decontamination practices. Human error is thought to be a contributing factor and could be lessened through the integration of human factors into infection prevention and control training and education for nurses and other healthcare professionals. Human factors training in other healthcare fields has proven beneficial in improving patient safety, health outcomes and the quality of care; however, further evidence of its effectiveness in relation to infection prevention and control practice is required.

References


