NHS National Services Scotland

Literature review: Safe Management of Linen

Version 4.0

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ARHAI Scotland

Antimicrobial Resistance and Healthcare Associated Infection

Contents

Key Information

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Document information	Description
Description:	This literature review examines the available professional literature on the Safe Management of Linen.
Purpose:	To inform the recommendations for the safe management of linen in the National Infection Prevention and Control Manual and Care Home Infection Prevention and Control Manual to facilitate the prevention and control of healthcare-associated infections in NHSScotland health and care settings.
Target Audience:	All staff involved in the prevention and control of infection in Scotland.
Update/review schedule:	Updated as new evidence emerges with changes made to recommendations as required. The review will be formally updated every 3 years, with the next review in (2027).
Cross-reference:	**National Infection Prevention and Control Manual** **Care Home Infection Prevention and Control Manual**
Update level:	Practice – The implications for practice are formulated based on a review of the available professional scientific literature on the infection prevention and control (IPC) aspects/impacts of linen management. Research – The implications for research are formulated based on a review of the available professional, scientific literature on the infection

Document information	Description
	prevention and control (IPC) aspects/impacts of linen management.

Contact

ARHAI Scotland Infection Control team:

Telephone: 0141 300 1175

Email: **NSS.ARHAIinfectioncontrol@nhs.scot**

Version history

This literature review will be updated in real time if any significant changes are found in the professional literature or from national guidance/policy.

Version	Date	Summary of changes
1.0	January 2012	Final for publication
2.0	October 2016	No change to recommendations, minor changes to text for clarity.
2.1	October 2017	Additional change to recommendation to include detergent in laundering process and update of Department of Health reference to latest version.
3.0	September 2020	Update of the literature review. • Objectives separated into SICPs and TBPs The question set was reviewed, and the following objectives added: • What is the definition of linen in health and care settings? • Is there any guidance/information for carers regarding washing used/infectious personal clothing at home?
4.0	January 2025	Three-year update of the literature review • Updated using a new methodology as outlined in the development process. • Databases were searched for evidence published between 2000 and 2023. • Search strategies added as Appendix 2. The question set was reviewed, and the following research questions were added. • How should used linen be safely handled? • What is the risk of infection transmission associated with linen in health and care settings?

Version	Date	Summary of changes
		• What is the available evidence for the effectiveness of antimicrobial-impregnated linen in reducing the risk of micro-organism transmission? • What is the available evidence on post-laundry disinfection of linen in healthcare? • When is linen deemed unfit for reuse? • How should linen deemed unfit for reuse be safely disposed? • How should curtains be put up and taken down to minimise transmission of infection? The following questions were modified from the previous review. • What is the available evidence/guidance on products or methods for effective laundering of linen? (Modification: The term ‘or methods’ was added) • How should beds be stripped or made to minimise risk of infection transmission? (Modification: The latter part of the question ‘to minimise risk of infection transmission’ was added to show the reason for interest in the question)

Approvals

Version	Date Approved	Name
1.0	January 2012	Steering (Expert Advisory) Group for SICPs and TBPs
2.0	October 2016	NPGO Steering Group
2.1	October 2017	NPGO Steering Group

Version	Date Approved	Name
3.0	September 2020	NPGO Steering Group
4.0	January 2025	National Policy Guidance and Evidence Working Group (NPGE)
		Care Home Infection Prevention and Control Working Group (CHIPC)
		Linen Services Expert Group (LSEG)

1. Objectives

The aim is to review the extant scientific literature regarding the safe management of linen in health and care settings to inform evidence-based recommendations for practice. The specific research questions of the review are provided below:

1. What is the definition of linen in health and care settings?
2. What are the legislative/mandatory requirements for the safe handling of linen?
3. How should linen be categorised?
4. What is the available evidence on products or methods for effective laundering of linen?
5. How should beds be stripped/made to minimise risk of infection transmission?
6. How should clean linen be safely handled?
7. How should clean linen be stored?
8. How should clean linen be transported?
9. How should used linen be safely handled?
10. How should used linen be sorted?
11. How should used linen be labelled?
12. How should used linen be stored?
13. How should used linen be transported?
14. Is there any specific evidence on the effective laundering of uniforms/scrubs?
15. Is there any evidence regarding washing used/infectious personal clothing at home?
16. What is the risk of infection transmission associated with linen in health and care settings?
17. How should infectious linen be safely handled?
18. How should infectious linen be sorted?
19. How should infectious linen be labelled?
20. How should infectious linen be stored?

21. How should infectious linen be transported?
22. What is the available evidence for the effectiveness of antimicrobial-impregnated linen in reducing healthcare-associated infection?
23. What is the available guidance on post-laundry disinfection for linen in healthcare?
24. When is linen deemed unfit for reuse?
25. How should linen deemed unfit for reuse be safely disposed?
26. How should curtains be put up and taken down to minimise transmission of infection?

2. Methodology

This targeted literature review was produced using a defined systematic methodology described in the National Infection Prevention and Control Manual: Development Process. The complete search strategy is provided in **Appendix 1**.

In addition to the exclusion criteria outlined in the **NIPCM: Development Process,** the following exclusion criteria were used in this review. Studies were excluded if they:

- reported impact of antimicrobial-impregnated linen on linen contamination but not HAI transmission
- included antimicrobial-impregnated hard surfaces in addition to antimicrobial-impregnated linen
- reported an outbreak without a strong link to linen evidenced by epidemiological typing or as a minimum, isolation of the same species of organism from both patient and environmental samples. An exception to this is outbreaks involving a rare infectious agent, where it can be reasonably deduced that exposure to the infectious agent via another source is not probable.

Definitions for grades of evidence are provided in **Appendix 2**. A PRISMA flowchart is presented in **Appendix 3**. Adapted from: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009).[1]

3. Discussion

3.1 Implications for practice

3.1.1 What is the definition of linen in health and care settings?

Four pieces of evidence were included to answer this question. Three of these were added for this update[2-4] and one document was carried over from the previous version of this review.[5] All were expert opinion guidance documents and graded as SIGN50 Level 4. Two each, of these were from the United Kingdom (UK)[4, 5] and the United States (US).[2, 3]

Within the body of evidence, linen was generally and consistently defined as 'reusable textile items that require appropriate cleaning or decontamination between uses'. [2, 4, 5] The terms 'textiles' and 'laundry' were also used to refer to linen.[2, 3]

Several examples of linen were provided. They include bed linen (blankets, bed sheets, cot sheets, counterpanes, pillowcases, duvets, duvet covers), canvases, curtains, hoist slings, patient clothing (including gowns, nightdresses, shirts, pyjama tops and bottoms), staff clothing (coats, scrub suits, tabards, uniforms), towels, and drapes for surgical procedures.[2-5]

3.1.2 Are there any legislative/mandatory requirements or standards for the safe handling and processing of linen?

Twelve pieces of evidence were included for this research question, all of which were added for this update of the review.[6-17]

Three were UK legislations graded as SIGN50 'Mandatory',[14-16] and one was a Scottish Government Directors Letter (DL) also graded SIGN50 'Mandatory'.[17]

Eight British standards were included and were graded SIGN50 Level 4.[6-13]

Legislation

The three pieces of legislation identified for this question are the Control of Substances Hazardous to Health Regulations 2002 (COSHH),[14] the Personal Protective Equipment at Work Regulations 1992[15] and the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2000.[16] They were neither specific to health and care settings nor particular to linen management. However, they provide general regulations on the protection of employees (as well as the public), from hazards to which they could be exposed in the course of their work, and this can be applied to the processes involved in the management of linen.

The Control of Substances Hazardous to Health Regulations 2002 (COSHH) provides regulation on the protection of employees from exposure to hazardous substances in the workplace. The document also provides regulations for training/instructing employees, procedures for dealing with accidents and emergencies and health surveillance for employees in relation to exposure to hazardous substances at work.[14] Substances hazardous to health include infectious agents which may be contained in used/infectious linen and to which a person handling linen may be exposed.

The Personal Protective Equipment at Work Regulations 1992 provides regulations for the provision of appropriate and suitable PPE to employees who are exposed to health or safety risks in the course of their work. This legislation also provides regulations on assessment, maintenance, storage of and training on the use of PPE.[15]

The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (also called the Carriage Regulations) although not specific to linen is applicable when heavily soiled infectious linen that contains infectious agents thought to pose a significant risk of disease transmission has to be transported to offsite laundries.[16]

Other mandatory documents

A Directors Letter (DL) from the Scottish Government was the only mandatory document identified that had provisions specific to linen management in health and care settings.[17] The document sets out the policy on uniform laundering for health

and care staff. It categorises uniforms into two groups for laundry purposes – used uniforms and contaminated uniforms, and provides guidance on how both categories should be laundered.[17]

Standards

Only three of the standards identified are specific for linen.[6, 8, 13] BS EN 14065:2016[6] provides specifications on risk and process management for linen while BS EN ISO 20743:2021[8] is focused on evaluating the antibacterial activity of antimicrobial-impregnated/treated linen products. BS EN 16616:2022 provides specifications for the evaluation of the microbicidal activity of processes of disinfection of contaminated linen.[13] The other standards provide specifications for the evaluation of disinfectants including those used in healthcare laundries.[7, 9-12] Further details on the standards are provided in **Appendix 4**.

At the time of writing, these discussed 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 the management of linen.

Conclusion

In summary, no specific legislative requirements for the management of linen in health and care settings were identified. However, there is legislation covering the general protection of employees from exposure to hazardous substances in the workplace, which can be applied to the safe management of linen. One Scottish Government DL was identified that provides specific regulations for the laundering of uniforms.

3.1.3 How should linen be categorised?

In total, 10 pieces of evidence were included to answer this research question. Nine of these were added for this update,[2, 4, 5, 17-22] with one carried over from the last version of this review.[23] Of this evidence, eight were expert opinion guidance documents graded SIGN50 Level 4. Four of these were published in the UK,[4, 5, 22, 23] two in Ireland, [20] one in the US,[2] and two internationally.[18, 19]

One guideline from Ireland, graded AGREE: 'Recommend with modifications', was included.[21] Although this guideline was based on a systematic review, the link between evidence and recommendation was sometimes unclear.

One Scottish Government DL was included and graded 'mandatory'.[17] This document is specific to uniforms.

No primary studies were included for this research question.

Linen is generally classified into four main categories – 'clean', 'used', 'infectious' and 'heat labile'.

Clean linen

Although only three pieces of evidence provide any information on this category of linen, there was consistency in the definition albeit from two perspectives. Two pieces of evidence, including one specific for social care, define it from a process perspective – as linen washed and ready for use.[22, 23] The third piece of evidence defines it from an outcome perspective as 'hygienically clean' – that is a clean state, without infectious agents in sufficient numbers to increase the risk of infection.[2]

Used linen

This category was identified in seven pieces of evidence.[4, 5, 17-19, 22, 23] Within healthcare settings, the definitions of this category were generally consistent. Used linen was generally defined as linen that has been used but without visible soiling or contamination by blood or body fluids.[17-19, 22, 23] However, in one piece of evidence, soiled and fouled linen was included in this category provided it had not been used for care of a patient known or suspected to be infectious.[5] Guidance published by the UK Department of Health specific to social care settings categorised used linen as requiring a 'standard process' – a category that includes used linen regardless of the level of soiling as long as there is no suspicion of infection.[4]

Infectious linen

There was variation in how this category was defined within the evidence base, and the terminologies used to describe it. Linen was generally described as infectious if it met either or both of two criteria, namely:

- soiling with blood or body fluids, or

- use in the care of infectious patients

Two documents describe infectious linen only with regards to soiling and did not consider the latter criteria.[2, 18] One of these is World Health Organization (WHO) expert opinion guidance which describes two categories of linen that have been used: linen soiled with blood, body fluids or other excretions which it calls ‘soiled or contaminated’ and ‘used linen’ which is linen that is not soiled.[18]

In contrast, in the UK Health Technical Memorandum (HTM) 01-04, soiled linen is classified as part of ‘used linen’ and is considered infectious only if the linen was used in the care of an infectious patient or a patient with diarrhoea.[4, 5]

An expert opinion guidance document published by the International Federation of Infection Control (IFIC) which was graded SIGN50 Level 4, places soiled linen in a separate category from used linen (which it defines as linen not visibly soiled) and infectious linen (which it describes as linen used in the care of infectious patients even if not visibly soiled).[19] This document also adds an extra category called ‘infested linen’, which is used to describe linen used in the provision of care for patients infested with parasites such as lice, fleas, scabies and bedbugs.[19]

Some documents, however, define infectious linen as those that meet either or both criteria.[17, 21-23] These include two Scottish documents – one graded SIGN50 mandatory[17] and the other graded SIGN50 Level 4.[23] Within these documents, infectious linen is broadly described as linen used in the care of patients or residents confirmed or suspected to be infectious, or linen soiled with blood or other body fluids for example, faeces. It is important to note that infections as described in these categorisations refer to highly infectious agents including varicella zoster, blood-borne viruses, cholera, dysentery, enteric fever, anthrax, plague, Ebola fever, Lassa fever, Marburg fever, smallpox, Severe acute respiratory syndrome (SARS) or other conditions specified by local policy.[5]

Guidance by the UK Department of Health, specific to social care, (graded SIGN50 Level 4) describes infectious linen as those requiring an enhanced process and defines this category as those used in cases where triggers of potential infectiousness are present. The triggers provided by this document include unexplained diarrhoea and vomiting, unexplained rashes, confirmed infection, unexplained fever and confirmed cases of scabies and lice.[4]

Heat labile linen

There was consistency between the two pieces of evidence within this category. Heat labile linen was broadly defined as linen – whether used or infectious, that will be damaged by thermal disinfection.[5, 23] Such damages include shrinkage and stretching.[23] Scottish Guidance for Safe Management of Linen, published by the (then) Health Protection Scotland in collaboration with Health Facilities Scotland (graded SIGN50 Level 4) provides 40°C as the maximum temperature above which heat labile linen risks being damaged.[23]

Conclusion

In summary, linen was found to be categorised into four major groups within the evidence identified. These groups are ‘clean’, ‘used’, ‘infectious’ and ‘heat-labile’. There was inconsistency in the way soiled linen was classified. They were categorised as ‘used’ or ‘infectious’ linen or placed in a separate category.

3.1.4 What is the available evidence on products or methods for effective laundering of linen?

In total, 17 pieces of evidence were included for this research question. Fourteen of these were added for this update[3, 4, 18, 19, 22, 24-32] while three were carried over from the previous version of this review.[5, 23, 33]

One guidance document graded AGREE: ‘Recommend with modifications’ was included. Although this guideline was based on a systematic review, the link between evidence and recommendation was sometimes unclear.[30]

Three experimental studies graded SIGN50 Level 3, were included for this question.[24, 25, 33] Two experimental studies use artificially inoculated linen swatches typically 5x5 centimetres (cm) in size.[25, 33] These square swatches may not reliably predict the outcomes in full-sized linen with seams, pockets, zips and other related items. Within the included studies, the swatches were inoculated with *Clostridioides difficile (C. difficile)* spores[33] and with two coronaviruses: HCoV-OC43 and HCoV-299E.[25] The organisms used across these studies are not reflective of all the organisms or strains to which linen are exposed to in health and care settings. No

study within the identified evidence evaluated the effectiveness of laundering products or processes on fungi.

Another consideration that can be drawn from these experimental studies, in which linen contamination is artificially achieved by inoculation, is the presence of soiling which is often present in practice and may impact the effectiveness of the laundering method. All three experimental studies simulated soiling.[24, 25, 33] Only one study used whole linen for their experiments –a polyurethane mattress cover[24] There was also only one study where contamination of the linen was natural rather than by artificial inoculation.[33]

The remaining evidence (n=13) were guidance documents graded SIGN50 Level 4 expert opinion. [3-5, 18, 19, 22, 23, 26-29, 31, 32] A potential risk of bias exists with this class of evidence because of a lack of supporting evidence and the unclear methodology with which these documents are formulated.

The differences in experimental parameters make it difficult to assess the degree of consistency within the primary studies. Such differences include the organisms (or indicator organisms) involved, machine type, and disinfecting agents used.

Linen reprocessing

From the evidence identified, the linen reprocessing or production process can be divided into three broad stages: washing, drying, and ironing.

The washing stage consists of three phases – washing, disinfection, and dilution, regardless of whether the linen to be reprocessed is infectious. The wash phase produces linen that is visibly clean, while the disinfection phase is aimed at killing microorganisms on the linen items to reduce their viable count. Dilution – rinsing – further reduces the number of viable organisms and removes detergents and disinfectants.[23]

Laundering temperature

Generally, the linen disinfection processes identified in the evidence for this research question can be classified into three based on the laundering temperatures and whether disinfectants are used. The categories include thermal disinfection, chemical disinfection, and chemo-thermal disinfection.[5] This categorisation provides a useful

approach to conceptualising the disinfection processes and has been used to describe the evidence identified for this question.

Thermal disinfection

Thermal disinfection also referred to as hot water washing, is disinfection by heat and is considered the traditional way to disinfect linen.[3, 5] Thermal disinfection refers only to a phase or cycle in the washing process, where the temperature is held at a certain temperature for a specified time.[23] One UK guidance document notes that a key advantage of this process is that time-temperature relationships can be easily set and monitored.[5] There was no primary evidence of sufficient quality that assessed the effectiveness of washing at different temperatures. Generally, most guidance documents recommend wash cycles that include a disinfection phase with temperatures at or above 71°C for laundering linen.[3, 5, 19, 23, 26, 27, 29] However, there is no consensus on the minimum duration for which this temperature is to be maintained or the need for detergent (chemo-thermal disinfection). Guidance documents from the UK[23, 27, 29] prescribe maintaining at 71°C for at least three minutes, or 65°C maintained for 10 minutes or more. Conversely, guidance from the US and elsewhere recommend maintaining 71°C for 25 minutes or more.[3, 19, 26] One UK guidance also noted that other time-temperature relationships may be used as long as they are equal or greater in efficacy compared to the 65°C or 71°C processes.[5] This document also specified that for machines with a degree of loading less than 0.056 kilograms per litre (kg/L), four extra minutes should be added to the minimum durations and eight extra minutes for loading degrees greater than 0.056 kg/l.[5]

Documents from the World Health Organization (WHO) were generally vague concerning specific laundering conditions. They recommend a broader wash temperature range (60–90°C) but did not provide a specific duration for which these temperatures should be maintained.[18, 31] One WHO guidance document specific for healthcare facilities specify washing linen including sheets, blankets and reusable caps at 70–80°C. However, this document also provided no specific duration.[18]

Chemical disinfection

Unlike thermal disinfection, chemical disinfection is achieved using chemical agents rather than high temperatures.[3, 5] As a result, it is the preferred method for disinfection of heat-labile linen.[30] It is also recommended as an alternative when thermal disinfection is not possible for other reasons including cost.[3] No primary evidence assessing chemical disinfection was found.

It is not clear how low the temperatures are expected to be for this category. One guidance document[19] states that it can be done with water at temperatures between 22–25°C. This position is shared by a UK guidance[5] document which notes that they can be operated at ambient temperature. However, this will depend on the chemical agent as chlorine bleach is activated at 57.2–62.7°C.[3] Other guidance documents simply state temperatures less than 70°C and hence may be considered chemo-thermal or chemical disinfection, as this does not fit neatly into either category.[3, 26]

Recommendations on chemical agents were generally not provided in most guidance documents. For example, one UK guidance document, in its section on chemical disinfection, notes only that hypochlorite should not be used on fire retardant-treated fabrics.[5] The chemical agents were also distinguished from detergents and were sometimes referred to as disinfectants/disinfecting agents,[19, 23] or chemicals for low-temperature washing.[3, 26] However, one guidance document from the International Federation of Infection Control (IFIC) recommends sodium hypochlorite or hydrogen peroxide.[19] This is consistent with an Irish guidance document specific to the management of *C. difficile* infections which also recommends introducing 150 parts per million (ppm) of chlorine into the second last rinse for disinfection of heat-labile linen items.[30] Another UK guidance document specific to social care also recommends using laundry bleach or other laundry disinfectant for delicate items of infectious laundry.[22] A WHO guidance document recommends soaking reusable gowns and caps with 0.5% bleaching powder (calcium hypochlorite) for 30 minutes.[18]

Chemo-thermal disinfection

This is a combination of thermal and chemical disinfection where a raised temperature (less than 65°C) is used alongside a chemical disinfectant.[5] No recommendation for this type of disinfection was found in the guidance documents identified for this review. However, an experimental study (graded SIGN50 Level 3) published in the UK, found that adding a disinfectant containing 15% sodium hypochlorite (NaOCl) to a 90–minute wash cycle which included a thermal disinfection phase at 75°C for 10 minutes resulted in an improvement in sporicidal efficacy compared to thermal disinfection alone.[33] The study which experimented separately using two strains of artificially inoculated *Clostridioides difficile* spores (NCTC 11209 and ribotype 001/072) on 5cm by 5cm 100% cotton swatches found that when 50ml of NaOCl was added, the number of spores recovered post wash was significantly reduced to 0-9 colony forming units (cfu)/25cm^2 for both strains, compared to the original inoculum (7 Log_{10} cfu/25cm^2) ($p<0.05$).
Cross-contamination, that is, spores recovered from sterile swatches added in with the contaminated swatches ranged from 0–14 cfu/25cm^2 across both strains. However, in the control thermal disinfection cycle (without the detergent), the number of spores recovered post-wash was 4.95 Log_{10} cfu/25cm$^{2.}$ Cross contamination was also high and ranged between 2.72–2.89 Log_{10} cfu/25cm^2 across both strains. However, there are several limitations. There was no direct statistical comparison between both processes, rather the comparison reported was within each process, that is the number of spores recovered post-wash, compared to the initial inoculum. There was also a limited number of repeats of the experiments (n=2) and only one material type (100% cotton strips) was used. As observed by this study, UK guidance published by the Department of Health notes that low levels of contamination of linen by *C. difficile* spores may still be present regardless of the process or machine used. It therefore advises that single-use linen products may be considered in cases where highly immunocompromised patients are involved.[5]

Another SIGN50 Level 3 experimental study published in the USA, observed that new and old (after 200 laundry cycles) polyurethane mattress covers laundered in a washer extractor in the presence of soiling, with a disinfection phase at 71.1°C held for 8 minutes with 12.5% chlorine bleach and dried at 71°C led to complete removal

of all the organisms inoculated before laundering.[24] No organisms were detected after laundering, representing a statistically significant reduction compared to pre-laundering colony counts ($P<0.05$). Compared to the positive controls (covers inoculated but not laundered), there was a >6.56 log_{10} and >6.02 log_{10} reduction of *C. difficile* spores in old and new covers respectively ($P=0.034$). Similar results were observed with *Mycobacterium terrae*, and a mixed suspension of *Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus* and *Klebsiella pneumoniae*. There were several limitations associated with this study.[24] The sample size was small and the organism recovery efficiency from the mattress covers, validated by sampling the positive control, ranged from 85–93%. There was also a lack of a comparison group of temperature alone to properly evaluate the role of the combined thermal-disinfecting agent. The mattress covers were made of polyurethane and hence the findings of this study may not be applicable to cotton or other types of fabrics which make up a large proportion of healthcare linen. There are also potential conflicts of interest as the study was funded by the manufacturer of the mattress covers, of which the lead author was employed.

Other considerations for laundering

Four SIGN50 Level 4 expert opinion guidance documents were consistent in advising that infectious or heavily soiled items can be washed in the same way as used linen but with an extra pre-wash or sluice cycle.[4, 5, 22, 30]

Products

A range of products used for laundering healthcare linen was identified in this review. They include detergents,[3] disinfecting agents, and souring agents.

- **Laundry detergents.** These are chemical substances that function to suspend oils. They also exhibit some antimicrobial properties.[3] They were generally required for all wash cycles regardless of the type of disinfection used.[3, 4, 18, 19, 23, 26, 28, 31] They were however not mentioned in most UK guidance documents which seemed to focus more on the disinfection phases of the laundry cycle.
- **Disinfecting agents.** Two primary studies (SIGN50 level 3) investigated the effectiveness of disinfecting agents on linen decontamination. The agent used

in both studies was sodium hypochlorite (NaOCl).[24, 33] Both studies, which also involved thermal disinfection phases, showed a significant reduction in counts of organisms and spores compared to the original inoculum. However, there were no statistical comparisons to wash processes run with other disinfecting agents or with no disinfecting agents. Hence, they provide no evidence of their comparative effectiveness with other disinfecting agents or thermal disinfection alone.

- **Souring agents.** The other additive identified from the evidence is peracetic acid sour (acetic acid and hydrogen peroxide), a souring agent used for the removal of residual alkali from linen items and reduces the risk of skin reactions.[3, 33]

Conclusion

In summary, linen can be disinfected during the laundry cycle using either heat (thermal disinfection), chemical agents (chemical disinfection) or both (chemo-thermal disinfection). Although thermal disinfection seems the method of choice in extant guidance, chemical disinfection is preferred for heat-labile linen items. No explicit recommendations for chemo-thermal disinfection were found in the guidance documents.

3.1.5 How should beds be stripped/made to minimise risk of infection transmission?

Seven pieces of evidence were included for this question, all added for this update.[5, 20, 27, 34-37]

One guidance graded AGREE: ‘Recommend with modifications’ was included. Although this guideline was based on a systematic review, no inclusion or exclusion criteria were provided and the criteria for selecting the evidence was generally unclear.[36]

Six SIGN50 Level 4 expert opinion guidance documents were included.[5, 20, 27, 34, 35, 37] This poses a potential risk of bias as there is often a lack of supporting evidence and the methodology with which these guidance documents are formulated is also unclear.

No primary studies were included for this research question.

Personal protective equipment

Three of the seven guidance documents included were specific for care homes.[20, 27, 37] Four documents recommend some form of PPE.[20, 27, 34, 37] One was from the UK and provided general guidance for infection prevention and control. It recommends the use of disposable aprons when making a bed.[27] This was consistent with the recommendation of an Irish guidance document focused on COVID-19.[20] An American guidance document on preventing the spread of multi-drug resistant organisms (MDRO) lists changing linens as part of high-contact resident care activities requiring enhanced barrier precautions. They require staff to wear gowns and gloves when changing linen for patients with infection or colonisation with an MDRO, or those with wounds and/or indwelling medical devices, regardless of their MDRO colonisation status.[37]

Process of bedmaking

No evidence was found for the process of making beds.

Process of bed-stripping

Two UK guidance documents,[5, 27] two from the Republic of Ireland,[20, 35] and one from Canada[34] touch on this point and provide consistent recommendations. All five SIGN50 Level 4 documents recommend the careful removal of linen from beds and placement in a container appropriate for the segregation category (not the floor) without unnecessary shaking to prevent the aerosolization of particles that may contain infectious agents.[5, 20, 27, 34, 35] Guidance from the Public Health Agency of Canada recommends that heavily soiled linen be rolled or folded such that the heaviest soil is contained in the centre of the bundle. It also recommends that large amounts of solid soil such as blood clots or faeces be removed with a toilet tissue into a bedpan or toilet for flushing and that gloves be worn for this.[34]

Hand hygiene

Four pieces of evidence including a WHO guideline graded ‘AGREE Recommend with modifications’ recommended hand hygiene after completion of the bedmaking process. [20, 27, 36, 37]

Conclusion

In summary, most guidance documents identified for this review recommend PPE use, particularly aprons and gloves for stripping beds and performing hand hygiene afterwards. On stripping beds, they recommend careful removal of linen from beds and direct placement into an appropriate container. No evidence was found for the process of bedmaking.

3.1.6 How should clean linen be handled?

Three pieces of evidence were included for this research question,[2, 5, 23] one of which was carried over from the previous version of this review.[23]

All three were graded SIGN 50 Level 4.[2, 5, 23] There is a potential risk of bias as there is often a lack of supporting evidence and the methodology with which these guidance documents are formulated is also unclear.

Two themes identified regarding this research question were:

- the need to perform hand hygiene before handling clean linen,[5, 23] and
- the need to ensure gloves worn to handle 'soiled' linen are not used for clean linen.[2]

Conclusion

All guidance documents highlighted the need for hand hygiene before clean linen is handled.

3.1.7 How should clean linen be stored?

A total of 16 pieces of evidence were included for this research question. Thirteen of these were added in this update[2, 4, 19, 21, 22, 27, 38-44] while three were carried over from the last version of this review.[3, 5, 23]

Two guidance documents were graded AGREE 'Recommend with modifications'.[21, 43] One of these was an Irish guidance document on the prevention and control of Methicillin-Resistant *Staphylococcus aureus* (MRSA).[21, 43] Although based on a systematic review, the link between evidence and recommendations was not always clear. The other was a guideline on prevention and control of norovirus

gastroenteritis outbreaks in healthcare settings by the US Centres for Disease Control and Prevention.[43] A key limitation of this document was that the method used for formulation of recommendations was not clearly stated.

An outbreak study graded SIGN50 Level 3 was also included.[41]

Thirteen SIGN50 Level 4 expert opinion guidance documents were included.[2-5, 19, 22, 23, 27, 38-40, 42, 44] There is a potential risk of bias as there is often a lack of supporting evidence and the methodology with which these guidance documents are formulated is also unclear.

Storage location

Fourteen pieces of evidence provide recommendations on where clean linen should be stored. There is consistency across this evidence base that clean linen should be stored in a dedicated clean and dry area/space or bay.[2, 4, 5, 21, 22, 27, 38-40, 42] Three documents also recommended that this area be separated from areas where used or infectious linen is stored and away from patient rooms.[23, 38, 40] Two documents recommend that linen be stored in cupboards with doors that can be closed or rooms with shelves that can be cleaned.[19, 22]

There is consistency within the evidence base that clean linen should be stored above floor level.[4, 5, 27, 44] However, only one document – an American guideline on laundering scrub attire published by the Association of Surgical Technologists– provides any specification on the distance of the storage base from the floor (eight inches).[44] One document also recommends that clean linen be stored away from water, and sunlight, and in places that allow free air movement.[5] Another document recommends an alcohol-based hand rub dispenser near the bay or space where clean linen is stored.[39]

Only one document provides recommendations on how linen should be stored in a healthcare laundry facility. This document, published by an American group - the Healthcare Laundry Accreditation Council (HLAC), also provides for linen to be stored in a designated area. They also recommend that unwrapped clean linen must be stored in carts or hampers that should always remain covered until it is delivered to the customer's facility.[2]

Temperature and air changes

While many guidance documents used vague terms such as ‘cool’ or ‘allows free air movement’, only one guidance document – an American guideline on laundering scrub attire published by the Association of Surgical Technologists – specifies a temperature at which clean linen should be held (20–25C°).[44] However, although this guidance document provides an evidence table and lists databases searched, its methodology cannot be adjudged to be systematic, nor does the document present it as such. Furthermore, although no reference was provided for this specification, the only reference provided for the section was the 2016 Accreditation Standards from the HLAC. The most recent version of this standard (2023) is included in this review but does not include this provision.[2] The 2016 version could not be accessed.

Another American guidance document was also the only one to provide a specification for air changes in linen storage rooms in ‘nursing facilities’ – a minimum of two per hour.[3] However, the evidence for this specification is unclear.

Bagging or covering

Three SIGN50 Level 4 documents recommend protecting linen from environmental contamination by covering them with impervious protective materials especially when they are not stored in cupboards.[23, 39, 40] Two of these also provide guidance for wrapping linen in protective dust covers before storing it on clean shelves at the facility.[39, 40] However, a SIGN50 Level 3 outbreak study found that storing linen in airtight plastic bags promoted the growth of *Bacillus cereus* spores in an outbreak in Singapore. As part of investigations during the outbreak, the investigators stored towels from the same washing batch in either sealed plastic bags or in porous canvas bags for 24 hours (10 per bag). The towels stored in the plastic bags had a significantly higher count of *B. cereus* spores compared to those stored in the canvas bags (4437 cfu/cm^2; CI: 3125–5750; vs 166 cfu/cm^2; CI:76–256; P<0.001). There are however key limitations to this experiment. The temperature and relative humidity inside the bags were not measured – this makes it difficult to apply to settings in Scotland which has a cooler climate than Singapore. The findings might not be applicable to bed linen as only towels were included in this investigation. This experiment was carried out only once. [41]

Return after excursion

Two guidance documents provide recommendations on returning unused clean linen from patient rooms back to the linen store.[40, 43] An American document on the prevention and control of norovirus graded AGREE 'recommend with modifications', recommends laundering all unused linen from the rooms of patients in isolation after they are discharged or transferred.[43] An Australian SIGN50 Level 4 graded document goes even further to state that clean linen taken out for bedmaking rounds, should not be returned to clean linen storage even if unused.[40]

Stock rotation

Three SIGN50 Level 4 documents[5, 39, 40] including one from the UK,[5] recommend that linen be stored in a manner that allows rotation of stock.

Cleaning

Two guidance documents (SIGN50 Level 4) were consistent on the need for linen storage areas to be easily cleanable and that there be agreed cleaning schedules in place.[5, 44]

Conclusion

The guidance documents identified for this review recommend that clean linen be stored in a designated cool and dry place, away from other linen and above floor level. Although some guidance documents recommend that clean linen be covered with impervious protective materials when they are not stored in cupboards, one study noted that this may encourage the growth of spores and found the use of porous bags to be a better alternative to plastic bags. The guidance documents also recommend that unused linen should not be returned to clean linen storage, even if unused.

3.1.8 How should clean linen be transported?

Seven pieces of evidence were included for this research question[2, 5, 19, 23, 40, 44, 45] including one which was carried over from the last version of this review.[23]

All seven were graded SIGN50 Level 4. They include a Scottish guidance on linen management,[23] and another from the UK.[5] There was also a guidance from the

International Federation for Infection Control (IFIC),[19] another from Australia[40] and three from the US.[2, 44, 45] These are generally subject to potential risk of bias because of the lack of supporting evidence and the unclear methodology with which these guidance documents are formulated.

Covering or bagging

All included guidance documents agree that clean linen should be protected from environmental contamination during transport.[2, 5, 19, 23, 40, 44, 45] Several methods were put forward to achieve this protection including the use of trolleys or carts covered with an impervious or fluid-resistant protective covering,[5, 23, 40, 44] sealed containers with lockable doors,[5] linen bags,[19] or simply wrapping the linen.[2]

Separation from used linen

There is also a clear consistency within the included evidence base that clean linen should not be transported together with used linen or waste in the same lift or vehicle unless they are adequately separated by a suitable physical barrier or sufficient space.[2, 5, 23, 40, 44]

Decontamination of transport vehicles

Four guidance documents were consistent in noting the need for decontamination or cleaning of vehicles, trolleys, carts or other items used for the transport of clean linen. The documents recommend daily decontamination, between trips if used to transport used linen, and whenever they appear soiled.[2, 5, 23, 44]

Spill kits and hand hygiene

Three guidance documents recommend that drivers have access to alcohol-based or waterless hand hygiene products.[2, 23, 44] All three documents also recommend that spill kits be available in all linen transfer vehicles for the management of spills.[2, 23, 44]

Personal protective equipment

No evidence was found for the use of PPE in the transport of clean linen. However, one document stated that gloves used to handle soiled linen must never be brought into contact with clean linen during the transport process.[2] More information on PPE can be found in the **gloves review** and **apron and gown review**.

Conclusion

In summary, guidance documents generally recommend that clean linen be protected from contamination during the transport process. This can be achieved by transporting them in carts or containers with impervious covering or lockable doors; completely separated from used linen. They also recommend that transport vehicles be decontaminated regularly and be equipped with hand rubs and spill kits.

3.1.9 How should 'used' linen be safely handled?

A total of 13 pieces of evidence were included for this research question, [2, 4, 5, 19, 22, 23, 27, 29, 34, 36, 40, 42, 46] one of which was carried over from the previous version of this review.[23]

One guideline graded AGREE: 'Recommend with modifications' was included. Although this guideline was based on a systematic review, no inclusion or exclusion criteria were provided and the criteria for selecting the evidence was generally unclear.[36]

Twelve SIGN50 Level 4 expert opinion guidance documents were included.[2, 4, 5, 19, 22, 23, 27, 29, 34, 40, 42, 46] As already noted in this review, there is a potential risk of bias with documents of this kind. No primary evidence was identified for this research question.

Handling

There was consistency in the evidence base that used linen should be handled carefully without shaking unnecessarily to prevent the dispersal of particles that may contain infectious agents.[2, 4, 19, 22, 27, 40, 42] Two SIGN50 Level 4 guidance documents provide specific recommendations on how this can be achieved when removing linen from the bed. One international guidance published by the International Federation of Infection Control (IFIC) [19] recommends folding linen towards the centre of the bed, while another document published in Australia advises 'rolling up' linen.[40]

Three UK documents specific to care settings also state that used linen should be held away from the chest to prevent contamination of uniforms and possible injuries from sharps.[4, 27, 40]

Bagging

There is consistency within the evidence identified that used linen be placed directly in the appropriate bags at the point where used linen is generated (for example patient or resident rooms) and that it should not be placed on the floor or other surfaces.[4, 19, 22, 23, 27, 40, 42] Some documents also state that bags should never be emptied onto the floor for sorting as this presents an avoidable and unnecessary risk.[4, 22, 23, 27]

Two documents specify that leak-proof plastic bags must be used for soiled or wet linen.[19, 40]

Hand Hygiene

There is consistency on the need for hand hygiene after handling used linen.[5, 27, 36, 40] A Scottish expert opinion guidance document published by (then) Health Protection Scotland (HPS) in collaboration with HFS recommends providing hand washing facilities at the entry and exit points of all linen reprocessing areas.[23]

Personal Protective Equipment

Seven documents recommend using PPE for handling used linen, particularly plastic aprons and suitable gloves.[2, 5, 22, 23, 27, 29, 46] One Scottish guidance published by the (then) HPS in collaboration with HFS recommends the use of puncture-resistant gloves by laundry staff to prevent injuries from sharps when decanting and sorting linen but noted that these are not required to be single-use as they should not be used to handle clean linen. It is however recommended that gloves should be washed between use and dried.[23]

One guidance document published in the UK also recommends waterproof plasters to cover cuts and grazes when handling linen.[23]

Conclusion

Within the evidence base, there were consistent recommendations that gloves and aprons be used for handling used linen and that linen be placed directly into bags at the point of use and carefully handled to prevent the dispersal of microorganisms. Evidence was consistent on the need for hand hygiene after handling used linen.

3.1.10 How should ‘used’ linen be sorted?

A total of five pieces of evidence were included for this research question,[2, 4, 5, 23, 27] one of which was carried over from the previous version of the review.[23] All five were graded SIGN50 Level 4. [2, 4, 5, 23, 27] The potential risk of bias for level 4 documents has already been noted. No primary evidence was identified for this research question.

Sorting process

There is consistency within the evidence identified for this research question, that used linen should be segregated at the point of use and bagged appropriately for each category.[4, 5, 23, 27] A UK guidance document, Health Technical Memorandum 01-04 provides two options on which classification and sorting can be based. In the first option, linen is categorised at the point of use and bagged appropriately. Infectious as well as heavily soiled linen is to be placed in red water-soluble bags (or bags with water-soluble seams) which are then placed in white appropriately labelled impermeable bags, while soiled and fouled linen should be placed in impermeable bags. It should be noted that in this document, the term ‘soiled and fouled’ linen means all ‘used linen’ whether soiled with body fluids or blood but excluding those from patients with suspected or confirmed infections and patients with diarrhoea. The water-soluble bags on arrival at the laundry are to be transferred into the washer without opening, followed by any reusable laundry bags. The second option involves treating all linen as infectious and hence not requiring segregation. All categories of linen are bagged in red water-soluble bags which are then placed in white appropriately labelled impermeable bags.[5]

Two guidance documents specific to social care settings recommend that used linen be sorted according to the ‘standard process’ into water-soluble bags which should then be placed in a white impermeable bag or a white cotton sack or directly into a white impermeable bag. They also specify that any solids, including sharps, should be removed from heavily soiled linen items before they are bagged.[4, 27]

HTM 01-04 recommends that heat-labile linen be placed in impermeable bags, the colour of which should be agreed on with the laundry.[5] Scottish guidance from HFS recommends that blue-coloured bags be used.[23]

HTM 01-04 notes that pre-wash sorting of used linen is not considered best practice and presents extra risks.[5] However, there is a recognition that it may be necessary for different reasons including operational or performance purposes.[5] An American laundry-specific guidance document advises that there should be a soil sort room and a sorting process in which foreign objects including reusable surgical instruments or disposable devices are to be removed from the linen to be processed.[2] This is also alluded to by Scottish expert opinion guidance published by the (then) HPS in collaboration with HFS while discussing PPE to 'prevent sharps injuries when decanting and sorting used linen'.[23]

Personal Protective Equipment (PPE)

Three guidance documents provide recommendations on PPE for pre-wash sorting of linen.[2, 5, 23] They include puncture-resistant gloves and plastic aprons.[5, 23] One guidance document also recommends waterproof coverage of forearms, and the use of visors, face -masks or hats, depending on the task.[5]

Conclusion

Within the body of evidence, there is consistency that pre-wash sorting be avoided where possible and that 'used' linen should be segregated at the point of use into the appropriate categories. In situations where it is required, appropriate PPE should be used.

3.1.11 How should 'used' linen be labelled?

Only one piece of evidence was identified for this research question and was carried over from the last version of this review; a SIGN50 Level 4 Scottish guidance document published by the (then) HPS in collaboration with HFS.[23]

The guidance document specifies that correct bagging and labelling is a criterion for acceptance of used linen at the laundry. The label must contain the hospital, care area or ward or department and date. It also states that linen that is not correctly labelled should not be accepted by portering or transport staff.[23]

3.1.12 How should ‘used’ linen be stored?

A total of eight pieces of evidence were included for this research question, [5, 19, 22, 23, 40, 42, 47, 48] including one from the previous version of this review.[23] One experimental study graded SIGN50 Level 3 was included.[48] The seven others were guidance documents, all graded SIGN50 Level 4.[5, 19, 22, 23, 40, 42, 47]

Storage location

Five pieces of evidence [5, 19, 23, 42, 48] provide recommendations on where used linen should be stored, including one experimental study.[48] There is consistency on the need for a designated area for appropriately bagged and labelled ‘used’ linen awaiting collection or laundering – which may be called a dirty linen room, dirty linen store or dirty area.[5, 19, 23, 42]

Two guidance documents recommend that the dirty linen storage areas should have doors that must be kept locked and that access to the area must be restricted.[19, 42]

One UK document stated that in conformity with BS EN 14065, a soiled linen area should be functionally separated from clean linen areas – through the use of a physical barrier, or negative air pressure in the soiled linen area and/or positive airflow from clean through to the soiled area with venting directly to the outside environment.[5]

Storage temperature

One experimental study published in Italy demonstrated that the temperature at which used linen is stored can have an impact on microbial contamination levels.[48] 10 x 10cm samples of different types of textiles (cotton mattress covers, cotton bedsheets, trilaminate theatre drapes) were inoculated artificially with at least two strains each of *E. coli, P. aeruginosa, S. aureus, Saccharomyces cerevisiae, Candida albicans,* and *Aspergillus brasiliensis*. The inoculated strips were then stored at either 4°C, 22°C or 37°C for 72 hours to simulate the average temperatures to which linen are exposed during autumn or winter and spring or summer seasons. Bacterial concentration was evaluated at 0, 8, 24, 48 and 72 hours.[48]

At 4°C, there was a general lowering in the mean concentration for all organisms at 72 hours compared to T=0. The mean total mesophilic count (TMC) for dry and wet

mattress covers decreased from 12±2.5 and 14±2 to 11±1 and 11±3.5 CFU/cm^2 respectively. The trend was the same for both dry and wet bedsheets (14±1 to 13±1.5 CFU/cm^2 for each) and dry trilaminate drapes (14±0.6 to 12±0.6 CFU/cm$^{2)}$. There was a slight increase however in the wet drapes with the mean TMC and yeasts concentration rising from 25±5 to 26±4.5 and 2±1.5 to 3±2 CFU/cm^2 respectively at 72 hours. The concentration for all other organisms showed a downward trend from 0 to 72 hours.

At 22°C, a gradual rise was observed from T=0 to 8 hours and reaching significantly high levels at 72 hours ($P<0.05$). The mean TMC for dry and wet mattress covers at 0, 8 and 72 hours increased from 11±1 to 12±3.5 to 9.4x10^4±10^3; and 20±5 to 63±5 and 9.9x10^4±5.8x10^2 CFU/cm^2 respectively. A similar result was obtained from the bedsheets with generally higher increases in concentration in wet sheets compared to dry sheets. This trend continued (with even higher increases in concentrations) in the trilaminate drapes with a higher increase in wet compared to dry drapes.

At 37°C, the concentration was highest for each fabric after 72 hours. For wet and dry mattress covers, the mean TMC rose from 11±1 at T=0, to 3.4x10^3 ± 126 at 8 hours and peaked at 3x10^5 ± 5.5x10^3. A similar trend was observed for wet mattress covers with slightly higher values at 8 and 72 hours. This was the same for bedsheets and trilaminate drapes with rising mean TMC which increased at 8 hours and peaked at 72 hours. The values were generally lower for dry linen compared to wet.[48] A key limitation of this study is the selective use of P-values and the lack of direct statistical comparison of the outcomes between the groups. Another consideration is whether such investment in storing used linen at low temperatures is worthwhile if adequate decontamination is achieved regardless of contamination levels.[48]

Storage bags and containers

One Australian guidance document recommends that containers including carts, bins and bags used to store soiled linen should be ‘waterproof, leak-proof, non-porous’; in good shape and able to withstand decontamination.[40]

There was consistency within three documents that storage bags should be securely tied and not over-filled.[22, 40, 42]

Conclusion

Within the identified evidence, there is consistency that used linen should be bagged, labelled, and stored in a designated area, separate from clean linen storage. Bags for used linen storage should be leak-proof and able to withstand decontamination.

3.1.13 How should 'used' linen be transported?

A total of six pieces of evidence were included for this research question,[2, 5, 19, 23, 40, 48] including one carried over from the last version of this review.[23]

One experimental study graded SIGN50 Level 3 was included.[48] A key limitation of this study was the selective reporting of p-values.

Five evidence sources were SIGN50 Level 4 guidance documents.[2, 5, 19, 23, 40] As with most SIGN50 level 4 guidance, there is a potential risk of bias as there is often a lack of supporting evidence and the methodology with which these guidance documents are formulated is also unclear.

Separation from clean linen

There is consistency within the included body of evidence that used linen should not be transported in the same vehicle as clean linen unless they are appropriately separated.[2, 5, 23, 40] However, different approaches were provided for achieving this separation including the use of moisture-impermeable bags,[2, 40] containers with suitable closures,[40] and the use of separate covered cages or trolleys.[23]

Transport process and conditions

One experimental study published in Italy showed that when artificially contaminated linen was stored at 22°C or 37°C, there was a significant increase in contamination levels after eight hours, compared to refrigerated storage at 4°C where no such increases were observed.[48]

Two UK guidance documents discuss the need for transport bags to be securely fastened before they are placed in transport vehicles.[5, 23] One of these documents also discusses the need for an acceptable weight for linen bags and that the bags should not be overfilled.[5]

Hand hygiene

Two guidance documents, including one specific to Scottish health and care settings, noted that linen transport vehicles (or drivers) should have alcohol-based hand sanitisers for hand hygiene and spill kits for managing fluid spillages.[2, 23] A laundry setting-specific expert opinion guidance document stated that gloves must be used by drivers to minimise contact with soiled textiles and that hand hygiene must be performed after gloves are removed.[2]

Vehicle and container cleanliness and decontamination

There is also consistency within the evidence that vehicles and other containers used for linen transport should be routinely decontaminated.[2, 5, 23, 40] One UK document recommends that this cleaning is done daily,[5] two documents including the earlier mentioned document, recommend cleaning between uses,[2, 5] while another document states only that compartments used to transport soiled linen be cleaned before they are used to transport clean linen.[40] Three guidance documents mention the need for the documentation and/or validation of the cleaning procedure or schedule.[2, 5, 23] However, only one – a laundry setting-specific guidance – provides recommendations for cleaning.[2] This guidance recommends any of the following: steam cleaning; cleaning with detergent and water; hospital-grade detergent disinfection; or any other alternative disinfection method as long as the manufacturer's instructions are followed and there is documentation of the efficacy of the process.[2]

Conclusion

In summary, within the literature, it is recommended that used linen be transported separated from clean linen, in securely fastened and properly weighted bags. Transport vehicles and containers should be routinely decontaminated and should contain appropriate products for hand hygiene and management of fluid spills.

3.1.14 Is there any specific evidence on the effective laundering of uniforms/scrubs?

Five pieces of evidence were included for this research question, [17, 22, 44, 49, 50] including one carried over from the previous edition of this review.[17]

This consisted of four pieces of evidence graded SIGN50 Level 4 expert opinion guidance.[22, 44, 49, 50] As with most Level 4 guidance documents, there is a potential risk of bias as there is often a lack of evidence to underpin their recommendations and the methodology with which these guidance documents are formulated are also unclear.

One SIGN50 'Mandatory' document was included, the Scottish Government National Uniform Policy, Dress Code and Laundering Policy.[17]

There was consistency within the identified evidence published in the UK that uniforms can be laundered at home.[17, 22, 50] However, the two documents identified from elsewhere (the US) were either ambivalent[49] or against home laundering.[44]
It must be noted that the document that was against home laundering was specific to surgical settings.[44] However, some reasons for this position also apply to scrubs or uniforms used in non-surgical settings. These reasons include the possible transfer of infectious agents from used scrub attire to clothes belonging to other family members washed alongside them, the deposition of infectious agents in parts of the washing machine which could contaminate subsequent laundry loads, and possible contamination of hands of staff or members of their household during transfer of wet laundered scrubs to the dryer. Another key reason was the lack of process and equipment monitoring of home laundering which the authors of the document argued can lead to inadequate decontamination.[44]

A mandatory document from the Scottish Government, National Uniform Policy, Dress Code and Laundering Policy, categorises uniforms into two classes for laundering purposes.[17] The first category 'used uniforms' refers to uniforms that have been worn with appropriate PPE; while the second 'contaminated uniforms' refers to those that are visibly contaminated with blood or other body fluids because of a failure of PPE or other incidents, or uniforms that are deemed contaminated by infection control. This document states that used uniforms may be laundered at home but that the hospital or facility laundry should be used if available. Contaminated linen on the other hand must be laundered in hospital or facility laundries and not be taken home for laundering.[17]

Domestic laundering

Two documents published in the UK, recommend that uniforms should be washed at 60°C for 10 minutes or at the highest temperature the fabric can tolerate.[22, 50] Both guidance documents also advise that heavily soiled items be washed separately to reduce the risk of cross-contamination, with one (published by NHS England) putting this recommendation under a common sense-based 'good practice' column.[22, 50] Another good practice point was that washing machines should not be overloaded to avoid reduced washing efficiency.[50]

An American document recommends a hot water wash cycle (ideally with bleach) followed by a drying cycle in a dryer.[49] But, mandatory Scottish Government guidance (the National Uniform Policy, Dress Code and Laundering Policy) recommends using detergent suitable for the wearers' skin type, noting that bleaches should not be added to the wash process or used to make uniforms whiter.[17] The position on drying was further supported by UK guidance specific for care settings which recommends tumble drying or ironing to remove the small number of microorganisms left after the wash. The Scottish Government Policy notes that uniforms may be tumble-dried or ironed according to the care label.[17]

Transport of uniforms to and from work

No evidence was found regarding the transport of uniforms to and from work. However, the Scottish Government Policy recommends hand hygiene using soap and warm water before handling clean uniforms and after handling soiled uniforms.[17]

Care for domestic washing machines

One UK guidance document recommends regular cleaning and maintenance of domestic washers and tumble driers to ensure that the efficiency of the machines is protected and that dirty machines do not contaminate subsequent wash loads.[50]

Conclusion

From the literature published in the UK identified in this review, 'used' uniforms including scrubs should be laundered at home at 60°C for 10 minutes or the highest temperature that the fabric can tolerate, followed by tumble drying or ironing.

'Contaminated' uniforms and scrubs should not be taken home for laundering but instead be laundered in hospital or facility laundries.

3.1.15 Is there any evidence regarding washing used/infectious personal clothing at home?

No applicable evidence was found for this research question.

3.1.16 What is the risk of infection transmission associated with linen in health and care settings?

This research question was added as part of this update to the review.

A total of 15 pieces of evidence were included for this research question.[41, 51-64]

This consisted of 14 SIGN50 Level 3 studies, one of which was experimental.[63] Thirteen were outbreak reports.[41, 51-62] Two of these included an extra research dimension in the form of an experiment or a case-control study.[53, 56] A key limitation of this type of evidence is publication bias as not all outbreaks are reported.

One SIGN50 Level 4 expert opinion guidance document was also included.[64]

Associated organisms

Several organisms were associated with outbreaks or infections in which linen was implicated. *Bacillus cereus* was the most reported and the only gram-positive organism within the identified evidence (n=6).[41, 57-61] Gram-negative organisms reported include *Klebsiella oxytoca*[55] and *Klebsiella pneumoniae*.[56] Fungal organisms were implicated in four reports, involving *Candida auris*,[52] *Lichtheimia corymbifera*,[51] and *Rhizopus* spp. (*R. microsporus, R. arrhizus*).[51, 53, 54] One case of mpox virus was also identified where one healthcare worker was infected, the only link with the infected patient being changing bed linen without proper protection – wearing only standard PPE (disposable aprons and gloves).[62]

Sources of contamination

In six of the included studies, the laundry facility was implicated as the source of the outbreak. Two of these studies (one each from the United States and China) reported poor conditions in the laundry facility on inspection during outbreaks of

Mucorales which resulted in recontamination of linen after they had been washed.[51, 53] One study at an American solid organ transplant centre noted that at their contracted laundry facility, both the exhaust and intake vents, ceiling, press, and fold machines were covered with thick layers of lint which yielded confluent growth of *Mucorales* and other moulds. The investigators also noted that carts containing processed linen were left uncovered as they awaited transport. The problem was not the washing process, as no *Rhizopus* spp. was detected immediately after the wash, however, the percentage of positive samples increased significantly to 12% post-drying and dropped to 7% after ironing and folding. Positive samples increased again to 17% pre-transport and upon arrival at the hospital 13% of the samples collected were positive for *Rhizopus* spp.[51] The situation was similar, albeit higher, with values reported for any fungal positivity, 5% post-wash, 29% after drying, 14% post-ironing and folding, 43% pre-transport and 45% at the time of arrival at the hospital. The authors reported that following the remediation of sources of *Mucorales* at the facility, only 0.3% (3/980) of samples collected in the next 27 months were positive for *Mucorales*, a significant reduction compared to 20% (19/95) before the remediation (p=0.0001). [51] A similar situation was reported in another study where samples from filters of tumble dryers and airflow machines, fans on the wall, and calendaring machine surfaces were covered with a thick layer of dust which was positive for zygomycetes. The authors noted that linen supply from the affected laundry provider was discontinued, however, they did not report the outcome of the outbreak.[53] A UK study reported that a cloth lanyard attached to a controlled drug locker key was identified as a reservoir for *Candida auris (C. auris)* in two adult intensive care units (ICUs). The outbreak closure coincided with the removal of the lanyard and other lanyards.[52] A key limitation of this study was that typing was not carried out to compare the *C. auris* found on the key lanyard to those found in patient samples.[52]

In four studies, involving *Bacillus cereus (B. cereus)*, although processed linen was found to be contaminated, the link between the contamination and the washing machine was not demonstrated.[41, 57, 58, 61] One Japanese study noted that a continuous tunnel washer which had not been cleaned for 10 years was the source of the outbreak.[61] Samples of water from the tap were negative for *B. cereus*, but those from the drain water and recovered water (water recycled and reused for

rinsing within the system) were positive. It is however unclear when the samples were taken, and whether the contamination noted was simply from the linen being processed in which case it may indicate a suboptimal laundering process. The mean level of contamination in towels decreased from 60-71,000 cfu/cm^2 to 81 cfu/cm^2 after implementation of control measures. However, because the control measures included autoclaving of linen, the precise role of the offending washing machine was unclear. A key limitation is that although a genetic link between patient and linen samples was demonstrated, positive water samples from the machine were not genetically compared to patient or linen samples.[61] Another Japanese study also observed that final rinse water and dryers in the linen room were positive for *B. cereus* – indicating suboptimal decontamination. *B. cereus* was not found in linen disinfected with NaOCl and laundered at an external facility – however limited information on this is provided.[58] A Singaporean study reported an outbreak of *B. cereus* where linen contamination was noted following construction activities beside the hospital. Air sampling showed high counts of Bacillus in the air outside (~600 cfu/m^3). Air-conditioned wards were reported to have higher counts compared to non-air-conditioned wards. A sampling at the laundry facility which used a continuous tunnel washer (CTW) and was located away from the hospital showed the presence of Bacillus in partially recycled pre-wash water (7.2 x102 cfu/ml) and in the compress water after final extraction from the CTW (2.4 x 10^2 cfu/ml and 4.1 x 10^4 cfu/ml). The internal surfaces of the machine were however not contaminated. Storage of processed linen in air-tight plastic bags may have encouraged the propagation of *B. cereus* spores.[41] A key limitation of this study was that no tests for genetic relatedness were performed, however, interventions coincided with a reduction in case numbers and cessation of interventions was associated with another rise in patient cases.[41]

One UK study which reported *Bacillus cereus* colonisation of newborns noted that processed linen was found to be contaminated on removal from the continuous tunnel washer. A decrease in contamination levels was observed when the laundry facility introduced an unstated increase in the amount of freshwater used for the wash process. As a result of the higher water costs, the facility later changed to selectively laundering labour ward linen using a washer extractor as this uses a higher water dilution compared to tunnel washers. It was also noted that before

increasing the amount of fresh water, an unnamed sporicidal agent was introduced which did not affect the contamination rates. A key limitation of this study is that no samples were taken from the continuous tunnel washer, hence it is unclear what the source of contamination was.[57]

An experimental study published in Japan demonstrated that wiping forearms with bath towels contaminated with *Bacillus cereus* can lead to a transfer of the organism onto the forearms which could increase the risk of catheter-related bloodstream infections. A 5cm x 10cm area of each volunteer's bilateral arm (n=9) which had initially been found to be negative for B. cereus was wiped with 5cm x 5cm pieces of naturally contaminated bed bath towels dampened with 2ml of sterile water and left to air dry. The bed bath towels had yielded 1.3x103 cfu/cm^2. One contaminated forearm was thereafter wiped with sterile water with a drenched gauze while the other arm was wiped twice with medical grade absorbent cotton containing 1.6ml ethanol. A median of 540 cfu/50cm^2 (range:240-1260) was found on the left forearm and 760 cfu/50cm^2 (range: 260-3200) on the right forearm.[63] When disinfected with alcohol, the amount of *B. cereus* present in the forearms were significantly reduced (6.4 cfu/cm^2 and 4.8 cfu/cm^2 on the left and right arm respectively; $p<0.05$).[63] This paper is limited by the lack of clarity in some areas. For example, although the authors state that the experiments on the forearms were conducted in duplicate, only one value was provided for each arm and no explanation was provided as to whether the values were means.

In two studies, one from a rehabilitation facility in the Netherlands[56] and another from a paediatric hospital ward in Germany,[55] domestic washing machines were found to be reservoirs for extended-spectrum beta-lactamase (ESBL)-producing *Klebsiella* spp. leading to contamination of processed laundry. In the former study, lifting slings and patient clothing usually soiled with faeces were washed in a domestic washing machine at low temperatures (30-40°C) with a detergent but without activated oxygen bleach (AOB). Samples from the filter and internal surface of the machine tested positive for the organism while samples from two other machines – a domestic machine used for washing non-faeces-contaminated personal clothing and a 'professional washing machine' used for bed linen and towels respectively –

were repeatedly negative.[56] In both studies, the outbreak was resolved when the offending washing machines were taken out of service.[55, 56]

In an outbreak of mpox in a UK hospital, bedmaking was noted as the probable transmission link between the index case who had a travel history and the second case – a healthcare assistant. The healthcare assistant had aprons and gloves on as the only PPE items while changing potentially contaminated bedding used by the index case who had developed skin lesions, but before a diagnosis of mpox had been considered.[62]

Interventions for outbreak management

Several linen–specific interventions were implemented for the outbreaks identified for this review with varying degrees of success. However, as the interventions were often bundled, it is almost impossible to estimate their impact. Generally, most outbreaks reported some form of cleaning or deep cleaning as part of their interventions.[41, 52, 59, 61]

Sterilisation of linen was used in three studies that reported outbreaks caused by *Bacillus cereus*.[41, 59, 61] Although the method of sterilisation was not mentioned in one of the studies,[59] autoclaving was used in the other two.[41, 61] In one of these studies which occurred in a neonatal care unit, the discontinuation of linen sterilisation coincided with the start of the outbreak and the outbreak ended after linen sterilisation was restored.[59] This demonstrates that linen sterilisation can be an effective measure for short term resolution of a linen related outbreak especially ones that involve spore forming organisms like *Bacillus cereus*. Linen sterilisation by gamma irradiation was also used in a *Mucorales* outbreak in a solid organ transplant unit.[51] This study also reported successful remediation of the offsite linen processing facility involved in the outbreak. They accomplished this through several interventions including the placement of filters around exhaust vents, repositioning of exhaust vents away from air intake vents, regular lint removal from the roof, enhanced environmental cleaning and covering over freshly laundered linen with plastic covering. [51]

The evidence identified for this research question demonstrates that removing *Bacillus cereus* from linen is difficult and that contamination with the organism is

positively associated with seasons with higher than average temperatures.[57, 58, 60, 61] One study reported no effect on contamination when a sporicidal agent was used, however, the said agent was not named.[57] However, two studies reported success with the use of NaOCl but did not provide sufficient information for meaningful conclusions to be drawn.[41, 58] One of the studies specified that for this to be achieved, a concentration of 200ppm of NaOCl was needed in the rinse phase.[41] Another study also noted the possible association between an increased amount of fresh water in the CTW wash process (or switching to a washer extractor) and a reduction in the level of *B. cereus* contamination. However, insufficient detail was provided. There was no information on the amount of freshwater introduced or the level of dilution achieved. No information was provided about its effectiveness in terms of cfus before and after this intervention.[57] This is corroborated by the recommendation of UK guidance that recommends an increase in the dilution during the wash process as a control measure when *Bacillus cereus* levels have exceeded the trigger limit. The guidance also advises that sporicidal agents should only be considered if they have proven effectiveness at the conditions in which the linen will be laundered.[64]

Another point demonstrated in one of the studies was the impact of storage conditions on spore growth on linen. Storing linen in porous canvas bags instead of plastic bags can significantly reduce the propagation of spores after 24 hours (166 cfu/cm^2; CI: 76-256 vs 4437 cfu/cm^2; CI: 3125-5750; $p<0.001$).[41]

In cases where domestic washing machines were implicated, the outbreak abated when the offending machine was removed.[55, 56]

Conclusion

The evidence shows that linen and linen-related items can act as a vehicle for transmission of infectious agents. This may be due to inadequate decontamination due to a faulty process or contaminated washing machines, recontamination due to improper storage or transport and inadequate handling of infectious linen. Organisms that have been implicated in such transmission events include gram-positive and negative organisms, fungi, and a case of the mpox virus.

Linen-specific interventions during the outbreaks identified include sterilisation of linen, modification of laundry routines, and removal of contaminated machines.

3.1.17 How should infectious linen be safely handled?

Twenty-nine pieces of evidence were included for this research question,[3, 5, 17, 18, 20-23, 26, 29, 34-36, 43, 45, 65-78] three of which were carried over from the last edition of this review.[3, 23, 45]

Four pieces of evidence were graded AGREE 'recommend with modifications'.[21, 36, 43, 78]

A document from The Scottish Government was graded 'mandatory'.[17]

Twenty-four expert opinion guidance documents were graded SIGN50 Level 4.[3, 5, 18, 20, 22, 23, 26, 29, 34, 35, 45, 65-77]

Seven of the included documents were from the UK,[5, 17, 22, 23, 69, 73, 74] including two from Scotland.[17, 23] six from the USA,[3, 26, 43, 45, 75, 76] Six were from Canada,[34, 65-67, 71, 72], four from the WHO;[18, 36, 77, 78] five from Ireland,[20, 21, 29, 35, 68] and one from the EU.[70]

Overview of evidence

Of the 29 pieces of evidence included, 13 provided general IPC recommendations,[3, 5, 17, 18, 22, 23, 26, 29, 34-36, 45, 69] Seven were specific for particular infectious agents namely Methicillin-resistant *Staphylococcus aureus* (MRSA),[21] SARS-CoV-2,[20, 66] *C. difficile* infection,[65] healthcare-associated pneumonia,[67] and norovirus infections.[43, 68] Nine pieces of evidence were focused on high-consequence infectious diseases (HCID): mpox,[70, 77] Middle Eastern Respiratory Syndrome Coronavirus (MERS-CoV)[71, 73] and viral haemorrhagic fevers including Ebola virus disease.[72, 74-76, 78]

Safe Handling

There is consistency within 11 documents (1 AGREE 'recommend with modifications', 10 SIGN50 Level 4) that infectious linen should be handled carefully with minimum agitation to prevent contamination of the environment including air and other surfaces.[18, 20, 22, 26, 34, 35, 43, 45, 65, 68, 72] Three documents (one graded

'mandatory, 2 SIGN50 Level 4) were consistent in advising that infectious linen be bagged as soon as possible and held away from the body during carriage.[17, 45, 73]

Some documents, particularly those from Canada, recommend that heavily soiled linen be rolled or folded inward such that the area with the heaviest soiling is contained in the centre of the bundle.[34, 65, 72]

PPE

Three documents providing general IPC guidance recommend PPE when infected linen is handled, including gloves and aprons.[22, 26, 29] However, there was a variation in the combinations of PPE recommended by these documents.

Hand hygiene

There was consistency within the documents providing general IPC guidance that hand hygiene be performed after handling infectious linen.[21, 22, 26, 34, 36]

HCIDs

Ebola virus disease (EVD) and other viral haemorrhagic fevers (VHF)

There is consistency among guidance documents from the UK, the USA and Canada, that linen used by patients with confirmed EVD, or other VHFs be disposed of as Category A waste instead of laundered.[72, 74, 76]

A UK document on viral haemorrhagic fevers recommended that all reusable linen from patients with confirmed VHF be treated and disposed of as Category A waste. Linen from patients with a high probability of VHF may be separated and stored safely pending PCR results. If this is not practicable, they should be treated as Category A waste. If the PCR test is negative, the linen can be treated as Category B.[74] The document also recommends that although items of clothing belonging to deceased VHF patients may be returned after autoclaving and then laundering, items with visible contamination should be disposed of.[74]

WHO guidance advises in a conditional recommendation that heavily soiled linen used in the care of patients with Ebola virus or Marburg disease be incinerated rather than decontaminated. In a subsequent section on 'practical implementation considerations', it is advised that a risk assessment should determine whether soiled linen can be safely decontaminated or incinerated. The document, however, states in

a good practice statement that healthcare workers handling linen should wear the same PPE recommended for other health and care staff but that the aprons and outer pair of gloves be heavy duty and that their shoes be waterproof boots.[78]

A Canadian document requires that linen management - including containing, handling, and on-site transport – be left exclusively to trained personnel wearing appropriate PPE.[72]

Conclusion

In summary, it is recommended within the literature, that infectious linen be handled carefully with minimum agitation, using appropriate PPE and that hand hygiene be performed afterwards. Linen used by patients with confirmed EVD, or other VHFs should be disposed of as Category A waste.

3.1.18 How should infectious linen be sorted?

Three pieces of evidence were included for this research question, all added for this update. [4, 5, 27]

All three were SIGN50 Level 4 expert opinion guidance documents.[4, 5, 27] As with documents of this type, there is a potential risk of bias as there is often a lack of supporting evidence and the methodology with which these guidance documents are formulated is also unclear. All three were published by the UK Department of Health[4, 5, 27] including two parts of HTM 01-04.[4, 5]

No primary studies were included as none that met the inclusion criteria was identified.

Pre-wash sorting

All documents are consistent in recommending that pre-wash sorting of infectious linen should be avoided.[4, 5, 27] A UK guidance document, Health Technical Memorandum HTM 01-04 (Management and Provision) provides for two scenarios for sorting of infectious linen. In the first scenario, infectious linen is segregated at source and sealed in a red water-soluble/alginate bag which is then placed in a white impermeable bag labelled as ‘infectious linen’. The water-soluble bags are transferred directly into the washer without opening or further sorting. In the second scenario, however, no segregation is done at the source and all linen is presumed

infectious. The document further recommends that if any form of pre-wash sorting is required for operation or performance purposes, the first scenario should be adopted.[5]

Another volume within the HTM 01-04 series specific to social care settings describes a simpler process to be adopted for use within these settings. Regarding how infectious linen should be sorted, it describes an 'enhanced process' which is essentially the first scenario described by its sister document – that is linen should be sealed in a red water-soluble bag immediately after they are taken off the bed.[4] This is echoed in another UK guidance document also specific to social care settings.[27] A key point to note is that both documents take a different approach to the classification of linen, hence linen requiring the enhanced process may only be classified as 'used linen' in the management and provision volume of the HTM 01-04.[4, 5]

Conclusion

Pre-wash sorting of infected linen is not recommended in the identified literature. Infectious linen should be segregated at the source and transferred directly into the washer without further sorting.

3.1.19 How should infectious linen be labelled?

A total of six pieces of evidence were included for this research question, [3-5, 21, 72, 78] – all added for this update of the review.

Two guidance documents graded AGREE 'Recommend with modifications' were included, published by the WHO[78] and the Irish National Clinical Effectiveness Committee.[21] Key issues identified were the lack of clarity on the link between the evidence and recommendations,[21] and an unclear methodology section for systematic and rapid reviews conducted.[78]

Four expert opinion guidance documents graded SIGN50 Level 4 were also included: two from the UK,[4, 5] and one each from Canada[72] and the USA.[3] As with most expert opinion guidance documents, there is a potential risk of bias as there is often a lack of supporting evidence and the methodology with which these guidance documents are formulated is also unclear.

No primary studies were included.

Colour-coding.

Two UK expert opinion guidance documents recommend that infectious linen should be placed in red water-soluble bags which should then be placed in white impermeable bags.[4, 5] Guidance documents from Ireland[21] and the US[3] recommend bags identified by label or colour; however, they did not specify any particular colour.

Labelling

All documents identified for this research question provide guidance for labelling the bags in which infectious linen is to be stored. [3-5, 21, 72, 78] Two documents specific for viral haemorrhagic fevers including a WHO document graded AGREE 'Recommend with modifications' are consistent in advising that soiled linen for elimination should be marked properly.[72, 78]

Two expert opinion guidance documents from the UK recommend that the impermeable bags be labelled as 'infectious linen'.[4, 5] However, one document, HTM 04-01 'Decontamination of linen for health and social care – Management and provision' states that the red water-soluble bag may be branded with a bold legend 'infectious linen', however, this is optional.[5]

Documents from Ireland,[21] and the United States[3] although stating that bags containing infectious linen be clearly labelled, provide no specifications.

Conclusion

There is consistency within the evidence that infectious linen bags should be clearly labelled. UK guidance advises that colour-coded bags are used to denote infectious linen.

3.1.20 How should infectious linen be stored?

Three pieces of evidence were identified for this research question, [23, 42, 72] including one carried over from the previous edition of this review.[23]

All of these were opinion guidance documents graded SIGN50 Level 4. [23, 42, 72] Two were published in the UK[23, 42] (including one specific to Scotland[23]), and one in Canada.[72] There is a potential risk of bias with documents of this kind as there is

often a lack of supporting evidence and the methodology with which these guidance documents are formulated is also unclear.

Designated area

There is consistency within the body of evidence identified for this question, that linen should be stored in a designated area or dirty linen store.[23, 42, 72] A Scottish document states that infectious linen must not be stored in domestic services rooms.[23]

Two documents, one focused on handling the deceased including those with infectious diseases[42] and the other, a Canadian document on EVD, recommends further restrictions to the area.[72] The former recommends that the storage be lockable if it is within an area accessible to the public with the latter noting that the storage areas for EVD-associated linen be separate from other storage areas and marked clearly with a biohazard symbol.[42, 72]

Conclusion

Infectious linen is recommended to be stored in a designated area.

3.1.21 How should infectious linen be transported?

A total of four pieces of evidence were identified for this research question,[5, 18, 26, 79] including one carried over from the last version of this review.[5]

All the included documents were expert opinion guidance graded SIGN50 Level 4. Two of these were published in the UK,[5, 79] one in the USA,[26] and another by the WHO.[18] As with evidence of this kind, there is a potential for bias owing to the lack of supporting evidence and the unclear methodology with which these guidance documents are formulated.

The following are additional provisions to the transportation of used linen already discussed in **section 3.1.13**.

Bagging

There is consistency within the evidence base on the need to ensure no leakage or spills from infectious linen during transport.[5, 18, 26] Two guidance documents specify the use of leak-resistant or impervious bags or containment.[18, 26] A guidance

document published in the UK prescribes that bags should be of acceptable weight, not overfilled and securely closed before they are sent to the laundry.[5]

HCID

As already discussed in **section 3.1.17**, reusable linen from patients with EVD or other VHFs is to be treated as Category A waste. Details on how these should be handled before transport are also covered in SHTN 03-01.[79]

Conclusion

From the identified evidence, it is recommended that infectious linen be transported in a way that ensures that there are no spills or leakage during transport.

3.1.22 What is the available evidence for the effectiveness of antimicrobial impregnated linen in reducing healthcare-associated infection?

This research question was added as part of this update to the review.

Seven studies were included for this research question.[80-86]

Two systematic reviews and meta-analyses, graded SIGN50 Level 1++ were included. Both meta-analyses assess the same studies already included in this review.[85, 86] One of them also includes a study excluded by this review because the interventions comprised antimicrobial surfaces in addition to antimicrobial-impregnated linen (AIL).[85]

Two studies graded SIGN50 Level 1+ were included.[83, 84] One was a crossover, double-blind controlled trial[83] and the other was a two-part cluster cross-over trial.[84] Only one part of the latter study was included, the other was excluded because of significant limitations related to uncontrolled confounding variables.[84]

Three studies were graded SIGN50 Level 3 including two before-and-after studies and one interrupted time series.[80-82]

Overview

All primary studies (n=5) used copper oxide-impregnated linen from the same manufacturer.[80-84] The same company provided funding for three of the five studies[81,

[83, 84] and supplied the linen free of charge in another study.[82] The chief medical scientist of the company was a co-author in two of the funded studies.[81, 83]

Effect on all HAIs

Four studies reported on the effect of antimicrobial-impregnated linen (AIL) on all HAIs. These include a prospective cluster randomised cross-over trial (SIGN50 Level 1+),[84] a before-and-after study (SIGN50 Level 3)[81] and two systematic reviews and meta-analyses (SIGN50 Level 1++).[85, 86]

The first study was described as a prospective cluster cross-over randomised control trial and was conducted in a 16-bed general ICU with two separate pods (Wards A and B) of eight beds each.[84] These two pods represented the two clusters for the study. Copper oxide AILs were supplied to Ward A for 23 weeks while standard linen was used in Ward B. This was followed by a 2-week washout period and a crossover which saw Ward A use standard linen and Ward B, AIL, for another 23 weeks. Linen referred to in this study included top sheets, fitted sheets, pillowcases, underpads, washcloths, towels, and patient gowns. The AILs were of salmon colour while the standard linen was white. Infection Control staff that monitored and reported patients with HAIs (according to definitions provided by the National Healthcare Safety Network) to the study investigators were blinded to what wards the patients were allocated to, as were the study investigators. A lower total HAI per 1000 patient days was reported in the AIL group (11.4) compared to the standard linen group (13.0). The HAI rate was 1.1 times higher when standard linen was used compared to AILs but this was not statistically significant (95% CI: 0.6 – 2.0; p=0.6). A total of 1282 patients were included (645 for the AIL group and 637 for the standard linen group)[84]

This study had several limitations. Although described as randomised, patients were assigned to either ward based on bed availability – even though the authors noted that hospital personnel who did the assignment were not involved in the study and had no knowledge of the timeframe or intervention. Other limitations include:

- disparity in the number of patients in each group as reported in the summary of results and the tables. This is unlikely to impact results given that the numbers are very similar and
- no power calculations were provided[84]

The second study, a before-and-after study (SIGN50 Level 3), collected data over two similar 6-month periods in a 35-bed head injury ward that provided long-term care for patients.[81] The study participants were all patients in a low-conscious state dependent on medical staff for everyday needs. In the first period, regular standard linens were used. These were all replaced with copper oxide AILs in the second period. The linens included bed sheets, pillowcases, patient clothing (gowns, shirts, pants), towels, underpads and patient robes. Fifty-seven patients (4337 hospitalisation days) and 51 patients (3940 hospitalisation days) were included in the first and second periods respectively. A statistically significant 24% reduction in HAIs was reported in the second period compared to the first (27.4 vs 20.8 HAI per 1,000 hospitalisation days; p=0.046). The study, however, had some limitations. It was part-funded and staffed by the product's manufacturer, and copper AILs were distinguishable from regular linen, but this is unlikely to have impacted results.[81]

One of the two meta-analyses[85] included two primary studies in its analysis (Marik 2020 [84] and Marcus 2017[83]). Although both primary studies were included in this review, the latter[83] is discussed in the next section because it does not report specifically on HAI rates but on parameters such as antibiotic treatment initiation events per hospitalisation days (ATIEs). This parameter is however included in the meta-analysis as a proxy indicator for HAI rates. The meta-analysis showed significantly lower rates of HAI with copper AILs compared to standard linen with a pooled risk ratio of 0.75 (CI: 0.58 – 0.98).

In the second meta-analysis,[86] a sub-group analysis was conducted which included only primary studies which reported on 'all HAIs' (n=3).[81, 83, 84] Studies that reported on organism-specific HAIs were excluded. It must be noted that the three primary studies used for this sub-group analysis were included in this review and have been discussed in the preceding paragraphs. Two[83, 84] of these studies were also included in the first meta-analysis.[85] The sub-group analysis showed a statistically significant reduction in all HAI rates (IRR=0.76; CI: 0.75 – 0.77). [86] Only the result of this sub-group analysis was included in this review because the other sub-group analysis (HAIs due to MDRO or *C. difficile*) included a primary study that was excluded because the intervention studied was copper-impregnated surfaces in addition to linen, which is out with the scope of the present review. For this reason, the total

values of the meta-analysis (i.e. 'all HAIs' and 'HAIs due to MDRO or *C. difficile*') were also not included.

Organism specific HAIs

Two SIGN50 Level 3-graded primary studies reported on the effect of AILs on HAIs caused by *C. difficile*. They include a before-and-after study[80] and a time-interrupted series.[82]

The before-and-after study conducted in six hospitals in the USA run by a not-for-profit group collected data at three time periods (90, 180 and 240 days) before and after the deployment of copper AILs.[80] The linen replaced included all patient gowns, fitted and flat sheets, towels, washcloths, bath and thermal blankets. The authors reported that similar IPC measures were in place before and after AIL deployment and hand hygiene compliance rates did not vary markedly in the study period. A significant reduction in the incidence rate of HAIs due to *C. difficile* per 10,000 patient-days in the hospital was reported in all three time periods after the linen replacement. There was a 61.2% reduction in the 90 days after compared to the 90 days before (p=0.0116), 41% in the 180 days (p=0.027) and 42.9% in the 240 days (p=0.0096). There were also reductions in the incidence rates of HAIs due to MDROs per 1,000 patient-days in hospital in all three time periods after the replacement; however, none of the reductions were statistically significant. Nevertheless, when the rates of HAIs due to *C. difficile* and MDROs were combined, the reduction was significant in the three time periods. There was a 59.8% reduction in the 90 days after compared to the 90 days before (p=0.0014), 39.9% in the 180 days (p=0.0145) and 37.2% in the 240 days (p=0.0108). Although the AILs were supplied by the product's manufacturer, the author disclosed no further involvement of the company in the study.

Another American study, an interrupted time series, demonstrated a different outcome.[82] This study collected data on monthly HAI rates over an initial 27-month pre-deployment period, a 27-month intervention period (when the AILs were deployed) and a further 10-month post-intervention period (after the AILs were withdrawn). The copper AILs were associated with significantly higher rates of hospital onset (HO) *C. difficile* infections (2.8 vs 1.5 cases per 1000 patient days; p=0.023) and HO-MDRO acquisition (6.3 vs 3.9 cases per 1000 patient days;

p=0.001). The mean monthly hand hygiene compliance was poorer during the intervention period compared to the control periods (90.9% vs 95.3%). This study had several limitations. There is a possibility that several factors including IPC practices could have changed over time which could have affected the outcomes, especially in the absence of a concurrent control group. Poorer hand hygiene compliance during the intervention period also means it is not possible to completely attribute all HAI rises to the copper-impregnated linens. Perhaps more significantly, the surveillance definition for CDI was changed halfway through the intervention period, so that symptoms of CDI no longer needed to be present. This could have led to an overestimation of the cases of CDIs in the last 12 months of the intervention period and the post-intervention 10-month period. The AILs used for the study were provided for free by the manufacturer.[82]

Another American study, the prospective cluster cross-over randomised control trial described in the previous section ('effect on all HAIs/HCAIs'), also reported a reduction in *C. difficile* rates with AILs but this reduction was not statistically significant.[84]

Other indicators

An Israeli crossover double-blind controlled trial, graded SIGN50 Level 1+ evaluated the effect of using copper AILs on four HAI indicators in chronic ventilator-dependent patients in a long-term care facility: antibiotic treatment initiation events (ATIEs), fever days, days of antibiotic treatment (dAB), and antibiotic defined daily dose (DDD).[83] The study included all patients in two similar ventilator-dependent wards and had two three-month intervention periods and a one-month washout period between them. The AILs included bed linen, patient clothes and towels. Use of AIL was associated with a significant 29.3% reduction in ATIEs (p=0.002), a 55% reduction in fever days (p<0.0001), a 23% reduction in dAB (p<0.0001) and a 27.5% reduction in DDD (p<0.0001). All values reported are per 1,000 hospitalisation days. The study had several limitations. Funding was provided by the product's manufacturer which also had a member of staff as one of the study authors. Despite noting that both staff and participants were blinded, the paper did not provide details on blinding except that linen were color-coded.[83]

Another Israeli study, a before-and-after study graded SIGN50 Level 3 which has been described previously, also observed a statistically significant 47% reduction in fever days per 1000 hospitalisation days (7.1 vs 13.4; p=0.0085), a 23% reduction in the number of times antibiotics were given per 1000 hospitalisation days (16.5 vs 21.44; p=0.052) and total days of antibiotics per 1000 hospitalisation days (257.1 vs 382.7; p<0.0001).[81]

Conclusion

The evidence base suggests that copper AILs may be effective in reducing general HAI rates and other specific proxy indicators. The evidence regarding *C. difficile* HAI was less certain as the quality of the primary studies is generally low, and the evidence is fraught with conflict of interest as most of the studies were funded in some way by the manufacturer of the product.

3.1.23 What is the available evidence on post-laundry disinfection for linen in healthcare?

A total of six pieces of evidence were included for this research question.[3, 5, 18, 41, 51, 74] This research question was added as part of this update.

Two outbreak studies were graded SIGN50 Level 3.[41, 51]

Four expert opinion guidance were graded SIGN50 Level 4.[3, 5, 18, 74]

Operating theatres and other special units

Three SIGN50 Level 4 expert opinion guidance were consistent in advising that certain situations may require sterility or very high microbiological quality, especially in operating theatres.[3, 5, 18] A WHO document recommended that linen supplied to high-risk areas such as burns and transplant units, should be autoclaved.[18]

Outbreak management

Two outbreak studies (SIGN50 Level 3) reported post-laundry treatment of linen as part of outbreak management measures.[41, 51] One study described a *Bacillus cereus* outbreak where post-laundry autoclaving was implemented as a control measure.[41] Management of a Mucorales outbreak included the use of gamma irradiation of linen

following laundering.[51] However, as these were part of bundled interventions, it is not possible to determine their effects in isolation.

HCID

An expert opinion guidance document (SIGN50 Level 4) on Hazard Group 4 viral haemorrhagic fevers published by the UK Advisory Committee on Dangerous Pathogens recommends autoclaving of clothing items belonging to deceased patients before the items are returned to their relatives. The document specifies that this can only be done if the items are not visibly contaminated, in which case they should be safely disposed of.[74]

Conclusion

The literature suggests that post-laundry disinfection of linen may be required in certain situations for example where linen sterility is required (in the operating theatre), or to reduce the risk of indirect transmission from deceased patients. Post-laundry disinfection has also been used as part of measures for the management of linen-related outbreaks.

3.1.24 When is linen deemed unfit for reuse?

This research question was added as part of this update to the review.

Eight pieces of evidence were included for this research question.[2, 17, 23, 42, 72, 74, 76, 78]

One guidance document was graded AGREE 'Recommend with modifications'.[78]

One Mandatory document published by the Scottish Government was included.[17]

Six expert opinion guidance documents were graded SIGN50 Level 4.[2, 23, 42, 72, 74, 76]

No primary studies were included.

Heavy contamination and HCID

There is consistency within the evidence, that linen should be considered unfit for reuse if it has been used in patients with HCID, particularly confirmed Category 4 infections. Linens in this category are not to be returned to the laundry.[17, 23, 72, 74, 76, 78] A Scottish document includes linen from patients with suspected Category 4 infections in this provision.[23] Although a WHO document graded AGREE

'recommend with modifications' gave a conditional recommendation in agreement with this, it noted that a risk assessment be conducted to determine if safe decontamination is possible or whether the linen needs to be eliminated.[78]
A mandatory Scottish Government document also noted that uniforms heavily contaminated with blood or body fluids may be condemned by the laundry after it has been laundered.[17] The document was unclear about the criteria to be met for such uniforms to be condemned.

Damage

Extant guidance is consistent that linen should be deemed unfit for reuse if it contains unremovable stains, is discoloured, or shows signs of thermal or physical damage such as stiffening or bad tearing.[2, 23, 42] An American standard for healthcare laundries recommends that linen with physical damage that negatively affects functional attributes be retired or removed from use.[2]

Conclusion

Within the evidence base identified for this question, linen was generally considered unfit for reuse when it is heavily contaminated or used in the care of patients with confirmed EVD or other Category 4 VHFs and when it is physically damaged.

3.1.25 How should linen deemed unfit for reuse be safely disposed of?

This research question was added as part of this update to the review and is very closely linked to the previous question.

Eight pieces of evidence were identified for this research question.[2, 17, 23, 42, 72, 74, 76, 78]

One guidance document was graded AGREE 'Recommend with modifications'.[78]

One document published by the Scottish Government was graded mandatory.[17]

Six expert opinion guidance documents were graded SIGN50 Level 4.[2, 23, 42, 72, 74, 76]

Overview

Within the evidence identified, there is consistency that the linen disposal method depends on why it has been deemed unfit.

Linen deemed unfit because of use in HCID

Two expert opinion guidance documents published in the UK including one from Scotland recommend that linen used for the care of patients with Ebola or other Category 4 VHFs be treated and disposed of as Category A infectious waste and incinerated.[23, 74] This is consistent with provisions of an expert opinion guidance document from the US[76] and one from the WHO graded AGREE 'recommend with modifications'.[78] The US document, however, also recommends autoclaving as an alternative for treatment of waste in this category.[76] A Canadian expert opinion guidance document simply recommends that linen in this category be treated and disposed of following biohazardous waste regulations.[72]

Heavily contaminated linen

A mandatory document from the Scottish Government states that uniforms condemned by the laundry as unfit because of heavy contamination should be placed in a healthcare waste sack and disposed of as healthcare waste.[17]
A document specific for autopsies recommends disposing of heavily soiled linen deemed unfit for reuse as clinical waste.[42]

Damaged linen

A Scottish expert opinion guidance document recommends that processed damaged linen be disposed of by laundries via the domestic waste stream and that the notifications be sent to the ward/department of origin if required.[23]

An American guidance document specific to healthcare laundries provides guidance for reusable surgical linen that fails to meet the minimum performance criteria for that category to be used in an alternative less stringent category (downgrading).[2]

Conclusion

Within the evidence identified for this question, linen deemed unfit due to use in the care of a patient with Category 4 VHFs should be disposed of as Category A waste and incinerated. Damaged linen may be disposed of as domestic waste or as clinical or healthcare waste if they are heavily contaminated.

3.1.26 How should curtains be put up and taken down to minimise transmission of infection?

Four pieces of evidence were included for this research question.[46, 87-89]

All four documents were graded SIGN50 Level 4.[46, 87-89] As with Level 4 expert opinion guidance documents, there is a risk of bias owing to the lack of supporting evidence and the unclear methodology with which these guidance documents are formulated.

Two pieces of evidence recommended that when curtains are taken down, they should be unloaded directly into a container and that they should be changed at the end of the cubicle furthest from the patient's head.[87, 88] All four documents require the use of PPE and hand hygiene.[46, 87-89] The National Cleaning Services specification published by HFS provides a step-by-step guide on curtain changing. However, the provisions to unload curtains directly into a container and change curtains at the point furthest from the patient's head, which has been noted earlier, are not mentioned.[89]

3.2 Implications for research

As shown by this review, there is a need for more high-quality research to evaluate the effectiveness of antimicrobial-impregnated linen (AIL) in reducing the rates of healthcare-associated infections. All the included primary studies used only copper-impregnated linen produced by the same manufacturer who also funded most of the studies. There is a need for primary studies that assess AILs produced by additional manufacturers, to determine if there are product-derived differences. There is also a need for studies that compare copper oxide AILs and AILs impregnated with silver or other biocides. Several studies on AILs were excluded from this review because although they compared contamination levels between AILs and standard linen, they did not report any impact on HAIs.[90-107] A list of all studies excluded from the review after critical appraisal is provided in **Appendix 5**.

This review also highlights a need for more primary studies to evaluate the impact of specific methods of making and stripping beds on the risk of developing HAIs. Although several studies were identified, how the beds were changed was not

described and hence these studies were excluded.[108-110] Some guidance documents including one in Canada recommend a method of stripping beds that involve rolling or folding soiled bed linen in such a way that the area with the greatest soiling is in the middle of the bundle.[19, 34, 40] However, there is no evidence to underpin this practice. No studies or guidance documents were found on how beds should be made to reduce the risk of contamination.

One recurring theme in linen-associated *Bacillus cereus* outbreaks identified for this review,[41, 57, 58, 61] including an outbreak study in the United Kingdom,[57] is the role of summertime temperatures. However, this was not evaluated within the evidence base and was generally not highlighted in any guidance documents. As this spore-forming bacteria can be difficult to remove through laundering, it may be helpful to have studies that evaluate the seasonal changes in *B. cereus* occurrence and contamination levels in linen to understand the associated factors and to implement strategies to mitigate them.

Some studies focused on linen decontamination methods especially curtains rather than laundering. These studies were excluded as being outwith the scope of this review.[111-118] The methods used included ultraviolet C devices, hydrogen peroxide sprays, alcohol and quaternary ammonium chloride. These may be considered in future iterations of this review.

Although evidence highlighted the need for linen sterility in operating rooms, there was no clarity on the quality requirements for other specialised units like burns and intensive care. High-quality studies that compare the use of sterile linen and laundered linen may provide some evidence to inform whether a change in practice is justified.

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Appendix 1: Literature Review Search Strategies

Medline/Embase

Search 2000 to current

Ovid MEDLINE(R) ALL <1946 to September 06, 2023>

1. exp Textiles/

2. exp "Bedding and Linens"/

3. Clothing/

4. Protective Clothing/

5. Surgical Attire/

6. textile*.mp.

7. linen*.mp.

8. bedding*.mp.

9. (fabric or fabrics).mp.

10. (bed sheet* or bedsheet* or duvet* or pillow* or slide sheet* or blanket* or curtain* or hoist sling* or towel* or clothes or clothing or gown* or scrubs or attire or workwear or garment*).ti,ab,kf.

11. (uniform or uniforms).ti,kf.

12. laundr*.mp.

13. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12

14. Disinfection/

15. disinfect*.mp.

16. Laundering/

17. Laundry Service, Hospital/

18. laundr*.mp.

19. (launder* or wash* or clean*).ti,ab,kf.

20. monitor*.ti,kf.

21. Decontamination/

22. decontamina*.mp.

23. antimicrobial.mp. 24. (bedmaking or bed making).mp. 25. handl*.ti,kf. 26. (store* or storage or storing).ti,kf. 27. warm*.ti,kf. 28. 14 or 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 29. exp Infections/ 30. exp Infection Control/ 31. exp Disease Transmission, Infectious/ 32. Cross Infection/ 33. (infect* adj5 (prevent* or control*)).mp. 34. (IDHC or HCID or high consequence infectious disease* or "infectious disease* of high consequence").mp. 35. exp Disease Outbreaks/ 36. exp Health Facilities/ 37. (healthcare or health care or hospital or hospitals).mp. 38. 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 39. 13 and 28 and 38 40. limit 39 to (english language and yr="2000 -Current")

Embase <1974 to 2023 September 06>

1. exp textile/
2. bed linen/
3. clothing/
4. protective clothing/
5. exp surgical attire/
6. textile*.mp.
7. linen*.mp.
8. bedding*.mp.
9. (fabric or fabrics).mp.
10. (bed sheet* or bedsheet* or duvet* or pillow* or slide sheet* or blanket* or curtain* or hoist sling* or towel* or clothes or clothing or gown* or scrubs or attire or workwear or garment*).ti,ab,kf.
11. (uniform or uniforms).ti,kf.
12. laundr*.mp.
13. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 106169
14. exp disinfection/
15. disinfect*.mp.
16. laundry/
17. laundr*.mp.
18. (launder* or wash* or clean*).ti,ab,kf.
19. monitor*.ti,kf.
20. decontamination/
21. decontamina*.mp.
22. antimicrobial.mp.

23. (bedmaking or bed making).mp.
24. handl*.ti,kf.
25. (store* or storage or storing).ti,kf.
26. warm*.ti,kf.
27. 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 1076736
28. exp infection/
29. exp infection control/
30. exp disease transmission/
31. cross infection/
32. (infect* adj5 (prevent* or control*)).mp.
33. (IDHC or HCID or high consequence infectious disease* or "infectious disease* of high consequence").mp.
34. exp epidemic/
35. exp health care facility/
36. (Healthcare or health care or hospital or hospitals).mp.
37. 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36
38. 13 and 27 and 37
39. limit 38 to (english language and yr="2000 -Current")
40. 39 not conference*.so,pt.

CINAHL

Search 2000 to current

S1 (MH "Textiles") OR (MH "Clothing") OR (MH "Protective Clothing")

S2 (MH "Bedding and Linens+")

S3 textile*

S4 linen*

S5 bedding*

S6 fabric or fabrics

S7 "bed sheet*" or bedsheet* or duvet* or pillow* or "slide sheet*" or blanket* or curtain* or "hoist sling*" or towel* or clothes or clothing or gown* or scrubs or attire or workwear or garment*

S8 TI (uniform OR uniforms) OR SU (uniform OR uniforms)

S9 laundr*

S10 S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9

S11 (MH "Sterilization and Disinfection")

S12 disinfect*

S13 (MH "Laundry Department")

S14 laundr*

S15 launder* or wash* or clean*

S16 TI (monitor*) OR SU (monitor*)

S17 decontamina*

S18 antimicrobial or anti-microbial

S19 bedmaking or bed making

S20 TI (handl*) OR SU (handl*)

S21 TI (store* or storage or storing) OR SU (store* or storage or storing)

S22 TI (warm*) OR SU (warm*)

S23 S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19

OR S20 OR S21 OR S22

S24 (MH "Infection+")

S25 (MH "Infection Control+")

S26 (MH "Disease Transmission+")

S27 (MH "Cross Infection")

S28 infect* N5 (prevent* or control*)

S29 IDHC or HCID or high consequence infectious disease* or "infectious disease* of high consequence"

S30 (MH "Disease Outbreaks+")

S31 (MH "Health Facilities+")

S32 healthcare or health care or hospital or hospitals

S33 S24 OR S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32

S34 S10 AND S23 AND S33

S35 S10 AND S23 AND S33 (Limiters - Published Date: 20000101-20231231 Search modes - Boolean/Phrase)

Appendix 2: Evidence levels

SIGN50 Evidence levels

The SIGN50 methodology was used to appraise and grade primary studies and expert opinion guidance documents.

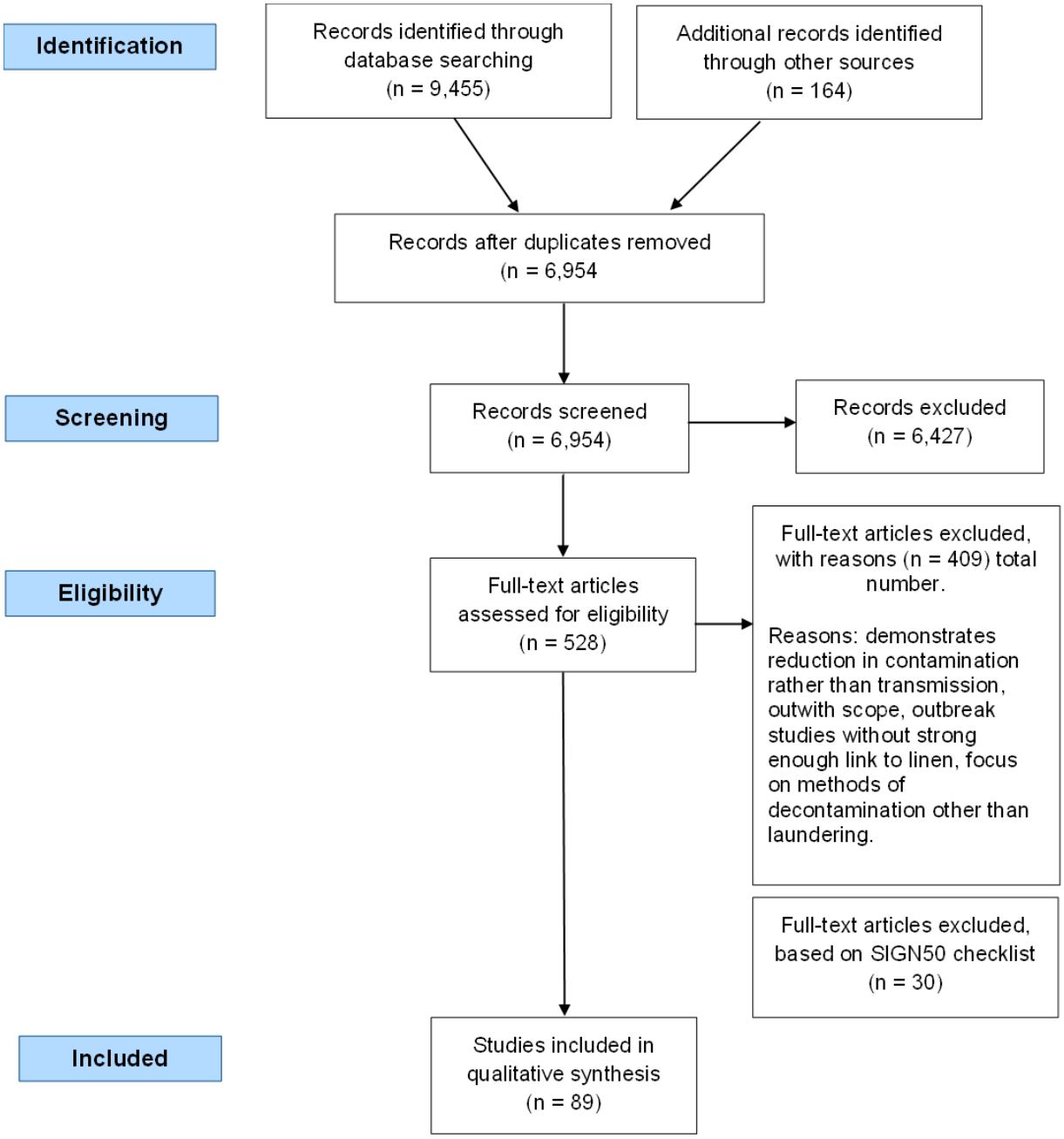
Grade	Description
1++	High-quality meta-analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias
1+	Well-conducted meta-analyses, systematic reviews of RCTs, or RCTs with a low risk of bias.
1-	Meta-analyses, systematic reviews of RCTs, or RCTs with a high risk of bias
2++	High-quality 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

The AGREE II tool was used to appraise guidelines which were based on a systematic review of evidence, and experts have formulated the recommendations/ statements.

Grade	Description
AGREE 'Recommend'	This indicates that the guideline has a high overall quality and that it can be considered for use in practice without modifications or alterations.
AGREE 'Recommend with modifications'	This indicates that the guideline has a moderate overall quality. This could be due to insufficient or lacking information in the guideline for some items. If modifications or alterations 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 has a low overall quality and serious shortcomings. Therefore, it should not be recommended for use in practice.

Appendix 3: PRISMA flow diagram



Appendix 4: Standards Pertaining to Linen Management

This appendix provides a non-exhaustive list of standards pertaining to linen management. 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	Publication Date
BS EN 14065:2016	Textiles. Laundry processed textiles. Biocontamination control system	This standard provides for a management system to ensure the provision of processed textiles with appropriate microbiological quality Although this standard provides specifications for healthcare linen, it is not specific for healthcare linen.	May 2016
BS EN ISO 20743:2021	Textiles — Determination of antibacterial activity of textile products	This standard provides specifications on quantitative test methods to determine the antibacterial activity of all textile products	June 2021

Standard	Title	Description	Publication Date
		claimed to have antibacterial properties.	
BS EN 16616:2022	Chemical disinfectants and antiseptics. Chemical-thermal textile disinfection. Test method and requirements (phase 2, step 2)	This standard provides specification on testing methods and minimum requirements for the microbicidal activity of specified processes for disinfection of contaminated textiles.	September 2022
BS EN 14885:2022	Chemical disinfectants and antiseptics — Application of European Standards for chemical disinfectants and antiseptics.	This standard provides specifications to which products claimed to have microbicidal activity has to conform It is applicable to products (including those for laundry) claimed to be active against bacterial spores, vegetative bacteria, yeasts, fungal spores and	July 2022

Standard	Title	Description	Publication Date
		viruses including bacteriophages.	
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)	This standard provides specification on test methods and minimum requirements for fungicidal and yeasticidal activities for textile disinfection products.	November 2021
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)	This standard provides specification for testing and the minimum requirements for virucidal activity of chemical disinfectants and antiseptic products including those for linen disinfection.	July 2019
BS EN 14348:2005	Chemical disinfectants and antiseptics.	This document provides specifications for	February 2005

Standard	Title	Description	Publication Date
	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, step 1)	testing method and minimum requirements for mycobacterial (or tuberculocidal) activity of chemical disinfectants and include those used in laundries.	
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)	This document provides specifications for testing method and minimum requirements for sporicidal activity of chemical disinfectants and include those used in linen disinfection.	December 2018

Appendix 5: Studies excluded following critical appraisal.

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

- Bache SE, Maclean M, Gettinby G, et al. Airborne bacterial dispersal during and after dressing and bed changes on burns patients. J Burns 2015; 41: 39-48.
- Bache SE, Maclean M, Gettinby G, et al. Quantifying bacterial transfer from patients to staff during burns dressing and bed changes: implications for infection control. 2013; 39: 220-228.
- Bujnicki B, Sowinski P, Makowski T, et al. Microbiologically Pure Cotton Fabrics Treated with Tetrabutylammonium OXONE as Mild Disinfection Agent. Materials (Basel) 2022; 15: 03.
- Campbell JR, Hulten K and Baker CJ. Cluster of Bacillus species bacteremia cases in neonates during a hospital construction project. Infect Control Hosp Epidemiol 2011; 32: 1035-1038.
- Das I, Lambert P, Hill D, et al. Carbapenem-resistant Acinetobacter and role of curtains in an outbreak in intensive care units. Journal of Hospital Infection 2002; 50: 110-114.
- Dougall LR, Booth M, Khoo E, et al. Continuous monitoring of aerial bioburden within intensive care isolation rooms and identification of high-risk activities. 2019; 103: 185-192.
- Duc BN, Gupta N, Abou-Daoud A, et al. A polymicrobial outbreak of surgical site infections following cardiac surgery at a community hospital in Florida, 2011-2012. American Journal of Infection Control 2014; 42: 432-435.
- Fujita R, Kurosu H, Norizuki M, et al. Potential risk of SARS-CoV-2 infection among people handling linens used by COVID-19 patients before and after washing. Sci 2022; 12: 14994. Research Support, Non-U.S. Gov't.

- Gould S, Atkinson B, Onianwa O, et al. **Air and surface sampling for monkeypox virus in a UK hospital: an observational study**, (2022, accessed 12 3).
- Hathway EA, Noakes CJ, Fletcher LA, et al. The role of nursing activities on the bioaerosol production in hospital wards. Indoor and Built Environment 2013; 22(2): 410-421.
- Hayajneh AA, Jaradat ZW, Alsatari ES, et al. Predictors of growth of Escherichia coli on lab coats as part of hospital-acquired infection transmission through healthcare personnel attire. International Journal of Clinical Practice 2021; 75: e14815.
- Jordan A, James AE, Gold JAW, et al. Investigation of a Prolonged and Large Outbreak of Healthcare-Associated Mucormycosis Cases in an Acute Care Hospital-Arkansas, June 2019-May 2021. Open forum infect 2022; 9: ofac510.
- Lakdawala N, Pham J, Shah M, et al. Effectiveness of low-temperature domestic laundry on the decontamination of healthcare workers' uniforms. Infect Control Hosp Epidemiol 2011; 32: 1103-1108.
- Lee ALH, Leung ECM, Wong BWH, et al. Clean clothes or dirty clothes? Outbreak investigation of carbapenem-resistant Acinetobacter baumannii related to laundry contamination through multilocus sequence typing (MLST). Infect Control Hosp Epidemiol 2023; 44: 1274-1280.
- Lopez-Gigosos R, Mariscal A, Gutierrez-Bedmar M, et al. Persistence of nosocomial bacteria on 2 biocidal fabrics based on silver under conditions of high relative humidity. American Journal of Infection Control 2014; 42: 879-884. Research Support, Non-U.S. Gov't.
- Mahida N, Beal A, Trigg D, et al. Outbreak of invasive group A streptococcus infection: contaminated patient curtains and cross-infection on an ear, nose and throat ward. Journal of Hospital Infection 2014; 87: 141-144.
- Nordstrom JM, Reynolds KA and Gerba CP. Comparison of bacteria on new, disposable, laundered, and unlaundered hospital scrubs. American Journal of Infection Control 2012; 40: 539-543.

- Ohsaki Y, Koyano S, Tachibana M, et al. Undetected Bacillus pseudo-outbreak after renovation work in a teaching hospital. J Infect 2007; 54: 617-622.
- Patel SN, Murray-Leonard J and Wilson AP. Laundering of hospital staff uniforms at home. Journal of Hospital Infection 2006; 62: 89-93. Evaluation Study.
- Shiomori T, Miyamoto H, Makishima K, et al. Evaluation of bedmaking-related airborne and surface methicillin-resistant Staphylococcus aureus contamination. Journal of Hospital Infection 2002; 50: 30-35.
- Shiomori T, Miyamoto H, Makishima KJAoOH, et al. Significance of airborne transmission of methicillin-resistant Staphylococcus aureus in an otolaryngology–head and neck surgery unit. 2001; 127: 644-648.
- Sridhar SA, Ledeboer NA, Nanchal RS, et al. Antimicrobial Curtains: Are They as Clean as You Think? Infect Control Hosp Epidemiol 2016; 37: 1260-1262. Letter.
- Teal LJ, Schultz KM, Weber DJ, et al. Invasive Cutaneous Rhizopus Infections in an Immunocompromised Patient Population Associated with Hospital Laundry Carts. Infect Control Hosp Epidemiol 2016; 37: 1251-1253.
- Twomey CL, Beitz H and Johnson HBJS. Bacterial contamination of surgical scrubs and laundering mechanisms: infection control implications. 2010; 6: 16-21.
- World Health Organization. TB/HIV: a clinical manual. 2nd ed. Geneva: World Health Organization, 2004.