NHS National Services Scotland

Safe Management of the Care Environment (Environmental Decontamination and Management of Blood and Body Fluid Spillages) Literature Review

Version 2.0

25 March 2026

Antimicrobial Resistance & Healthcare Associated Infection (ARHAI) Scotland
An NHS Scotland Assure Service

Version History

Version	Date	Summary of changes
V1.0	November 2020	SICPs Routine cleaning of the environment and TBPs Environment Decontamination reviews were amalgamated and updated using a double reviewer methodology. The question sets were reviewed and the following objectives added: • How are patient zones defined in regards to cleaning? • What is the definition of decontamination? • What is the definition of contact time in relation to cleaning of equipment and the environment?
V2.0	March 2026	Scheduled update of the Safe Management of the Care Environment Literature Review: • Updated using a new methodology, details of which can be found within V5.0 of the development process in the NIPCM. • Search strategies added as Appendix 2. The Safe management of the care environment (environmental decontamination) and Management of blood and body fluid spillages in health and care settings reviews were amalgamated.

Approvals

Version	Date Approved	Group/Individual
V1.0	December 2020	NPGO Steering Group
V2.0	March 2026	ARHAI Scotland National Policy, Guidance and Evidence (NPGE) Working Group

Key information

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Document information

Document information	Description
Description:	This literature review examines the available professional literature on Safe management of the care environment (environmental decontamination and management of blood and body fluid spillages).
Purpose:	To inform the National Infection Prevention and Control Manual in order to facilitate the prevention and control of healthcare associated infections in NHS Scotland health and care settings.
Target Audience:	All NHS staff involved in the prevention and control of infection in NHS Scotland.
Update/review schedule:	Updated as new evidence emerges with changes made to recommendations as required. Review will be formally updated every 3 years with next review in 2029.
Cross reference:	National Infection Prevention and Control Manual

Contact

ARHAI Scotland Infection Control team:

Telephone: 0141 300 1175

Email: NSS.ARHAIinfectioncontrol@nhs.scot

Abbreviation list

Acronym	Definition
AGREE II	Appraisal of Guidelines for Research and Evaluation II
APSIC	Asia Pacific Society of Infection Control
BS EN	British, European Standards
CDI	Clostridioides difficile infection
COSHH	Control of Substances Hazardous to Health
CPE	Carbapenemase-producing Enterobacterales
HAI	Healthcare associated infection
HCW	Healthcare worker
HDL	Health workforce directorate letter
HICPAC	Healthcare Infection Control Practices Advisory Committee
HSE	Health and Safety Executive
IPC	Infection prevention and control
MDRO	Multidrug-resistant organism
MRSA	Methicillin-resistant Staphylococcus aureus
NCSS	National Cleaning Services Specification
NIPCM	National Infection Prevention and Control Manual
PFGE	Pulsed field gel electrophoresis
PPE	Personal protective equipment
ppm	Parts per million
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RCN	Royal College of Nursing
SARS	Severe Acute Respiratory Syndrome
SCN	Senior Charge Nurse
SIGN 50	Scottish Intercollegiate Guidelines Network 50
SHFN	Scottish Health Facilities Note
SOP	Standard Operating Procedure
WHO	World Health Organization

Contents

1 Objective

The aim is to review the extant scientific literature regarding the safe management of the care environment (environmental decontamination and management of blood and body fluid spillages) in health and care settings to inform evidence-based recommendations for practice. The specific objectives of the review are to determine:

1. What is the risk of Healthcare Associated Infection (HAI) from the care environment?
2. What is environmental decontamination?
3. For the purpose of environmental decontamination what is the care environment, including patient zones?
4. What different types of environmental decontamination are undertaken in health and care settings and why are they required?
5. Are there any legislative requirements or standards that should be adhered to when undertaking environmental decontamination?
6. What methods (techniques) are recommended for decontamination of the health and care environment?
7. When and how are different products used for decontamination of the health and care environment?
8. How should blood and body fluid spillages be managed?
9. What is the recommended frequency for environmental decontamination?
10. Are there specific requirements for the decontamination of soft furnishings?
11. Who has responsibility for ensuring the care environment is decontaminated appropriately?
12. How should environmental decontamination equipment be managed and stored?

2 Methodology

This targeted literature review was produced using a defined systematic methodology as described in the National Infection Prevention and Control Manual: Development Process. The complete search strategy is provided in Appendix 1. Database searches were performed on 22 February 2024.

In addition to the exclusion criteria outlined in the NIPCM: Development Process the following evidence was excluded in this review.

- Evidence assessing the use of existing and emerging technologies for decontamination and other novel technologies such as studies assessing efficacy of antimicrobial coatings on surfaces.
- Evidence focussing on decontamination of linen or equipment.
- Manufacturers guidance on products for environmental decontamination.
- Studies that could not evidence a plausible epidemiological link between the environment and the patient, for example single-point sampling studies.

Definitions for grades of evidence are provided in Appendix 2. A PRISMA flowchart is presented in Appendix 3. Adapted from Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).[1]

3 Discussion

3.1 Implications for practice

3.1.1 What is the risk of Healthcare Associated Infection (HAI) from the care environment?

Two pieces of evidence were included for this research question, including one prospective cohort study (SIGN 50 level 2+)[2] and one outbreak study (SIGN 50 level 3).[3] The included primary literature was undertaken in the US[2] and Hong Kong.[3]

Evidencing risk of transmission of HAI from the health and care environment is complex and ethically challenging, specifically when undertaking controlled studies, therefore much of the available evidence base is observational. A large body of evidence was identified hypothesising the risk of HAI from environmental sources in health and care settings globally. The exclusion list can be found in Appendix 4.

A major limitation of the excluded studies was lack of genetic testing to compare environmental and clinical isolates and determine a strain match. Therefore, these studies were unable to confirm that the case was infected or colonised with the infectious agent identified in the environment. Another significant limitation in the literature was the uncertainty in the direction and source of transmission and if this was directly from the environment to the patient, or from other sources such as direct contact, or colonisation or infection prior to hospital admission. Many studies failed to appropriately adjust for this or consider this within the methods. However, this was a common limitation in the evidence base given retrospective sampling and selective nature of culturing often carried out during outbreak investigations. Similarly, much of the research was bundled with other infection prevention and control (IPC) measures that could impact transmission risk, making it unclear as to how this may have impacted environment to patient HAI risk or acquisition.

The two studies included for this research question demonstrated a probable epidemiological link from an environmental exposure. Both studies attempted to mitigate study limitations, as previously mentioned, by undertaking genetic testing,[2, 3] monitoring hand hygiene,[3] testing healthcare workers (HCW) hands for contamination,[2] and carried out environmental sampling before patient admission to

the hospital room after terminal decontamination.[3] Cheng *et al*. (2019)[3] investigated a nosocomial outbreak (SIGN 50 level 3) of community-associated methicillin-resistant *Staphylococcus aureus* (MRSA, strain ST59-SCC*mec* type V), reportedly associated with outbreaks in both the community and health and care settings. This outbreak was in a neonatal intensive care unit and involved 15 neonates and one HCW. Environmental cleaning was carried out twice daily and patient cases were isolated in a single room or cohorted, with terminal decontamination carried out between patients using 125 parts per million (ppm) chlorine dioxide during phase 1 of the outbreak. Admission screening, surveillance and weekly and ad hoc environmental sampling were carried out during phase 2 and HCWs were screened voluntarily and cohorted during phase 3. Whole genome sequencing indicated a contaminated window bench was linked to the transmission of MRSA to three patients. Although there was a clear temporal link indicating environmental contamination for at least one of the patients in this cluster, mode of transmission was unclear.[3] This analysis also identified transmission between patients, and from patients to the environment and the HCW, so environmental contamination was not the only source of transmission in this outbreak. Case-control analysis identified length of hospital stay and cephalosporins as risk factors for colonisation or infection in this study.[3] Chen *et al*. (2019) conducted a prospective cohort study (SIGN 50 level 2+) of 80 patients, investigating transmission of multidrug-resistant organisms (MDROs) between environmental sites and hospitalised patients, specifically in general medicine and oncology wards.[2] Patients who were placed in rooms whose prior occupant was on contact precautions were included. The study reported two patient cases of *Clostridioides difficile* infection (CDI) acquired from the environment, confirmed by PFGE. Despite daily cleaning with bleach and terminal decontamination between patients with quaternary ammonium, low levels of bacterial contamination of the CDI strain were identified from environmental sampling at the time of admission (whilst patient baseline samples indicated that they were negative on admission) indicating acquisition from the environment. It is unclear from the study what specific environmental surface was indicated as the source, so exact mode of transmission could not be determined. This study also demonstrated transfer of the infectious agent from patients to the environment.[2] Prospective cohort studies may be more reliable than outbreak studies at demonstrating direction of transmission of HAIs from the health and care environment to patients (who have

tested negative on admission), as environmental sampling can be undertaken before a case is identified.

Summary

The included studies provide evidence of risk of HAI from the health and care environment despite environmental decontamination protocols in place, specifically for MDROs including CDI and MRSA.[2, 3] These studies were likely under-powered due to small sample sizes, and generalisability of these findings to other infectious agents cannot be determined as risk factors for transmission such as environmental survivability have not been assessed as part of this research question. Moreover, the findings from the study investigating risk of HAI from the environment in a neonatal unit may not be generalisable to adult patient populations. It should be noted that inclusion of only two studies to address this objective does not denote the absence of HAI risk from the environment in health and care settings, as risk of HAI from the environment is multifactorial and therefore challenging to demonstrate with certainty in primary evidence.

3.1.2 What is environmental decontamination?

Thirteen documents were included for this research question, 12 expert opinion guidance (SIGN 50 level 4)[4-15] and one guideline graded using the AGREE II tool as 'recommend with modifications'.[16] The guideline was published in the UK,[16] and the guidance was published in the UK,[6, 11] Canada,[7, 9] Australia,[8] US,[5, 10, 13-15] Asia Pacific region[4] and by an international organisation (the World Health Organization, WHO).[12] SIGN 50 level 4 guidance is subject to methodological and reporting limitations and is considered low-quality evidence due to unclear methodology and inconsistent in-text citations linking to supporting evidence. The included guidance and guidelines are applicable across all health and care settings, including 'emergency medical vehicles'.[7] No primary evidence was identified to inform this research question.

Environmental Decontamination

Environmental decontamination can be defined as the use of physical or chemical methods to remove, inactivate, or destroy microorganisms (including infectious

agents) on a surface or item so that it is no longer capable of cross-transmission. This is consistent across six available evidence (including the AGREE II guideline graded 'recommend with modifications').[5, 6, 8, 9, 12, 16]

Environmental decontamination can be considered an umbrella term, encompassing different levels of decontamination, including cleaning, disinfection and sterilisation.

Cleaning

Cleaning is described as the physical removal of contamination,[6] (including soil, dirt, dust, blood, secretions, excretions and some microorganisms) from surfaces,[16] using friction as a means of removal (six SIGN 50 level 4 and one AGREE II 'recommend with modifications').[4, 7-11] The UK Health and Safety Executive (HSE) state that cleaning does not necessarily destroy all microorganisms, even if a surface looks visibly cleaner (one SIGN 50 level 4).[6] Manual or mechanical methods for cleaning are referenced in six SIGN 50 level 4 guidance,[4, 5, 7-9, 12] with use of detergents or surfactants and water discussed in eight SIGN 50 level 4.[4-10, 12] Although three guidance refer to the term 'cleaning' but do not define the product that should be used for this.[13-15] The extant guidance emphasises that cleaning should always be undertaken before disinfection,[4, 5, 10, 16] or sterilisation (four SIGN 50 level 4 and one AGREE II 'recommend with modifications' guideline).[6]

Disinfection

Disinfection is the use of chemical or physical methods, including heat,[12] to reduce the number of viable microorganisms on surfaces,[16] to a level that is unlikely to cause infection.[6] Extant guidance states that disinfection can kill most microorganisms, but may not kill all bacterial spores and some viruses.[4-7, 9] This definition is consistent in four SIGN 50 level 4 guidance and one AGREE II 'recommend with modifications' guideline.

Sterilisation

Sterilisation is consistently defined in five SIGN 50 level 4 guidance as the destruction of all forms of microorganisms,[6, 8] including bacteria, viruses, spores and fungi,[7, 10] often using physical or chemical methods.[5, 8] Sterilisation is more relevant to medical equipment and device decontamination[5] and not for the decontamination

of the health and care environment. Please see the NIPCM management of care equipment review for further detail.

Summary

In summary, extant guidance consistently defines environmental decontamination as the use of physical or chemical methods such as heat to remove, inactivate, or destroy microorganisms (including infectious agents) on a surface or item so that it is no longer capable of cross-transmission. Three principal categories exist for environmental decontamination: cleaning, disinfection and sterilisation. Each has a different intended outcome. Although most of the evidence in this research question was expert opinion and therefore low quality, it is understood that these levels of environmental decontamination are well established in IPC practices globally.

3.1.3 For the purpose of environmental decontamination what is the care environment, including patient zones?

Five pieces of guidance were included for this topic, all were graded SIGN 50 level 4 expert opinion.[4, 8, 12, 17, 18] Level 4 guidance is subject to methodological and reporting limitations and is considered low-quality evidence. The included guidance is applicable across all health and care settings from the UK,[17] Australia,[8] Asia Pacific region[4] and internationally (the WHO)[12, 18] including surgical settings.[12] No primary evidence was identified to inform this research question.

Four SIGN 50 level 4 guidance documents divide the care environment into high or frequently (for example bedrails, buttons and monitors),[4, 8, 12, 18] minimal and low touch surfaces (for example floors and walls)[4, 12] for the purpose of environmental decontamination. The NHSScotland National Cleaning Service Specification (NCSS) Scottish Health Facilities Note (SHFN) 01-02[17] by NHS Scotland Assure has been specifically developed for application in NHS Scotland health and care settings and divides the care environment into categories using an alphanumeric-coding system to categorise clinical and non-clinical areas that require cleaning. See research question nine regarding how this relates to frequency of environmental

decontamination. A similar system is also applied in guidance by the Asia Pacific Society of Infection Control (APSIC).[4, 17]

Patient zones are described in two SIGN 50 level 4 guidance documents as the environment immediately surrounding the patient.[8, 18] This typically includes all inanimate surfaces that are touched by or in direct physical contact with the patient. This also includes surfaces frequently touched by HCWs whilst caring for the patient such as monitors, knobs and buttons as well as other high touch surfaces.[4, 8, 18]

Summary

For the purpose of environmental decontamination, the available evidence consistently divides the care environment by how frequently surfaces are touched. Similarly, patient zones are also defined by frequency of touch in the areas surrounding the patient. The NCSS (SHFN 01-02) divides the care environment into clinical and non-clinical areas.

3.1.4 What different types of environmental decontamination are undertaken in health and care settings and why are they required?

Seven pieces of evidence were included for this research question, including six guidance documents, graded SIGN 50 level 4 expert opinion[4, 7-10, 17] and one guideline graded using the AGREE II tool as 'recommend with modifications'.[16] Evidence graded as SIGN 50 level 4 is subject to methodological and reporting limitations. The included guidance and guideline was developed in the UK,[16, 17] Australia,[8] Canada,[7, 9] Asia Pacific region[4] and the US.[10] This body of evidence is applicable across all health and care settings, including for 'emergency medical vehicles'.[7] No primary evidence was included to inform this research question.

The included evidence outlines different types of environmental decontamination undertaken in health and care settings to minimise the risk of cross-transmission. Often 'cleaning' is used to describe a process involving disinfection in the evidence and in practice. Therefore, it should be noted that the terminology used here and throughout the literature review is consistent with the definitions provided in research question two, "What is environmental decontamination?".

Routine Cleaning

Three SIGN 50 level 4 guidance describe routine cleaning as regular cleaning, which is carried out on a scheduled basis and performed as part of usual practice, not on an ad hoc basis and not in response to an outbreak.[7-9] Routine cleaning is implemented to reduce the risk of cross-contamination,[9] and to remove any dust, soil, stains and residue.[7] Guidance by NHS Scotland Assure (the NCSS, SHFN 01-02)[17] and the US Centers for Disease Control and Prevention (CDC) and Healthcare Infection Control Practices Advisory Committee (HICPAC)[10] mention routine cleaning throughout but do not provide a definition. Other guidance refers to this within 'routine practice' or as a 'hotel clean', although the general principles remain the same.[4, 9]

Check Cleaning

The NCSS (SHFN 01-02) (SIGN 50 level 4) describes check cleaning, which can be defined as "a visual check or measure of cleanliness, for example, for spots, spillages and/or general debris, at a specified frequency throughout the day". "Sufficient cleaning should be carried out to restore the area or item to an acceptable standard using the agreed cleaning procedures."[17]

Enhanced Decontamination

The UK epic3 guideline, graded as AGREE II 'recommend with modifications' defines enhanced decontamination. This is described as "cleaning methods in addition to standard cleaning specifications", including "increased cleaning frequency for all or some surfaces, or the use of additional cleaning equipment". This can also be applied in specific circumstances, including "the transfer or discharge of patients who are colonised or infected with a pathogenic microorganism".[16]

Terminal Decontamination

Often referred to as 'terminal clean' within the evidence, terminal decontamination is defined as decontamination of an area following transfer or discharge of a patient by three expert opinion guidance documents including the NCSS (SHFN 01-02) and one guideline graded AGREE II 'recommend with modifications'.[8, 9, 16, 17] This could be in cases of patients with suspected or known infection or colonisation to ensure a

safe environment for the next patient.[9, 16, 17] Guidance from the APSIC[4] and the CDC and HICPAC[7, 10] refer to terminal cleaning or disinfection throughout their guidance but do not define this.

Discharge Cleaning

The Scottish NCSS (SHFN 01-02) advises that discharge cleaning should take place after each patient is discharged from an area or room to reduce the risk of cross-infection.[17] This terminology has been used interchangeably in extant guidance (graded SIGN 50 level 4) with 'terminal cleaning'.[8]

Source Isolation Cleaning

The Scottish NCSS (SHFN 01-02) describes source isolation cleaning as occurring where patients with a known or suspected alert organism or communicable disease are cared for with minimal contact with other patients.[17]

Summary

The available evidence presents the different types of environmental decontamination undertaken in health and care settings, including routine, check, enhanced, terminal, discharge and isolation. Not all included guidance describes each environmental decontamination type, and there is some inconsistency in specific terminology used as detailed above. Furthermore, the term 'cleaning' is frequently used to describe the different types of environmental decontamination however, this terminology refers to only implementing that specific level of decontamination and does not account for situations where disinfection or sterilisation would occur (see research question two for further information). Consistent terminology in extant guidance would improve clarity and communication, support correct understanding of environmental decontamination processes and reduce potential errors that could arise from the use of inconsistent language.

3.1.5 Are there any legislative requirements or standards that should be adhered to when undertaking environmental decontamination?

Eighteen pieces of evidence were included for this research question. This includes four guidance documents[11, 17, 19, 20] and nine British and European (BS EN) standards,[21-29] all graded SIGN 50 level 4 expert opinion. The included guidance and standards were developed in the UK. Evidence graded as SIGN 50 level 4 is subject to methodological and reporting limitations and is considered low quality evidence. Five pieces of legislation were also included in this research question which were graded 'mandatory' and are applicable in the UK.[30-34]

Legislation

Four of the included legislations are relevant to undertaking environmental decontamination in NHS Scotland health and care settings. 'The Public Health etc. (Scotland) Act 2008' states the duties of health boards to protect public health, including the prevention and control of infectious diseases.[32] Similarly, 'The Health and Safety at Work etc Act 1974' states that it is the duty of every employee to "take reasonable care for the health and safety of himself and of other persons who may be affected by his acts or omissions at work".[31] Both legislations are applicable when undertaking activities related to environmental decontamination, including the correct application of local policies and procedures.

Two legislations are applicable to the use of decontamination products. 'The Control of Substances Hazardous to Health (COSHH)' applies across any workplace setting, as outlined in the legislation and supplementary guidance supporting implementation.[11, 19, 33] The UK HSE provide an approved code of practice detailing guidance for performing a risk assessment, including the prevention and control of hazards, which claims to support adherence to COSHH regulations.[19] The NCSS (SHFN 01-02) signposts to COSHH in relation to controlling employee exposure to hazardous substances.[17] The 'Detergents (Amendment) (EU Exit) Regulations 2020' applies to the biodegradability of surfactants used in detergents and is therefore applicable to environmental decontamination, particularly the manufacturers that supply these products.[20, 30]

Personal protective equipment (PPE) is covered more generally within the NIPCM in relation to IPC, and the use of PPE is regulated by such legislation as; the 'The Personal Protective Equipment at Work Regulations 1992', COSHH regulations, and 'Health and Safety at Work 1974, etc Regulations'.[31, 33, 34] These legislations are applicable to occupational health and/ or health and safety at work regarding the use of chemicals or other aspects of decontamination are outside of the scope of this review which focuses on IPC.

Standards

The BS EN standards refer to a collection of documents outlining a methodological process for testing the minimum microbiological efficacy of surface disinfectants used in the medical setting. This excludes products classified as detergents as they have no antimicrobial claims.[21] BS EN 14885:2022 lists eight standards that are relevant to environmental decontamination in NHS Scotland health and care settings;[21] these include BS EN 13727,[23] 13624,[29] 17387,[28] 14348,[22] 14476,[27] 16777,[25] 17126,[26] and 16615[24] (see Appendix 5). The standards are comprised of two phases: in vitro testing and simulation of practical conditions with and without mechanical action. According to BS EN 14885, obligatory standards to be passed for surface disinfectants used in the medical area include bactericidal and yeasticidal activity, with additional consideration given to fungicidal activity, tuberculocidal, mycobactericidal activity, sporicidal activity and enveloped viruses.[21] Test organisms for these claims are listed in full in Appendix 5. The British Standards Institute state that these test organisms were chosen as representative species considering "their relative resistance, […] relevance to practical use […] handling properties and the microbiological safety".[21] However, it should be noted that limited detail on methodology for developing these standards and a focus on laboratory studies to investigate product efficacy may not replicate contamination patterns (such as biofilms), and therefore efficacy, in real-world clinical settings.

At the time of writing, the included standards were the most recent versions available. It should be noted, however, that these are subject to amendment and that the standards discussed here may not represent all standards which apply to environmental decontamination.

Summary

Adhering to the stated UK and Scottish legislation is mandatory when undertaking environmental decontamination in NHS Scotland health and care settings. For specific use of detergents, 'The Detergents (Amendment) (EU Exit) Regulations 2020' applies, and for surface disinfectants, the included BS/ EN Standards provide a consistent and transparent methodology for assessing microbiological efficacy of surface disinfection products, noting limited applicability of test organisms and laboratory methods to real-world Scottish clinical health and care settings.

3.1.6 What methods and techniques are recommended for decontamination of the health and care environment?

Twelve pieces of evidence were included for this research question. Eleven guidance documents were graded SIGN 50 level 4 expert opinion[4, 7-13, 17, 35] due to methodological and reporting limitations. The included guidance was developed in the UK,[11, 17, 35] Canada,[7, 9] Australia,[8] Asia Pacific region,[4] the US[5, 10, 13] and internationally (by the WHO)[12] and is applicable across all health and care settings, including 'emergency medical vehicles and equipment'[7] and surgical settings.[12] One primary study was also included - a laboratory study from the UK[36] graded SIGN 50 level 3.

For this research question, 'methods' represents steps taken to carry out environmental decontamination, and 'techniques' represents how environmental decontamination is carried out, namely mechanical actions such as scrubbing and wiping. See research question nine for detail on frequency of environmental cleaning.

One primary study was included which investigated efficacy of mechanical wiping for environmental decontamination, graded SIGN 50 level 3. This laboratory study by Ungurs *et al.* (2011) found that mechanical wiping was significantly more effective at reducing *C. difficile* contamination than product on its own. The most effective method for reducing contamination was mechanical wiping with detergent and then a chlorine-based product (4.00+/-0.33 $\log_{10}$ reduction).[36] This study was carried out in a controlled laboratory setting, with a test strain of *C. difficile* on stainless steel

surfaces which may limit applicability to real-world health and care settings. Although this study demonstrates efficacy of mechanical wiping, what was meant by this action was not defined, and efficacy differed depending on the cleaning product used,[36] suggesting that both method or technique and product are important. Products and their use are addressed in research question seven "When and how should different products be used for environmental decontamination of the health and care environment?".

Four expert opinion guidance, including the NCSS (SHFN 01-02), advise that decontamination should be undertaken from cleanest or least soiled to the dirtiest or most soiled areas,[4, 17, 35] including in emergency vehicles.[7] The NCSS alongside three SIGN 50 level 4 guidance documents advise that, due to significant variation in health and care settings, local risk assessments should be undertaken related to environmental decontamination methods[8, 11, 17] and local policies and procedures be available based on situation or degree of patient contact and soiling.[13] For example, the CDC and HICPAC and the WHO advise avoidance of dusting methods that disperse dust in areas for immunocompromised patients[10] and in surgical settings.[12] The CDC and HICPAC suggest wet-dusting with a clean cloth soaked in detergent or disinfectant may be carried out on horizontal surfaces in areas with immunocompromised patients (one SIGN 50 level 4)[10] and the CDC for environmental decontamination in general (one SIGN 50 level 4).[5]

Terminal decontamination

Two SIGN 50 level 4 guidance documents provide more detail on methods for terminal decontamination. Namely, that patients' belongings, bed screens, curtains and bedding should be removed prior to the room or area being decontaminated[4] including removal of contaminated, disposable or used items.[4, 9]

Standard operating procedures (SOPs) in Scottish guidance

The NCSS (SHFN 01-02)[17] and Safe Management of the Care Environment (SHFN 01-05) (care homes NCSS) [35] have been developed specifically for NHS Scotland health and care settings, arranging environmental decontamination operations into a series of tasks to be carried out in patient accommodation categories; specific methods and minimum required frequencies are detailed for each task group. This

includes detailed methods for routine, isolation, terminal and discharge decontamination. However, although IPC elements of these SOPs are guided by evidence in the NIPCM, specific recommendations and methods in these guidance documents are not based on scientific evidence and have been created by an expert opinion task group.

Summary

One primary study was included that demonstrated efficacy of specific methods or techniques (mechanical wiping), but the findings are not conclusive without consideration of specific products for environmental decontamination, which are addressed in research question seven "When and how should different products be used for decontamination of the health and care environment?". Moreover, the applicability of the findings is limited by the controlled laboratory setting and specific test strains investigated. The included guidance documents are generally high-level and lack specific detail on decontamination methods (techniques), although the overall principles are consistent. These include focussing environmental decontamination from cleanest or least soiled to the dirtiest or most soiled areas. The NCSS and care homes NCSS provide detailed methods for environmental decontamination tasks specific for NHS Scotland health and care settings.

3.1.7 When and how should different products be used for decontamination of the health and care environment?

Sixteen pieces of evidence were included for this research question, fifteen guidance documents were graded SIGN 50 level 4 expert opinion[4-9, 12-15, 17, 35, 37-39] and one guideline was graded AGREE II 'recommend with modifications'.[16] Evidence graded as SIGN 50 level 4 is subject to methodological and reporting limitations and is considered expert opinion. The included guidance and guideline was developed in the UK,[6, 16, 17, 35] Europe,[37] Canada,[7, 9, 39] Australia,[8] Asia Pacific region,[4] US[5, 13-15, 38] and applicable internationally (the WHO).[12] The guidance and guideline appears to apply across all health and care settings, including surgical settings, operating rooms[12, 15] and 'emergency medical vehicles'.[7]

This research question is focused on liquid-based environmental decontamination products (detergents and disinfectants). Please see 'existing and emerging technologies for decontamination' in the NIPCM for literature reviews which assess use of airborne hydrogen peroxide, antimicrobial copper surfaces, antimicrobial copper and silver solutions, adenosine triphosphate bioluminescence and fluorescent markers, chlorine dioxide, electrolysed water, high-intensity narrow-spectrum light, microfibre, steam ultraviolet light, wipes, and ozone. Variation in how microbiological efficacy is measured creates challenges when synthesising the available primary evidence base (see Implications for Research). There is a considerable variety of microorganisms present in the health and care environment; therefore, it is important that a disinfectant product has broad-spectrum effectiveness against bacteria, viruses, yeast, and fungi (see research question five "Are there any legislative requirements or standards that should be adhered to when undertaking environmental decontamination?" and Appendix 5 for applicable standards). Primary evidence was considered for inclusion for this research question but was excluded at the critical appraisal stage due to low quality.

Detergents

The physical action of cleaning with a detergent, usually diluted with water is described in three SIGN 50 level 4 guidance.[4, 7, 8] Two SIGN 50 level 4 guidance describe detergents as removing or breaking down organic material, microorganisms, grease and dirt from surfaces.[4, 7] However, the CDC state that detergents usually have no antimicrobial claims.[5] Detergents used for cleaning are not required to demonstrate antimicrobial effectiveness, for example using the BS EN standards to demonstrate minimum log reductions. This is only applicable to surface disinfectant products used in the medical area (see research question five "Are there any legislative requirements or standards that should be adhered to when undertaking environmental decontamination?").

When to use a detergent product for environmental decontamination

Five guidance including the care homes NCSS (SHFN 01-05), graded SIGN 50 level 4 expert opinion, recommend the use of detergents for routine cleaning.[4, 5, 8, 12, 35] Australian guidance and the CDC advise to clean (with detergent) general surfaces and fittings when visibly soiled and immediately after spillage.[5, 8] Expert opinion

guidance advises that a detergent should be applied before using a disinfectant (four SIGN 50 level 4)[4, 8, 12, 13] or in a combined detergent and disinfectant product (four SIGN 50 level 4)[4, 8, 9, 12] however, it is unclear what evidence informed this recommendation.

Disinfectants

Disinfectants are described by APSIC as being used for disinfection, and not for general cleaning.[4] As detailed in research question two "What is environmental decontamination?", disinfectants act to reduce the number of viable microorganisms on surfaces to a level that is unlikely to cause infection. Some examples of active ingredients commonly used as disinfectants include chlorine, phenolics, iodophors and alcohols.[4, 6] Five guidance documents (SIGN 50 level 4) advise that disinfectants should be 'hospital grade' for health and care settings, dependent on country-specific legislation.[4, 6-9] In the UK, the BS EN Standards set out the antimicrobial requirements for surface disinfectants used in medical areas (see research question five "Are there any legislative requirements or standards that should be adhered to when undertaking environmental decontamination?" and Appendix 5 of standards).

When to use a disinfectant product for environmental decontamination

There is some inconsistency in the evidence regarding routine disinfection of specific surfaces. The care homes NCSS (SHFN 01-05) recommends the use of a disinfectant, specifically a chlorine-releasing agent at 1,000ppm, for the routine disinfection of sanitary fixtures and fittings.[35] However, the more recently published NCSS (SHFN 01-02) does not recommend chlorine-based products specifically, but rather refers to cleaning and disinfectant solutions more generally.[17] SIGN 50 level 4 guidance recommends routine or regular disinfection of frequently touched surfaces for 'emergency medical vehicles and equipment',[7] in cases of respiratory viral infections,[37] and in areas housing patients on contact or isolation precautions.[13] For surgical settings, two guidance advise that 'high touch' surfaces are disinfected between patients or operating room use.[12, 15]

Whereas, other than high-touch surfaces, extant guidance advises disinfection in the health and care environment in the following situations:

- during uncertainty about the nature of soiling on surfaces such as “blood or body substance contamination versus routine dust or dirt” [5] or when surfaces come into contact with blood or body fluids.[12]
- outbreak situations.[8, 9]
- for cases of infection or colonisation with an infectious agent that is known to survive in the environment[16] (specific examples were not provided).
- in the presence of norovirus,[8, 9] MDRO’s,[8, 14] including *Clostridioides difficile (C. difficile)*[4, 8, 9] and carbapenem-resistant gram-negative *Bacilli* colonisation or infection.[39]
- when undertaking isolation or terminal decontamination.[17]
- between patients in dentistry settings.[5]

How to use a detergent and/or disinfectant product for environmental decontamination

Seven guidance documents graded SIGN 50 level 4 specify that the method for using a detergent and/ or disinfectant depends on different factors which should be specified in the manufacturer’s instructions[4, 5, 7, 9, 13, 15, 38] or by ‘facility policy’.[5] The UK HSE states that this should include concentration, contact time, dose, surface type and pathogen-specific information.[6] The care homes NCSS (SHFN 01-05) specifies that fresh solutions of general-purpose neutral detergent in warm water should be used for routine cleaning (one SIGN 50 level 4).[35] There is lack of consistency regarding how regularly solutions should be changed. The NCSS advises changing cleaning and disinfection solution every 15 minutes or when moving on to carry out decontamination in a new location, as per manufacturer’s instructions (one SIGN 50 level 4).[17] While the CDC also recommend regularly changing disinfect solutions, they also recommend avoiding ‘double dipping’ used cloths.[5] Although this term is not defined, it is understood to refer to submersing used cleaning consumables back into the same solution after use.

Summary

The available guidance specifically recommends the use of detergents for routine cleaning. Disinfectants are advised for specific surfaces in the health and care environment and in cases of infection or colonisation. Extant guidance advises that

both cleaning agents and disinfectants are applied following manufacturer's instructions. There is a lack of primary evidence on when and how to use products for environmental decontamination in health and care settings and much of the included guidance is high-level and lacks detail for implementation.

3.1.8 How should blood and body fluid spillages be managed?

Ten documents were included for this research question, all graded SIGN 50 level 4 expert opinion.[4-6, 8, 10-13, 38, 40] Three documents were developed in the UK, [6, 11, 40] and one in Australia,[8] one in Asia Pacific region,[4] four in the USA[5, 10, 13, 38] and one by an international organisation (the WHO).[12] The guidance is applicable across all health and care settings, including surgical settings.[12] Evidence graded as SIGN 50 level 4 is subject to methodological and reporting limitations and is considered low quality due to lack of referencing to support evidence for recommendations which may be explained by the overall lack of primary evidence in the literature investigating the management of blood and body fluid spillages.

Five SIGN 50 level 4 guidance are consistent in advising that spills of blood and body fluids and areas that are visibly soiled with blood and body fluids are prioritised for decontamination,[4, 5, 8, 10, 13] while seven SIGN 50 level 4 guidance specify that spills of potentially infectious materials such as blood are decontaminated immediately. [4, 5, 8, 10-12, 38]

Local policy

Four SIGN 50 level 4 guidance documents state that health and care settings should have local policies[10, 11] that clearly state the recommended procedures, specifically including the type of product to use dependent on infectious material, volume and surface material.[6, 8, 11]

Products

Meanwhile, three SIGN 50 level 4 guidance specify the use of chlorine-based products for blood and body fluid spillages management, but do not provide justification for use of these products specifically.[4, 6, 10] The use of products with

specific label claims for human immunodeficiency viruses or hepatitis B virus are also recommended by the CDC and HICPAC.[10]

Use of personal protective equipment (PPE)

Five SIGN 50 level 4 guidance documents advise that appropriate PPE should be worn when managing blood and body fluid spillages. If the spillage is extensive or splashing is likely to occur while undertaking decontamination, additional PPE should be worn for example, eye and face protection.[4-6, 8, 10]

Waste management

Four SIGN 50 level 4 guidance documents recommend that contaminated materials after decontamination are discarded into the appropriate healthcare waste stream.[4, 6, 8, 10]

Spills management according to size

Five SIGN 50 level 4 guidance documents advise that the correct methods for decontamination of blood and body fluid spillages varies according to spill size (small or large):[4-6, 8, 10]

Small spills

There is inconsistency in two SIGN 50 level 4 guidance regarding classification of small spill size, with CDC guidance suggesting this is 10ml of blood[5] and Australian guidance advising this is 10cm in diameter.[8] Australian guidance recommends using an absorbent material,[8] whilst others advise using paper towels soaked in freshly prepared hypochlorite solution containing 10,000ppm[4, 6] or 500–615 ppm[10] in the first instance to wipe or soak up any blood or body fluids. While HSE state that the area should then be washed with water and detergent and allowed to dry,[6] not all guidance recommend a final clean with water and detergent,[4, 5] or in that order. For example, guidance from Australia recommends the use of absorbent material first, then detergent followed by sodium hypochlorite.[8]

Larger spills

Guidance from Australia defines larger spills as over 10cm in diameter.[8] Five SIGN 50 level 4 guidance advise using absorbent materials[5, 8, 10] to remove organic matter, for example via a clumping agent[8] or dichloroisocyanurate granules.[4, 6]

However, it is worth noting the Safety Action Notice published by NHS National Services Scotland regarding risk of death and severe harm from ingesting superabsorbent polymer gel granules.[40] These products should be prepared in accordance with the manufacturers' instructions and left for the required contact time[4, 6] before clearing up with disposable cloths, paper towels or dustpan. Three SIGN 50 level 4 guidance provide instructions for alternative management of spills using paper towels, with variation in the concentration of chlorine used to flood the paper towel (10,000ppm available chlorine[4, 6] or 5,000–6,150 ppm available chlorine)[10] and if the surface should be further decontaminated with disinfectant or detergent (three SIGN 50 level 4).[6, 8, 10] Two SIGN 50 level 4 guidance note that chlorine use on urine may promote the release of free chlorine from the treated area,[4, 6] and there is inconsistency in extant guidance on how to manage this risk. Guidance from APSIC[4] recommends avoiding use of chlorine on urine whereas the UK HSE[6] state that if this is used then ventilation of the area is necessary.

Summary

In summary, the extant guidance is consistent in the high-level management of blood and body fluids including undertaking immediate decontamination, application of appropriate PPE and waste disposal and the use of chlorine-based disinfectants for the management of blood spillages, regardless of spill size. There is inconsistency amongst extant guidance, particularly in the detailed methods related to product concentration, order of product use and using chlorine on urine-based contamination. However, the available evidence consistently recommends that health and care facilities have local policies detailing this. Due to the lack of primary evidence available for management of blood and body fluid spillages, superiority of specific methods could not be assessed. This was reflective in the included guidance which cited low quality studies or no reference to primary evidence supporting recommendations.

For information on decontamination of blood and body fluid on soft furnishings, see research question 12 "How should environmental decontamination equipment be managed and stored?".

3.1.9 What is the recommended frequency for environmental decontamination?

Fifteen pieces of evidence were included for this research question, 14 guidance documents graded SIGN 50 level 4 expert opinion,[4, 5, 8-15, 17, 35, 37, 38] and one guideline graded 'recommend with modifications' using the AGREE II tool.[16] Evidence graded as SIGN 50 level 4 is subject to methodological and reporting limitations. The included guidance and guideline was developed in the UK,[11, 16, 17, 35] Europe,[37] Australia,[8] Canada,[9] Asia Pacific region,[4] US[5, 10, 13-15, 38] and internationally (the WHO).[12] The guidance is applicable across all health and care settings, including surgical settings.[12, 15]

The NCSS (SHFN 01-02) provides an alphanumeric coding system and generic risk assessments for use by NHS Scotland Boards,[17] which advises that appropriate frequency of decontamination should be based on local risk assessment, consistent with three expert opinion guidance documents.[4, 8, 11] NCSS coding is based on specific areas within the health and care setting that require decontamination. While the care homes NCSS (SHFN 01-05) advises site analysis which considers risk and frequency of decontamination tasks may be adjusted "accordingly to achieve an acceptable quality output".[35] Three SIGN 50 level 4 guidance advise regular floor cleaning,[5, 10, 37] although what is meant by 'regular' is not defined.

Specific areas and scenarios were highlighted as requiring more frequent decontamination:

- Frequently touched surfaces (ten SIGN 50 level 4 guidance, including the NCSS).[4, 8-10, 12-15, 17, 38] Examples provided in extant guidance include light switches,[10] door knobs and surfaces in and around patient ensuite toilets[10, 13] such as taps, dispensers and toilets.[12]
- The patient zone (four SIGN 50 level 4 guidance).[9, 13, 14, 38]
- Areas where patients that are high-risk for HAIs are cared for (two SIGN 50 level 4 guidance)[4, 15] including operating rooms.[15]
- When there is contamination, or increased soiling or spillage (seven SIGN 50 level 4 guidance).[4, 5, 8, 10, 12, 13, 38]

- During outbreak situations[8, 9] including cases of MDRO's[14] and 'special pathogens' areas which were defined by the CDC and HICPAC as antibiotic-resistant gram-positive cocci, CDI, respiratory and enteric viruses in paediatric-care settings, Severe Acute Respiratory Syndrome (SARS) virus and Creutzfeldt-Jakob disease (four SIGN 50 level 4 guidance).[10]

Four SIGN 50 level 4 guidance including the NCSS (SHFN 01-02) do not recommend routine disinfection of the health and care environment.[4, 8, 17, 35] One guidance document from the CDC advises routine disinfection, however this document is outdated with references from pre-2000 that may not reflect current IPC practices.[5] Two SIGN 50 level 4 guidance (including the NCSS) and one guideline state that, along with scheduled decontamination, terminal and discharge decontamination should be undertaken upon patient transfer or discharge.[9, 16, 17] The NCSS also recommends that isolation rooms are decontaminated at least daily, and ambulances daily and weekly.[17]

Summary

Extant guidance consistently recommends frequent decontamination of frequently touched surfaces. There is a degree of variation in extant guidance regarding environmental decontamination frequency due to circumstances such as outbreaks, unexpected contamination, use of isolation rooms and discharge of patients. Therefore, extant guidance advises risk assessment to determine the frequency of decontamination to support local clinical need.

3.1.10 Are there specific requirements for the decontamination of soft furnishings?

In total, five pieces of evidence[6, 8, 10, 17, 35] were included for this research question. All five are guidance documents graded SIGN 50 level 4 expert. Guidance was developed in the UK,[6, 17, 35], US[10] and Australia.[8]

Guidance from the CDC and HICPAC, and NHS Scotland Assure (SHFN 01-05) consistently define soft furnishings as carpets, upholstered furniture and furnishing.[10, 35] The care homes NCSS (SHFN 01-05) provides further detail on specific types including "chairs, foot stools, couches and cushions" in relation to care

home settings specifically.[35] For carpets, all five SIGN 50 level 4 guidance, including the NCSS (SHFN 01-02), consistently recommend vacuuming or suction cleaning[8, 10, 17, 35] and use of wet vacuuming or carpet cleaning kits for effective decontamination.[6, 8, 35]

Blood and body fluid spillages

For areas where blood and body fluid spillages are common, the CDC and HSE advise that the use of carpet, upholstery and soft furnishings should be avoided.[6, 10] If decontamination is not possible, the CDC and HICPAC (2019) advise that the soft furnishing should be removed due to contamination risk[10] with the UK HSE specifying this is of particular note if the contamination is with suspected infectious materials.[6] There is variation in the available guidance regarding the products used for decontamination of soft furnishings, with two SIGN 50 level 4 guidance advising detergent use,[6, 8] followed by steam cleaning.[6] Use of a disinfectant such as sodium hypochlorite is not recommended in Australian guidance.[8]

Summary

To conclude, extant guidance for the decontamination of soft furnishing in health and care settings is low quality and lacks detail for implementation. This could be due to the absence of primary research on specific methods and products for decontamination of soft furnishings which may be due to the large variation in soft furnishings in health and care settings, and the need for following specific manufacturer's instructions when decontaminating specific materials and objects. This would not usually be found in the primary evidence base, and assessing individual manufacturer's instructions is out with the scope of the review. Therefore, it is not possible to conclude specific requirements for environmental decontamination of all soft furnishings in health and care settings.

3.1.11 Who has responsibility for ensuring the care environment is decontaminated appropriately?

Five pieces of evidence were included for this research question which includes one NHS health workforce directorate letter (HDL),[41] two guidance documents published by NHS Scotland Assure,[17, 35] and two UK developed guidance documents.[11, 42] All

five were graded SIGN 50 level 4 expert opinion due to the lack of a rigorous systematic methodology or reference to the evidence base.

The available guidance related to environmental decontamination responsibility is inconsistent in terminology related to specific job roles and staffing structures, due to the variation in health and care settings. HDL(2005)07[41] establishes that Senior Charge Nurses (SCNs) are responsible for ensuring safe working conditions within their clinical area, including all aspects of environmental cleanliness in NHS Scotland. This includes "authority to require local cleaning services to act on any problems identified". Similarly, guidance from the Royal College of Nursing (RCN) suggest overall responsibility lies with the ward or department manager.[11] The NCSS (SHFN 01-02) states the responsibilities of the different roles within domestic services and the importance of communication between teams (domestic team, nursing, or IPC), particularly in notification of an outbreak.[17] For care home settings, the care homes NCSS (SHFN 01-05) states that care home managers have overall responsibility for ensuring appropriate decontamination.[35] The HDL states that it is the responsibility of staff, visitors, patients and the public to report concerns about environmental cleanliness, and all staff should be trained and supported accordingly[41] consistent with four SIGN 50 level 4 guidance documents.[5, 11, 35, 42]

Summary

Responsibility for ensuring the care environment is decontaminated appropriately varies by health and care setting and specific staffing structures. Extant guidance suggests that this responsibility lies with SCNs, ward, department or care home managers depending on setting, although all staff should be appropriately trained and supported.

3.1.12 How should environmental decontamination equipment be managed and stored?

In total, six pieces of evidence were included for this research question. Two primary studies were included, both graded SIGN 50 level 3 – an experimental study from the US[43] and an outbreak study from the UK.[44] The remainder include two guidance documents published by NHS Scotland Assure,[17, 35] one UK developed guidance

document from the RCN[11] and one Australian guidance document,[8] graded SIGN 50 level 4 expert opinion, which is subject to methodological and reporting limitations.

Tembo *et al.* 2023 investigated the efficacy of an automated floor cleaner at removal of *Staphylococcus aureus* (*S. aureus*) from vinyl flooring in an experimental study. The authors reported on contamination of the equipment following floor cleaning – mean $\log_{10}$ densities of *S. aureus* were significantly higher in the wastewater compared to the basket and squeegee ($p<.001$). Contamination of the automated floor cleaner parts was significantly higher when neutral cleaner was used when compared with disinfectant products (hydrogen peroxide and quaternary ammonium compounds, $p<.05$).[43] Tembo *et al*. demonstrate contamination of equipment following environmental decontamination which varies by cleaning product used, indicating the potential for cross-transmission to other areas. However, the findings are limited to the make of floor cleaner, products and test strain investigated[43] so may not be generalisable to equipment used in Scottish health and care settings.

Benbow *et al.* described a multi-site outbreak of carbapenemase-producing Enterobacterales (CPE), with 12 patients identified over a period of three years.[44] Environmental sampling revealed CPE contamination of an electric floor scrubber used in the hospital's central food production unit and mop fibres used for toilets located close to the kitchen. PFGE analysis confirmed a match with the patient isolates. Although the authors' hypothesis that the floor scrubber had contaminated food preparation areas which then led to faeco-oral transmission of CPE could not be proven, following decommissioning and replacement of this equipment (amongst other control measures), no further cases were detected.[44] The new floor scrubber was sampled weekly to ensure it had not become re-contaminated. The findings of this study demonstrate that cleaning equipment may act as a reservoir for CPE in clinical settings.

Four of the included guidance documents address how decontamination equipment should be managed. Expert opinion guidance by the CDC addresses when to change mop heads – at the beginning of the day, or according to local policy.[5, 10] Guidance from Australia also notes the decontamination, with detergent and disinfectant, of environmental decontamination equipment in the presence of MDRO's.[8] Decontamination solutions (for example detergents and disinfectants) should be stored in locked facilities,[8] including in care homes.[8, 35]

Four SIGN 50 level 4 guidance documents, including the NCSS (SHFN 01-02), consistently advise that health and care settings have dedicated facilities (including carts)[8, 17] and that storage spaces and equipment be maintained to an appropriate standard of cleanliness[8, 11] (following manufacturer's instructions).[35]

The NCSS (SHFN 01-02)[17] and care homes NCSS (SHFN 01-05)[35] are specific for NHS Scotland health and care settings and provide detail on environmental decontamination equipment and storage. Both documents state that a colour coding system (red, blue, green and yellow) should be used for management and storage of reusable cleaning materials. It is understood that the different colours are used to separate cleaning equipment for use in different areas, to ensure that only specific equipment is used in high-risk areas, therefore minimising the risk of cross-contamination between high and low risk spaces.

Summary

In summary, the available guidance suggests that environmental decontamination equipment (including detergent and disinfectants) require dedicated storage facilities or spaces in health and care settings and that both equipment and storage spaces should be appropriately decontaminated. Much of the available evidence is low quality, expert opinion and lacks sufficient detail for implementation.

3.2 Implications for research

This systematic literature review has highlighted significant limitations in the available evidence related to environmental decontamination (including management of blood and body fluid spillages). Most of the evidence in this review is derived from guidance which is not evidence-based and the rationale behind expert opinion-based recommendations is not detailed. However, it is apparent that there is a lack of robust primary evidence related to all areas of environmental decontamination. Further research is needed investigating the risk of HAI from the health and care environment, particularly focussing on study types that provide reliable evidence of an epidemiological linkage between a source and case. Similarly, more high-quality research is required to ascertain the most appropriate methods (techniques) for decontamination of the health and care environment, including for blood and body

fluid spillages, particularly in real-world clinical settings. This review has emphasised the need for correct terminology to be consistently applied across guidance and in practice when referring to environmental decontamination levels and types.

Primary studies investigating detergent and disinfectant efficacy were considered for inclusion, but several limitations exist within this body of literature. In vitro studies are inherently limited in their methodologies which impacts their applicability and transferability to NHS Scotland health and care settings, particularly due to heterogeneity in active ingredient, contact or exposure times, dose, formulations, and type or strain of pathogen investigated in the studies. Similar inconsistencies are apparent with in-vivo studies, including variation or lack of detail in the decontamination method used (for example, missing protocols for direct comparability) and sampling methods used to recover the test organism from surfaces. The evidence base for product efficacy was as follows:

- Two studies demonstrated efficacy of detergents against *C. difficile* spores[36] and *S. aureus*.[43] However, in both these studies, detergent alone was reportedly less effective than disinfectant products.
- There was a breadth of experimental and laboratory studies supporting efficacy of chlorine-based disinfectants against the following: CDI,[36, 45-50] *S. aureus*,[51-54] MRSA,[53] *Klebsiella spp.*,[51, 54, 55], *Escherichia coli,*[51, 54] *Pseudomonas aeruginosa*,[51, 54] *Bacillus subtilis (B. subtilis),*[46] *Clostridium sporogenes (C. sporogenes),*[46] *Candida spp.*,[52] *Serratia marcescens (S. marcescens), Acinetobacter baumannii (A. baumannii)* and *Achromobacter xylosoxidans,*[55] influenza H1N1,[56] gastroenteritis virus,[57] coronavirus,[58] poliovirus types[59, 60] and adenoviruses[55, 61] The large number of primary studies evidencing the antimicrobial activity of chlorine-based products, and less so for the other discussed active ingredients, indicates potential reporting bias, and more evidence is needed on the efficacy of combined detergent and disinfectant products. Laboratory studies were identified that also evidenced efficacy of alcohol-based disinfectants against viruses (H1N1,[56] gastroenteritis virus, coronaviruses,[58] adenovirus eight,[61] and vaccina virus[60]), bacteria (MRSA,[52] *S. marcescens, Klebsiella spp.*,

A. baumannii and *Achromobacter xylosoxidans*.[55]) and fungi (*Candida spp*.[52]).

- There were three laboratory studies, one experimental study and one before-after study that demonstrated the efficacy of quaternary ammonium-based products against *C. difficile*,[48] MRSA,[52] MSSA,[53] *S. aureus*,[43, 62] vancomycin-resistant *Enterococcus* (VRE) and multidrug-resistant *A. baumannii*.[62] However, one study reported that a quaternary ammonium-based product was minimally effective against *Candida spp.*.[52]
- Alternative disinfectants also investigated in primary evidence which were considered for inclusion include peracetic acid which demonstrated microbiological efficacy against *C. difficile*,[49] *Candida spp.*,[52] MRSA,[52] Adenovirus five and eight,[60, 61] Poliovirus type 1 and Vaccinia virus;[60] hydrogen peroxide with antimicrobial properties against *Candida spp.*,[52] MRSA,[52] *C. difficile*, *B. subtilis*, *C. sporogenes*,[46] *S. aureus*,[43, 62] VRE and multidrug-resistant *A. baumannii*[62] and Adenovirus eight (under 3 log)[62]; and benzalkonium chloride with efficacy against SARS-CoV.[63]

However, only three of these studies followed a BS EN standard in their methodologies demonstrating efficacy of disinfectants against *C. difficile*,[36] a range of gram-negative bacteria (*S. marcescens, Klebsiella pneumoniae, Klebsiella oxytoca, A. baumannii* and *Achromobacter xylosoxidans*)[55] and viruses (poliovirus, adenovirus and vaccinia virus).[60] Evidence using a standard methodology as demonstrated in the BS EN standards would allow for greater synthesis of the evidence base due to comparable methods and findings related to active ingredient, and would allow for more robust recommendations regarding minimum microbiological requirements for surface disinfection products (see research question five “Are there any legislative requirements or standards that should be adhered to when undertaking environmental decontamination?” for further information).

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health care facilities. Antimicrobial agents and chemotherapy 2006; 50: 1419-1424.

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Appendix 1: Search strategy

Medline

1. exp Bodily Secretions/
2. exp Body Fluids/
3. Feces/
4. Amniotic Fluid/
5. (blood or bloodstained or f?eces or diarrh?ea or urine or bile or human milk or breastmilk or breast-milk or vomit or cerebrospinal fluid or pleural fluid or peritoneal fluid or pericardial fluid or synovial fluid or semen or amniotic fluid or vaginal secretion* or body fluid* or bodily fluid* or bodily secretion*).ti,ab,kf.
6. 1 or 2 or 3 or 4 or 5
7. (spill or spills or spillage or spillages or spilled or splash or splashes or splashing or splashed).ti,ab,kf.
8. 6 and 7
9. exp *Disease Transmission, Infectious/
10. *Cross Infection/
11. *Communicable Disease Control/
12. Infection Control/
13. (cross infection or healthcare associated or health care associated or hospital acquired or hospital onset).ti,kf.
14. 9 or 10 or 11 or 12 or 13
15. (environment* adj3 contamina*).ti,ab,kf.
16. (environment* adj3 decontamina*).ti,ab,kf.
17. (environment* adj3 disinfect*).ti,ab,kf.
18. (environment* adj3 steril*).ti,ab,kf.

19. (environment* adj3 clean*).ti,ab,kf.
20. (surface* adj3 contamina*).ti,ab,kf.
21. (surface* adj3 decontamina*).ti,ab,kf.
22. (surface* adj3 disinfect*).ti,ab,kf.
23. (surface* adj3 clean*).ti,ab,kf.
24. (enhanced adj3 clean*).ti,ab,kf.
25. (deep adj3 clean*).ti,ab,kf.
26. (terminal adj3 clean*).ti,ab,kf.
27. (terminal adj3 disinfect*).ti,ab,kf.
28. *Decontamination/
29. exp *Surface-Active Agents/
30. exp *Sterilization/
31. *Housekeeping, Hospital/
32. 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31
33. 8 and 14
34. 8 and 32
35. 14 and 32
36. 33 or 34 or 35
37. limit 36 to (english language and yr="2000 -Current")

Embase

1. exp bodily secretions/
2. exp body fluid/
3. feces/
4. amnion fluid/
5. (blood or bloodstained or f?eces or diarrh?ea or urine or bile or human milk or breastmilk or breast-milk or vomit or cerebrospinal fluid or pleural fluid or peritoneal fluid or pericardial fluid or synovial fluid or semen or amniotic fluid or vaginal secretion* or body fluid* or bodily fluid* or bodily secretion*).ti,ab,kf.
6. 1 or 2 or 3 or 4 or 5
7. (spill or spills or spillage or spillages or spilled or splash or splashes or splashing or splashed).ti,ab,kf.
8. 6 and 7
9. exp *Disease Transmission, Infectious/
10. *Cross Infection/
11. *Communicable Disease Control/
12. Infection Control/
13. (cross infection or healthcare associated or health care associated or hospital acquired or hospital onset).ti,kf.
14. 9 or 10 or 11 or 12 or 13
15. (environment* adj3 contamina*).ti,ab,kf.
16. (environment* adj3 decontamina*).ti,ab,kf.
17. (environment* adj3 disinfect*).ti,ab,kf.
18. (environment* adj3 steril*).ti,ab,kf.
19. (environment* adj3 clean*).ti,ab,kf.

20. (surface* adj3 contamina*).ti,ab,kf.
21. (surface* adj3 decontamina*).ti,ab,kf.
22. (surface* adj3 disinfect*).ti,ab,kf.
23. (surface* adj3 clean*).ti,ab,kf.
24. (enhanced adj3 clean*).ti,ab,kf.
25. (deep adj3 clean*).ti,ab,kf.
26. (terminal adj3 clean*).ti,ab,kf.
27. (terminal adj3 disinfect*).ti,ab,kf.
28. *decontamination/
29. exp *surfactant/
30. exp *disinfection/
31. *hospital service/
32. 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31
33. 8 and 14
34. 8 and 32
35. 14 and 32
36. 33 or 34 or 35
37. limit 36 to (english language and yr="2000 -Current")

CINAHL

S1 (MH "Body Fluids+")

S2 (MH "Secretions+")

S3 (MH "Feces")

S4 (MH "Amniotic Fluid")

S5 TI (blood or bloodstained or f#eces or diarrh#ea or urine or bile or human milk or breastmilk or breast-milk or vomit or cerebrospinal fluid or pleural fluid or peritoneal fluid or pericardial fluid or synovial fluid or semen or amniotic fluid or vaginal secretion* or body fluid* or bodily fluid* or bodily secretion*) OR AB (blood or bloodstained or f#eces or diarrh#ea or urine or bile or human milk or breastmilk or breast-milk or vomit or cerebrospinal fluid or pleural fluid or peritoneal fluid or pericardial fluid or synovial fluid or semen or amniotic fluid or vaginal secretion* or body fluid* or bodily fluid* or bodily secretion*) OR SU (blood or bloodstained or f#eces or diarrh#ea or urine or bile or human milk or breastmilk or breast-milk or vomit or cerebrospinal fluid or pleural fluid or peritoneal fluid or pericardial fluid or synovial fluid or semen or amniotic fluid or vaginal secretion* or body fluid* or bodily fluid* or bodily secretion*)

S6 S1 OR S2 OR S3 OR S4 OR S5

S7 TI (spill or spills or spillage or spillages or spilled or splash or splashes or splashing or splashed) OR SU (spill or spills or spillage or spillages or spilled or splash or splashes or splashing or splashed) OR AB (spill or spills or spillage or spillages or spilled or splash or splashes or splashing or splashed)

S8 S6 AND S7

S9 (MM "Disease Transmission")

S10 (MM "Cross Infection")

S11 TI (cross infection or healthcare associated or health care associated or hospital acquired or hospital onset) OR SU (cross infection or healthcare associated or health care associated or hospital acquired or hospital onset

S12 (MM "Infection Control")

S13 S9 OR S10 OR S11 OR S12

S14 TI (environment* N2 contamina*) OR AB (environment* N2 contamina*) OR SU (environment* N2 contamina*)

S15 TI (environment* N2 decontamina*) OR AB (environment* N2 decontamina*) OR SU (environment* N2 decontamina*)

S16 TI (environment* N2 disinfect*) OR AB (environment* N2 disinfect*) OR SU (environment* N2 disinfect*)

S17 TI (environment* N2 steril*) OR AB (environment* N2 steril*) OR SU (environment* N2 steril*) OR TI (environment* N2 clean*) OR AB (environment* N2 clean*) OR SU (environment* N2 clean*)

S18 TI (surface* N2 contamina*) OR AB (surface* N2 contamina*) OR SU (surface* N2 contamina*)

S19 TI (surface* N2 decontamina*) OR AB (surface* N2 decontamina*) OR SU (surface* N2 decontamina*)

S20 TI (surface* N2 disinfect*) OR AB (surface* N2 disinfect*) OR SU (surface* N2 disinfect*)

S21 TI (surface* N2 steril*) OR AB (surface* N2 steril*) OR SU (surface* N2 steril*) OR TI (surface* N2 clean*) OR AB (surface* N2 clean*) OR SU (surface* N2 clean*)

S22 TI (enhanced N2 clean*) OR AB (enhanced N2 clean*) OR SU (enhanced N2 clean*)

S23 TI (deep N2 clean*) OR AB (deep N2 clean*) OR SU (deep N2 clean*)

S24 TI (terminal N2 clean*) OR AB (terminal N2 clean*) OR SU (terminal N2 clean*)

S25 TI (terminal N2 disinfect*) OR AB (terminal N2 disinfect*) OR SU (terminal N2 disinfect*)

S26 (MM "Sterilization and Disinfection")

S27 (MM "Surface-Active Agents")

S28 (MM "Housekeeping Department")

S29 S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28

S30 S8 AND S13

S31 S8 AND S29

S32 S13 AND S29

S33 S30 OR S31 OR S32

Limiters - Publication Date: 20000101-20240231; English Language

Appendix 2: Evidence Levels

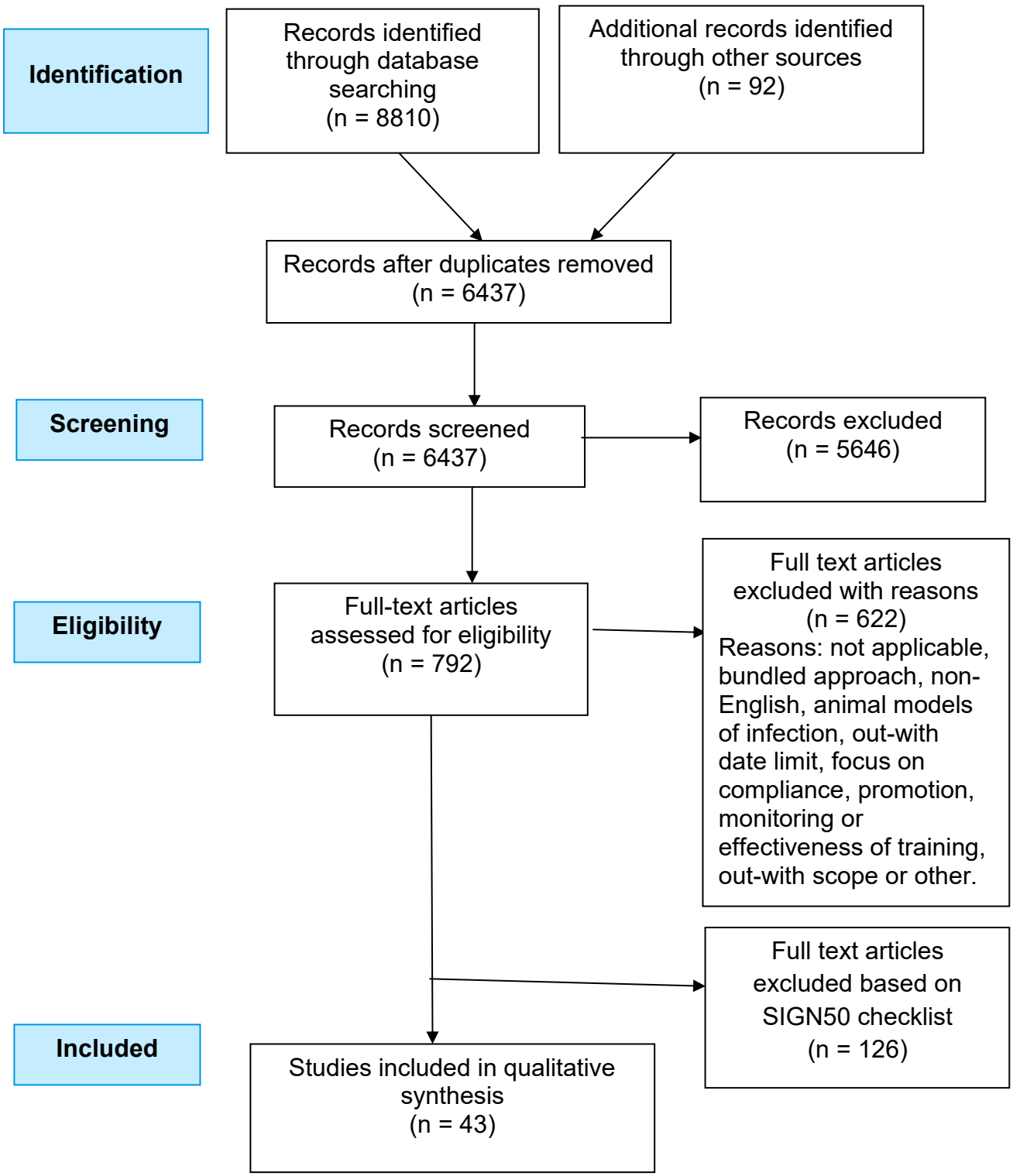
SIGN 50 Evidence Levels

Grade	Description
1++	High quality meta analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias
1+	Well conducted meta analyses, systematic reviews of RCTs, or RCTs with a low risk of bias
1-	Meta analyses, systematic reviews of RCTs, or RCTs with a high risk of bias
2++	High quality systematic reviews of case-control or cohort studies. High quality case-control or cohort studies with a very low risk of confounding, bias, or chance and a high probability that the relationship is causal
2+	Well conducted case control or cohort studies with a low risk of confounding, bias, or chance and a moderate probability that the relationship is causal
2-	Case control or cohort studies with a high risk of confounding, bias, or chance and a significant risk that the relationship is not causal
3	Non-analytic studies, for example case reports, case series
4	Expert opinion

AGREE II Evidence Levels

Grade	Description
AGREE 'Recommend'	This indicates that the guideline is of high overall quality and can be considered for use in practice without modifications.
AGREE 'Recommend with modifications'	This indicates that the guideline is of moderate overall quality. This could be due to insufficient or lacking information in the guideline for some items. If modifications are made, the guideline could still be considered for use in practice when no other guidelines on the same topic are available.
AGREE 'Do not Recommend'	This indicates that the guideline is of low overall quality and has serious shortcomings. Therefore, it should not be recommended for use in practice.

Appendix 3: PRISMA flow diagram



Appendix 4: Studies excluded following critical appraisal

The following studies were excluded during critical appraisal based on their limitations:

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Appendix 5: Standards pertaining to environmental decontamination in health and care settings

BS EN Standards for surface disinfectants in the medical area (from BS EN 14885:2022). The standards listed represent the most recent versions available at the time of publication. Please note, however, standards are subject to amendments and the most recent versions should always be sourced and used in practice.

Standard	Title	Description	Test pathogen (s)
BS EN 13727:2012+A2:2 0 15	Chemical disinfectants and antiseptics. Quantitative suspension test for the evaluation of bactericidal activity in the medical area - Test method and requirements (phase 2, step 1)	Standard applies to chemical disinfectant and antiseptic products used in the medical area for disinfection of surfaces by wiping, spraying, flooding or other means.	*Pseudomonas aeruginosa* *Staphylococcus aureus* *Enterococcus hirae*
BS EN 17387:2021	Chemical disinfectants and antiseptics. Quantitative test for the evaluation of bactericidal and yeasticidal and/or fungicidal activity of chemical disinfectants in the medical area on non-porous surfaces without mechanical action.	Standard applies to chemical disinfectant products used in the medical area for disinfection of non-porous surfaces without mechanical action.	*S. aureus* *Enterococcus hirae* *Pseudomonas aeruginosa* *Candida albicans* *Aspergillus niger/ Aspergillus brasiliensis*

Standard	Title	Description	Test pathogen (s)
	Test method and requirements (phase 2, step 2)		
BS EN 13624:2021	Chemical disinfectants and antiseptics. Quantitative suspension test for the evaluation of fungicidal or yeasticidal activity in the medical area. Test method and requirements (phase 2, step 1)	Standard applies to chemical disinfectant and antiseptic products used in the medical area for disinfection of surfaces by wiping, spraying, flooding or other means.	*Candida albicans* Or *Candida albicans* and *Aspergillus brasiliensis*
BS EN 14348:2005	Chemical disinfectants and antiseptics. Quantitative suspension test for the evaluation of mycobactericidal activity of chemical disinfectants in the medical area including instrument disinfectants. Test methods and requirements (phase 2, step1)	Standard applies to chemical disinfectant products used in the medical area.	*Mycobacterium terrae* or *Mycobacterium avium* and *Mycobacterium terrae*
BS EN 14476:2013+A2-2019	Chemical disinfectants and antiseptics. Quantitative suspension test for the evaluation of virucidal activity in the medical area. Test method and requirements (Phase 2/ Step 1)	Standard applies to chemical disinfectant and antiseptic products used in the medical area for disinfection of surfaces (by wiping, spraying, flooding or other means) and textiles.	Poliovirus Adenovirus Vacciniavirus Murine norovirus Murine parvovirus

Standard	Title	Description	Test pathogen (s)
BS EN 16777:2018	Chemical disinfectants and antiseptics. Quantitative non-porous surface test without mechanical action for the evaluation of virucidal activity of chemical disinfectants used in the medical area. Test method and requirements (phase 2/ step 2)	Standard applies to chemical disinfectant and antiseptic products used in the medical area for disinfection of non-porous surfaces.	Adenovirus Murine norovirus Vacciniavirus
BS EN 16615:2015	Chemical disinfectants and antiseptics. Quantitative test method for the evaluation of bactericidal and yeasticidal activity on non-porous surfaces with mechanical action employing wipes in the medical area (4- field test). Test method and requirements (phase 2, step 2)	Standard applies to chemical disinfectant products used in the medical area for disinfection of non-porous surfaces by wiping.	*Enterococcus hirae* *Pseudomonas aeruginosa* *Staphylococcus aureus* *Candida albicans*
BS EN 17126:2018	Chemical disinfectants and antiseptics. Quantitative suspension test for the evaluation of sporicidal activity of chemical disinfectants in the medical area. Test method and requirements (phase 2, step 1)	Standard applies to chemical disinfectant products used in the medical area for disinfection of surfaces by wiping, spraying, flooding or other means.	*Bacillus subtilis* *Bacillus cereus* *Clostridium difficile*