ARHAI Scotland

Antimicrobial Resistance and Healthcare Associated Infection

NHS National Services Scotland

Existing and emerging technologies used for the decontamination of the healthcare environment: Steam

Literature review and practice recommendations

Publication date: 18 November 2021

Key Information

Document title: Existing and emerging technologies used for the decontamination of the healthcare environment: Steam

Date published/issued: 18 November 2021

Date effective from: 18 November 2021

Version/issue number: 3.0

Document type: Literature review and practice recommendations

Document status: Final

Contact

ARHAI Scotland Infection Control team:

Telephone: 0141 300 1175

Email: **nss.hpsinfectioncontrol@nhs.scot**

Document Information

Description:	This literature review examines the available professional literature on the use of Steam Decontamination Systems in the healthcare setting.
Purpose:	To inform the ARHAI Scotland program on Infection Control in the Built Environment and Decontamination.
Target Audience:	All health and care staff involved in the prevention and control of infection in Scotland.
Circulation list:	Infection Control Managers, Infection Prevention and Control Teams, Public Health Teams
Update/review schedule:	Updated as new evidence emerges with changes made to recommendations as required. Review will be formally updated every 3 years with next review in 2024.
Cross reference:	National Infection Prevention and Control Manual
Update level:	Practice – No changes to currently advised practice. Research – Calls for research into the clinical effectiveness of steam decontamination systems, with suitable comparison to cleaning protocols currently in use within NHS Scotland. Additionally, there is a need for research into the efficacy of steam decontamination systems that does not include other interventions and technologies, such as microfiber cloths. There is also a need for research assessing the cost-effectiveness of steam decontamination systems.

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
3.0	November 2021	Review undertaken using the National Infection Prevention and Control Manual (NIPCM) methodology. New recommendations added.
2.0	December 2016	Addition of categories for recommendations. No changes made to the content of the literature review.
1.0	May 2015	Defined as final

Approvals

Version	Date Approved	Name
3.0	November 2021	National Policies and Outbreaks Steering Group
2.0	December 2016	
1.0	May 2015	

Contents

1. Objectives

The aim of this review is to examine the extant professional literature regarding the use of steam systems for the decontamination of healthcare environments. The specific objectives of the review are to determine:

- Are steam decontamination systems currently in use in UK healthcare settings?
- What is the actual or proposed mechanism of action of steam decontamination systems?
- What is the procedure for using steam decontamination systems?
- What is the scientific evidence for effectiveness of steam for decontamination of the healthcare environment?
- Are there any safety considerations associated with using steam decontamination systems in the healthcare setting?
- Are there any practical or logistical considerations associated with using steam decontamination systems in the healthcare setting?
- What costs are associated with using steam decontamination systems in the healthcare setting?
- Have steam decontamination systems been assessed by the Rapid Review Panel?

N.B. This review did not assess the use of steam disinfection systems used to sterilise medical equipment.

2. Methodology

This targeted literature review was produced using a defined single-person methodology as described in the National Infection Prevention and Control Manual: Methodology

3. Discussion

3.1 Implications for practice

Are steam decontamination systems currently in use in UK healthcare settings?

Steam decontamination systems are not mentioned in in the recommendations of the NHSScotland National Infection Prevention and Control Manual (NIPCM),[1] or the NHSScotland Infection Prevention and Control Manual for older people and adult care homes (CH IPCM).[2] Steam decontamination systems are referenced within the NIPCM systematic literature review regarding Safe Management of the Care Environment[3], with the National Patient Safety Agency and NHSScotland National Cleaning Services Specification cited. The NHSScotland National Cleaning Services Specification (NHSScotland NCSS)[4] mentions that steam decontamination systems may be used for the cleaning of surfaces, floors and patient care equipment in ambulances and patient transport vehicles, if available. However, they state that steam cleaners must only be used by staff who have received appropriate training. The use of steam decontamination systems within certain health and care settings to aid in the cleaning of soft furnishings is known. Prior to any use, this should be discussed with local health protection or infection control teams.

The National Patient Safety Agency (NPSA) Revised Healthcare Cleaning Manual[5] states that the use of steam decontamination machines is increasing. The manual suggests that the use of steam cleaning is at least as effective as standard cleaning, with the added benefit of being able to clean crevices and hard-to-reach surfaces. It highlights the importance of training staff in the use of steam decontamination devices and notes that, as commercially available steam decontamination machines can vary considerably in quality and effectiveness, careful consideration should be given to the relative merits of products available. Instructions on how

to use steam devices for routine cleaning, deep cleaning and terminal cleaning tasks, are also included.[5]

The Health and Safety Executive (HSE)[6] recommends using steam decontamination in response to spills on carpet and upholstery, after detergent cleaning is complete, as long as materials tolerate this. It is also highlighted that steam decontamination treatments are variable in efficacy, depending on the nature of textiles being treated, equipment, and disinfectants being used. These factors should be considered when using this method of decontamination.

The NPSA Revised Healthcare Cleaning Manual[5] details the protocol for routine and terminal cleaning using steam decontamination devices, suggesting these systems are used within UK healthcare settings. Royal United Hospital Bath NHS Trust[7] provides a further steam decontamination protocol.

A Black Country Partnership NHS Foundation Trust[8] guidance document recommends that steam decontamination be used as part of regular cleaning of carpets and other textiles, as well as periodic deep cleaning of all clinical areas. Steam decontamination of carpets and other textiles is also recommended by Harrogate and District NHS Foundation Trust.[9]

Garvey et al[10] presented an observational report that outlines a bundled IPC approach, including steam decontamination after standard terminal clean, when cleaning a treatment room after a single patient positive for carbapenemase-producing organisms (CPO). This approach was taken within University Hospitals Birmingham NHS Foundation Trust[10].

The two steam decontamination systems which have been assessed by the Public Health England Rapid Review Panel were both classified as grade 6, meaning that they are considered established products.[11]

These findings suggest that steam decontamination systems are currently in use within UK healthcare settings.

What is the actual or proposed mechanism of action of steam decontamination systems?

Steam decontamination systems use superheated dry steam, delivered under pressure at a temperature of 140°C or greater, which kills microorganisms. Steam decontamination units can also loosen organic debris that is then removed from the surface using a vacuum suction component, providing a dual cleaning and disinfection process.[5, 12] .

There are a variety of dry-saturated steam systems available. All of those included in the efficacy section below generate steam vapour at a pressure of between 6 and 8 bar, and a temperature between 165-180˚C. Devices that generate steam at higher temperatures (around 180˚C) are often classed as overheated dry atomised steam cleaners. Some systems can also be used with a sanitising solution that contributes to the disinfecting action of steam.

Efficacy of systems is dependent on use following manufacturer's instructions or guidance provided by the Health and Safety Executive (HSE).

What is the procedure for using steam decontamination systems?

Correct training in the use of steam decontamination devices is particularly important. It is a complex process and the apparatus includes a range of attachments; each environmental site requires the appropriate delivery system. Any staff using these cleaners must be trained appropriately and their cleaning should be monitored and supervised. [4, 5, 12-15]

Prior to steam decontamination, all equipment should be gathered including hazard signs, any PPE which may be required and the appropriate cloths, mops, or paper towels. At this time, the correct accessories for the steam decontamination system should be assembled.[5, 7, 14] The NPSA and the Irish Health Service Executive (Irish HSE) Cleaning Manual both recommend that a plan be made before starting cleaning.[5, 14]

It is unclear from the literature if detergent cleaning before steam decontamination is required. Dancer[16] reports that unlike ultraviolet light and airborne hydrogen peroxide disinfection systems, steam can be applied to surfaces without prior cleaning. This is supported by Gillespie *et al.*[15], who reported a reduction of detergent use to 0 litres, across two wards, after implementation of a steam decontamination protocol, due to the lack of cleaning prior to the steam system being used. However, the HSE[6] notes that steam decontamination should only be undertaken, after detergent cleaning. Yoshino *et al.*[13] also reported that sanitising chemicals were used prior to steam decontamination as part of their comparative study.

Warning signs should be placed in the area that steam decontamination is taking place, hand hygiene should be undertaken and any PPE required should be donned. Some manufacturers state that PPE is not required while using their devices, however, the NIPCM and NHSScotland NCSS recommends the use of appropriate PPE when cleaning the healthcare environment. Risk assessment regarding the use of PPE should be undertaken before use of steam

decontamination devices. The steam decontamination unit should be filled and allowed to come to temperature and pressure, as per the manufacturer's instructions.[5, 7, 14] The NPSA Revised Healthcare Cleaning Manual states that this should take around 4 to 8 minutes, however, this will vary between devices.[5]

When the steam decontamination unit reaches the required temperature, decontamination can commence working in sections of 1-2 meters, starting at the highest point and working downwards.[5] The Royal United Hospital Bath NHS Trust recommend wiping cleaned areas down with paper towels to remove any condensed water produced during the decontamination process, while others recommend cloths.[5, 7, 14] It is recommended that the device be switched off when changing the cleaning head or other accessories.[5] The procedure for cleaning should always be guided by the manufacturer's instructions for use.[14]

The NPSA Revised Healthcare Cleaning Manual[5] also highlights that the effectiveness of steam decontamination depends on the skill of the user in ensuring that the steam nozzle remains the optimum distance from the treated surface and that each part of the surface is exposed to steam for the optimum length of time. If the steam nozzle is too far away from the surface being treated, or if it passes over the surface too quickly, the desired temperature will not be reached.

After use, dirty water, used cloths, mops, and paper towels should be disposed of appropriately. The steam decontamination device should be cleaned before being returned to the storage area. After this, cleaning personnel should remove warning signs from the area, doff PPE appropriately, and perform hand hygiene.[5, 7, 14]

Since steam decontamination devices are electrical appliances, they should be checked thoroughly for damage regularly to maintain safety.[7, 14]NHS organisations are also required to undertake PAT testing on all electric equipment before use and at regular intervals.

There is some degree of consensus across the included literature as to the procedure that should be used when undertaking steam decontamination. However, the need for detergent cleaning prior to steam decontamination is unclear.

What is the scientific evidence for effectiveness of steam for decontamination systems in the healthcare setting?

Steam decontamination devices have shown efficacy against a wide range of pathogens, including VRE, MRSA, and Gram-negative bacilli.[17] The Department of Health[12] reported that

steam cleaning and disinfection systems have been shown to completely remove MRSA, *Acinetobacter*, *Klebsiella*, and *C. difficile*, from a range of test surfaces, including laminate work surface, stainless steel, vinyl coverings, textiles, and both smooth vinyl and textured linoleum floor tiles. HSE highlight that the efficacy of steam decontamination devices can vary depending on the materials that are being cleaned.[6] In addition, it was noted across the literature that the correct tools and technique are required to ensure the efficacy of steam decontamination.[4, 5, 12-15]

The NPSA[5] reports that, with proper use, steam decontamination devices are at least as effective as conventional cleaning methods at removing soil from surfaces, and may be more effective when applied to difficult to reach surfaces. However, it is noted that the efficacy of steam decontamination devices will vary. The NPSA notes that moist heat decontamination systems functioning above 80˚C will be effective against most hospital pathogens, except bacterial spores. Highlighting that for effective cleaning, systems must be functioning at a high enough temperature to kill any pathogens present.

It should be noted that the evidence provided by The Department of Health, HSE, and the NPSA is considered expert opinion or guidance which under the SIGN methodology is designated level 4 evidence.

Four studies that performed in situ testing of steam decontamination devices were included in this review; two observational studies, one interrupted time series, and one before and after study. The observational study by Doan *et al.*[18] investigated the clinical and cost effectiveness of eight disinfection methods for terminal disinfection of hospital isolation rooms contaminated with *C. difficile*. The study included two steam disinfection methods: steam decontamintion and overheated dry atomised steam decontamination and compared these to a chlorine-releasing agent used at 1,000 ppm available chlorine (. Based on this study, steam decontamination was almost as clinically effective as the chlorine-releasing agent with a standardised median log10 reduction in colony count of 2.0, as opposed to 2.3 for the chlorine-releasing agent. However, overheated dry atomised steam decontamination was significantly less clinically effective, showing a standardised median log10 reduction in colony count of 0.4, compared with 2.3 for the chlorine-releasing agent.

The interrupted time series by Gillespie *et al.*[19] compared the efficacy of steam decontamination and microfibre cloths against standard terminal cleaning using detergent, followed by 1,000 ppm sodium hypochlorite solution, on the transmission of VRE in the ICU of an acute medical-

surgical and trauma facility in Monash (Australia). Following the four-month baseline period of standard cleaning, the VRE transmission rate initially fell but then transiently increased, coinciding with a reduction in cleaning staff hours as a consequence of the allocation of additional responsibilities to the staff. A further significant improvement was demonstrated 15 months after introduction of the intervention (p = 0.003). The study combined multiple intervention components – hence, it was not possible to determine whether this impact was solely from the use of steam decontamination or microfibre technology. In addition, a number of potential confounding factors were identified: an educational programme for cleaning staff, training in the use of fluorescent markers for monitoring of environmental contamination, and alterations in cleaning staff working hours.

Sexton *et al.*[20] performed a before and after study in single bed intensive care unit rooms assessing the efficacy of a steam decontamination device with novel thermal-accelerated nanocrystal sanitation (TANCS) technology, at 12-15 psi with a surface contact time of 10-20 seconds, against *C. difficile*, methicillin-intermediate *staphylococcus aureus* (MISA), and methicillin-resistant *S. aureus* (MRSA). Six surfaces were sampled from eight patient rooms using moistened cotton swatches, before and after decontamination with the steam system and colony forming units were calculated to evaluate microbial contamination. Both MISA and MRSA were reduced below detectable levels (<4.0 cfu/in) on all surfaces after steam decontamination. *C. difficile* was only found on one door push panel before treatment, and none was found after. Heterotrophic plate counts were reduced more than 90% by steam decontamination. The findings of this study suggest that steam decontamination can reduce the bacterial contamination of high touch surfaces to undetectable levels. However, the sample size of this study was small, with only eight rooms sampled. Additionally, no data was presented on the infection status of patients admitted to these rooms, or how rooms were selected for inclusion. Finally, all of the test surfaces; chair arm, bedrail, table, sink, and door push panel; were hard materials and so efficacy on textiles was not assessed.

The observational study performed by Oztoprak *et al.*[21] compared the efficacy of a steam decontamination device, with a 10 second contact time using 8-bar steam at 174˚C, in reduction of high touch surface bioburden against that of two-step detergent cleaning and sodium hypochlorite disinfection, with 1,000 ppm and 5,000 ppm solutions used. Each of the three protocols were used in one single-bed intensive care unit room each. Five high-touch test sites were inoculated with *Staphylococcus aureus* (MRSA), *vancomycin-resistant Enterococcus faecalis* (VRE), *carbapenem-resistant Pseudomonas aeruginosa*, and MDR *Acinetobacter*

baumannii, at 0.5 McFarland concentrations. Environmental bioburden was measured using microbial culture and Adenosine triphosphate (ATP) monitoring. No bacterial growth was reported after any of the tested decontamination protocols, suggesting that steam decontamination was as effective as the two-step protocols. Moreover, ATP monitoring results were significantly lower when using steam decontamination than for either sodium hypochlorite protocol ($p<0.05$). The findings of Oztoprak *et al*. suggest that steam decontamination is as effective as the two-step protocols using detergent cleaning and disinfection with either 1,000 ppm or 5,000 ppm sodium hypochlorite. However, each protocol was only used in a single room and this should be taken into account when considering these findings.

Three in vitro observational studies assessing the efficacy of steam decontamination systems were identified and included in this review. The non-randomised controlled laboratory trial by Song *et al.*[22] showed that the TANCS disinfection system was able to kill > 99.95 % of bacterial cells in a biofilm within three seconds. The study compared the TANCS disinfection system with sodium hypochlorite and showed that a treatment time of less than one second with TANCS achieved similar disinfection to 10 − 20 minutes of contact time with sodium hypochlorite. However, this is not a useful comparison as they used a solution of sodium hypochlorite with 10 ppm available chlorine, which is very weak compared to the 1,000 ppm currently recommended for terminal cleaning in the hospital environment in NHSScotland.

The observational laboratory trial by Bagattini et al.[23] investigated the effectiveness of an overheated dry-saturated steam vapour system compared to standard cleaning using sodium hypochlorite solution, with 1,400 ppm available chlorine, on microbial bioburden, as measured using a surface time-kill test. The steam decontamination system was found to be bactericidal after a contact time of between 5 and 7 minutes, both with and without presence of an organic substance (bovine serum albumin). Similar bactericidal effect was observed when sodium hypochlorite was used without organic substance. However, it was demonstrated that, in the presence of an organic substance, the antimicrobial activity of sodium hypochlorite was reduced, unlike that of the steam system. Current guidelines in NHSScotland recommend that detergent cleaning be performed alongside hypochlorite application to remove any organic debris remaining, so this finding is not directly comparable to current cleaning and decontamination recommendations. However, as steam cleaning is a single-step process, it may affect the cost and time taken for cleaning. In addition, the study was based within a laboratory setting in Italy; therefore, it may not be appropriate to extrapolate the findings of this study to the clinical setting.

An observational study by Tanner[17] assessed the efficacy of the steam decontamination device with the TANCS component against a number of microbial suspensions including *E. coli*, VRE, MRSA, *P. aeruginosa*, MSSA, *Aspergillus niger*, *C. difficile*, and MS2, on clay coupons. Efficacy was assessed by observing microbial load, and calculating infection risk based on the quantity and type of microorganism remaining on the surface, and the likelihood that these organisms would transfer to skin if touched. All tested organisms were found to be inactivated within a 5-second contact time with steam. In the same contact time, infection risk was removed, since no microorganisms were detected on test surfaces after treatment. It should however, be noted that these results were only recorded on a single test surface (clay) and so further assessment would be required to confirm the action of steam decontamination on other materials.

To summarise the experimental evidence, it can be concluded that there is insufficient and inconsistent evidence to support the use of steam for routine and terminal cleaning procedures in the healthcare environment. In accordance with SIGN methodology, the interrupted time series, before and after study, and five observational studies undertaken in situ and in vitro were designated level 3 (low-quality) evidence.

Are there any safety considerations associated with using steam decontamination systems in the healthcare setting?

Steam decontamination utilises very high temperatures; it is therefore important to use the equipment carefully to avoid scalds and burns. The NPSA Healthcare Cleaning Manual[5] advocates caution when using steam, recommending that the high pressure nozzle is directed away from the user and other people.[5] Dancer also highlights the risk of scalds and burns, however, it is noted that these should be avoided when devices are used correctly.[16] Gillespie *et al.* and Oztoprak *et al.*[15, 21] both stated that no scalds or burns were reported during their implementation of steam decontamination.

Additionally, a number of pieces of evidence mention the potential risk from inhalation of vapour while steam decontamination is in progress and the possible breathing problems this could cause for staff and patients.[15, 16, 21] To avoid this risk, it is recommended that steam decontamination only take place in well ventilated spaces. However, there are no reports of breathing problems in the included literature.[16, 21]

Gillespie *et al.*[15] included a number of other potential injuries within their analysis (e.g. allergic reactions, chemical irritation, or musculoskeletal injuries), however, none were reported.

Oztoprak *et al.*[21] also noted that staff using the steam decontamination device within their study provided positive feedback based on contact with chemicals not being required with this cleaning method. Since The Control of Substances Hazardous to Health (COSHH) Regulations[24] state that exposure to hazardous substances within the workplace should be prevented where possible, the removal of chemical cleaning agents from healthcare cleaning protocols should be viewed as a positive.

The NPSA and the Irish HSE[5, 14] highlight the fact that steam may activate fire detectors and should be used with care within their proximity. The Cleaning Procedure Manual from Royal United Hospital Bath NHS Trust[7] recommends that estates staff are alerted to the fact that steam decontamination will be taking place in order to adjust the function of fire detection systems to avoid false alarms. The NHS Scotland National Fire Safety Advisor recommends that before starting steam decontamination, the local fire safety advisor should be contacted to liaise with the estates team and arrange for temporary measures to be put in place to prevent unwanted fire alarm signals. These measures must ensure that the fire alarm system is fully reinstated, immediately, upon completion of the maintenance works.

It is noted that steam should NEVER be used on electrical sockets, so if any sockets are identified and present a potential hazard in the risk assessment then they should be made safe/protected before steam decontamination commences.[5, 14] Furthermore, standard safety precautions for using electrical equipment should be adhered to when using steam decontamination devices.[7, 14]

There is a risk of residual moisture being created when steam cools and condenses back to water, causing a hazard for slips when cleaning floors. However, no incidents were reported within the included literature[15, 21] and this can be remedied by ensuring to wipe surfaces dry after cleaning.[5, 7, 21] Additionally, Dancer et al highlight concerns in ensuring the efficacy of steam decontamination on textiles due to the inability to visually confirm complete coverage of material with steam.[16] However, across the included literature, any risks relating to textiles remaining wet after steam decontamination were not addressed.

The UK Department of Health[12] raised concerns over aerosolisation of contaminants by steam decontamination systems, however no evidence of this occurring was provided.

Finally, across a number of pieces of literature, the need for personal protective equipment and warning signs is mentioned.[5, 7, 14] As recommended in the NIPCM and the NHSScotland NCSS,

PPE should be worn while undertaking cleaning tasks, and risk assessment should be completed before implementation of steam decontamination as part of cleaning protocol.

Are there any practical or logistical considerations associated with using steam decontamination systems in the healthcare setting?

There are a number of practical considerations associated with using steam-based disinfection in the healthcare setting.

Across the identified literature, there is a consensus that training is required before using steam decontamination devices. Part of this training should include the knowledge that decontamination could be inefficient if the correct cleaning tool is not used as part of the system.[4, 5, 12-15] Additionally, a number of sources also recommend having a monitoring system in place so cleaning standards remain while using steam decontamination devices.[12, 13, 15]

Consensus was not met across the included literature in regards to cleaning time. Yoshino *et al*[13] found that, as expected, cleaning time varied greatly depending on the size of the space being cleaned, however the average time was less when using steam decontamination compared to conventional methods, with a 58.43% reduction in cleaning time noted. Dancer[16] also stated that cleaning time was reduced when using steam decontamination methods, and Oztoprak *et al.*[21] reported that steam decontamination took half the time of a two-step chlorine-based protocol.

However, Doan *et al.*[18] reported that terminal cleaning of isolation rooms with a chlorine-releasing agent took 30 minutes, while using a steam decontamination device took 44 minutes, and using high-temperature overheated dry atomised decontamination took 95 minutes. Furthermore, there could be difficulty in gaining access to beds, lockers and other areas around a patient, areas that act as significant environmental reservoirs of pathogens. Busy wards are likely to have very short turnaround times, allowing little opportunity to clean the bed-space between patient changeover.[16] These factors make steam decontamination impractical for routine use in a crowded ward and, as a result, the Department of Health recommends that steam decontamination is better suited to periodic deep cleaning rather than daily use.[12] For this reason, terminal cleaning of single-bed rooms with steam decontamination devices could also be considered.

One major consideration that should be taken into account regarding the use of steam decontamination devices is the compatibility of different materials with the process. The NSPA[5] notes electrical sockets as an example, while Dancer[16] highlights concerns over efficacy on textiles compared to hard surfaces, due to an inability to visually confirm sufficient exposure on soft surfaces.

Sexton *et al.*[20] tested a steam decontamination method and found it to be non-hazardous to hard surface equipment and staff when correct cleaning protocols were followed.

Gillespie *et al.*[15] state that steam decontamination does not require any chemical disinfectants and can reduce water use by 90 %, thereby reducing the negative impact of cleaning on the environment, and keeping staff safe from hazardous chemicals.[24] Yoshino *et al* likewise found that steam cleaning reduced their consumption of water by 73 % and Dancer reported a 90% reduction in water consumption, while highlighting that steam decontamination removes the need to use toxic chemicals.[13, 16] The Department of Health[12] outlined a number of other considerations regarding steam decontamination. The size of the equipment and the presence of electrical cables and steam hoses can be of significant concern in confined spaces, adding to the risk of injuries when the devices are used. The process also generates significant noise, which can make it unsuitable for use near patients.

Finally, the type of steam cleaner and the tools required should be considered before using steam decontamination devices, as it was noted across the literature that the correct tools and technique are required to ensure the efficacy of steam decontamination.[4, 5, 12-15]

What costs are associated with using steam decontamination systems in the healthcare setting?

The use of new equipment such as steam decontamination machines requires initial capital investments. Steam decontamination systems can cost between £750 and £2,200 for new models with specialist application tools for the healthcare environment. However, hospitals might choose to lease the equipment rather than purchasing it, or they might have the option to use specialist contractors who provide the equipment and personnel needed to carry out periodic steam decontamination.[12] According to manufacturer's websites, the cost for some of the steam cleaning technologies reviewed ranged from £1500 to £4000..[25-27]

Gillespie *et al.*[15] detailed initial costs associated with implementing a new steam decontamination procedure as $1,100 for each steam cleaning device, which was expected to be replaced every 5 years, and $552 for mop heads which were expected to be replaced after 3 years.

Gillespie *et al.*[15] also report that the time saved using steam decontamination methods provided the opportunity to increase the range of cleaning tasks carried out by the workforce.

The study by Doan *et al.*[18] demonstrated that using steam decontamination devices was more expensive than decontamination using a chlorine-releasing agent, when comparing both daily and monthly costs. With chlorine-releasing agent cleaning, costing £14.14 per use or £149.65 per month compared to £19.77 per use or £209.20 per month for one steam decontamination system and £36.86 per use or £390.10 per month for another[18]

However, both Gillespie *et al.* and Oztoprak *et al.*[15, 21] found reductions in cost related to using steam decontamination devices. Reductions in cost of between 76% and 91% per bed space for cleaning were reported. Additionally, consumption of water and cleaning products has been reported to lower when using steam decontamination devices, this relates to financial savings. Gillespie et al reported a monthly budget reduction for consumables of over $7,000 ASD.[15]

Have steam decontamination systems been assessed by the Rapid Review Panel?

The Rapid Review Panel[11] (RRP) is a panel of UK experts established by the Department of Health to review new technologies with the potential to aid in the prevention and control of healthcare-associated infections. The RRP reviewed two steam decontamination products in 2005:

- 2005: Polti Dry Steam Cleaning Unit (Polti)
- 2005: Steam Cleaning Unit (Ecostream)

Both systems were awarded grade 6 recommendation status:

“An established product that does not merit further consideration by the panel.” (R6)

No further steam decontamination products have been assessed by the RRP, however, it should be noted that the most recent evaluation on the PHE website was published in August 2019.

3.2 Implications for research

The review identified several gaps in the literature in relation to steam decontamination systems. The paucity of available evidence on the use of steam decontamination made it difficult to gauge the effectiveness of steam decontamination compared to the currently recommended methods. Due to this, a larger proportion of evidence included in this review was assessed as SIGN level 4 (expert opinion), such as the guideline documents from NHS Boards and Trusts. Future studies assessing the clinical effectiveness of steam systems for decontamination should include suitable comparison groups to enable the results to be transferable to clinical practice within NHSScotland.

The Department of Health[12] comments on the fact that the equipment can be easily implemented in the healthcare environment despite the low volume of well-conducted studies.

It was also notable that several of the studies combined multiple infection control interventions with the use of steam disinfection, such as the use of microfibre cloths. Microfibre cloths are evaluated separately by ARHAI Scotland in another novel technologies systematic literature review. Ideally, studies that evaluate the effectiveness of steam decontamination systems should exclude other infection control interventions in order to minimise the risk of confounding factors producing a spurious result.

Finally, very few studies thus far have evaluated the cost-effectiveness of steam decontamination systems. Of the few that have, the majority have focussed upon the capital costs of the necessary equipment and the cost savings afforded through the reduction in water and chemical disinfectant consumption. It can therefore be seen that a comprehensive cost-effectiveness evaluation for the use of steam decontamination systems in NHSScotland would be timely.

4. Recommendations

This review makes the following recommendations based on an assessment of the extant professional literature regarding the use of steam systems for the decontamination of healthcare environments:

Are steam decontamination systems currently in use in UK healthcare settings?

Available literature suggests that steam decontamination systems are currently in use within UK healthcare settings

(Category C)

However, steam decontamination systems are not recommended for routine use in the NCSS or NIPCM. The use of these systems on soft furnishings should be discussed with local health protection or infection control teams.

(Mandatory)

What is the actual or proposed mechanism of action of steam decontamination systems?

Steam decontamination systems use superheated dry steam, delivered under pressure at a temperature of 140°C or greater, which kills microorganisms

(Category C)

Steam decontamination units can also loosen organic debris that is then removed from the surface using a vacuum suction component, providing a dual cleaning and disinfection process

(Category C)

What is the procedure for using steam decontamination systems?

Training is required before using steam decontamination devices, and monitoring of cleaning should be conducted routinely.

(Category C)

A detailed SOP must be established before steam cleaning is implemented to ensure there is clarity on when and how steam cleaning is used.

(Category C)

Proper safety measures should be in place including warning signs, and personal protective equipment.

(Category C/Mandatory)

The local fire safety advisor should be contacted to liaise with the estates team and arrange for temporary measures to be put in place to prevent unwanted fire alarm signals

(Category C)

Steam cleaning equipment must be maintained in good working condition and a planned programme of maintenance put in place and evidenced.

(Category C)

What is the scientific evidence for effectiveness of steam for decontamination of the healthcare environment?

There is insufficient evidence of in situ efficacy to support the use of steam decontamination systems over that of routine 1,000 ppm sodium hypochlorite, unless in circumstances where sodium hypochlorite cannot be used

(Category B)

There is insufficient evidence of in vitro efficacy to support the use of steam decontamination systems over that of 1,000ppm sodium hypochlorite, unless in circumstances where sodium hypochlorite cannot be used

(Category B)

Are there any safety considerations associated with using steam decontamination systems in the healthcare setting?

Training should be provided in order to avoid staff injury (e.g. burns and scalds) when using steam cleaning devices.

(Category C)

Appropriate personal protective equipment should be worn when using steam decontamination systems.

(Mandatory)

Decisions on what personal protective equipment is appropriate in order to use steam decontamination systems should be made by risk assessment and following manufacturer's instructions.

(Mandatory)

Steam decontamination should take place in well ventilated areas, where possible.

(Category C)

Steam cleaners should not be used on electrical sockets or appliances.

(Category C)

Surfaces should be wiped dry of any condensed steam to ensure safety.

(Category C)

Manufacturer's instructions should always be followed to maintain safe working.

(Category C)

Are there any practical or logistical considerations associated with using steam decontamination systems in the healthcare setting?

All staff involved in the use of steam cleaning must be trained in the use of the product.

(Category C/B)

Consideration needs to be given to the type of steam cleaning system used, its application, and the tools required to efficiently clean the selected environment.

(Category C)

Consideration should be given to the type of material being cleaned and its tolerance to steam decontamination.

(Category C)

The local fire safety advisor should be contacted to liaise with the estates team and arrange for temporary measures to be put in place to prevent unwanted fire alarm signals

(Category C)

What costs are associated with using steam decontamination systems in the healthcare setting?

Initial investment of between £750 and £4000 were reported when using steam decontamination systems

(Category C)

Ongoing costs associated with using steam decontamination systems vary, with monthly cost between £200 and £400 reported

(Category C)

Have steam decontamination systems been assessed by the Rapid Review Panel?

Both the Polti Dry Steam Cleaning Unit and the Ecostream Steam Cleaning Unit have been assessed by the Rapid Review Panel, with both being considered established products (grade 6)

(Category C)

References

1. ARHAI Scotland. National Infection Prevention and Control Manual. 2021.
2. ARHAI Scotland. Infection Prevention and Control Manual for older people and adult care homes. 2021.
3. ARHAI Scotland. Safe Management of the Care Environment (Environmental Decontamination). 2020.
4. Health Facilities Scotland. The NHS Scotland National Cleaning Services Specification. 2016.
5. NHS National Patient Safety Agency. The Revised Healthcare Cleaning Manual. 2009.
6. Health and Safety Executive. Blood Borne Viruses: Methods of Decontamination, https://www.hse.gov.uk/biosafety/blood-borne-viruses/methods-of-decontamination.htm.
7. Royal United Hospital Bath NHS Trust. Cleaning Procedure Manual. 2009.
8. Black Country Partnership NHS Foundation Trust. Infection Prevention and Control Assurance - Standard Operating Procedure 7: Decontamination (Cleaning, Disinfection and Sterilisation). 2019; Version 1.1.
9. Harrogate and District NHS Foundation Trust: Infection Prevention and Control. COVID-19 Deep Cleaning Guidance in Care Homes. 2020.
10. Garvey MI, Bradley CW and Jumaa P. Environmental decontamination following occupancy of a burns patient with multiple carbapenemase-producing organisms. *Journal of Hospital Infection* 2016; 93: 136-140.
11. Public Health England Rapid Review Panel. Guidance: RRP recommendation listing: December 2004 to January 2015. 2015.
12. UK Department of Health. An Integrated Approach to Hospital Cleaning: Microfiber Cloth and Steam Cleaning Technology. 2008.
13. Yoshino ST HA, de Carvalho R. Implementation of a steam terminal cleaning service in operating rooms. *Rev Sobecc* 2015; 20. DOI: 10.5327/Z1414-4425201500020008.
14. Health Service Executive. Cleaning Manual - Acute Hospitals.

15. Gillespie E, Brown R, Treagus D, et al. Improving operating room cleaning results with microfiber and steam technology. *American Journal of Infection Control* 2016; 44: 120-122.

16. Dancer SJ. Controlling hospital-acquired infection: Focus on the role of the environment and new technologies for decontamination. *Clinical Microbiology Reviews* 2014; 27: 665-690.

17. Tanner BD. Reduction in infection risk through treatment of microbially contaminated surfaces with a novel, portable, saturated steam vapor disinfection system. *American Journal of Infection Control* 2009; 37: 20-27.

18. Doan L, Forrest H, Fakis A, et al. Clinical and cost effectiveness of eight disinfection methods for terminal disinfection of hospital isolation rooms contaminated with Clostridium difficile 027. *Journal of Hospital Infection* 2012; 82: 114-121.

19. Gillespie E, Williams N, Sloane T, et al. Using microfiber and steam technology to improve cleaning outcomes in an intensive care unit. *American Journal of Infection Control* 2015; 43: 177-179.

20. Sexton JD, Tanner BD, Maxwell SL, et al. Reduction in the microbial load on high-touch surfaces in hospital rooms by treatment with a portable saturated steam vapor disinfection system. *American Journal of Infection Control* 2011; 39: 655-662.

21. Oztoprak N, Kizilates F and Percin D. Comparison of steam technology and a two-step cleaning (water/detergent) and disinfecting (1,000 resp. 5,000 ppm hypochlorite) method using microfiber cloth for environmental control of multidrug-resistant organisms in an intensive care unit. *GMS Hygiene and Infection Control* 2019; 14: Doc15.

22. Song L, Wu J and Xi C. Biofilms on environmental surfaces: evaluation of the disinfection efficacy of a novel steam vapor system. *American Journal of Infection Control* 2012; 40: 926-930. Research Support, Non-U.S. Gov't.

23. Bagattini M BR, Giannouli M, Mattiacci D, Bellopede R, Grimaldi N, Nardone A, Zarrilli R, Triassi M. Effect of treatment with an overheated dry-saturated steam vapour disinfection system on multidrug resistant nosocomial pathogens and comparison with sodium hypochlorite activity. *BMC Research Notes* 2015; 8. DOI: 10.1186/s13104-015-1534-9.

24. UK Government. The Control of Substances Hazardous to Health Regulations 2002.

25. Osprey Deep Clean. Steam & Vac Pro.

26. Osprey Deep Clean. Provap Evo Vac,

27. Advanced Vapor Technologies. VaporJet 240 Steam Vapor System,

Appendix 1 Grading of recommendations

Grade	Descriptor	Levels of evidence
Mandatory	'Recommendations' that are directives from government policy, regulations or legislation	N/A
Category A	Based on high to moderate quality evidence	SIGN level 1++, 1+, 2++, 2+, AGREE strongly recommend
Category B	Based on low to moderate quality of evidence which suggest net clinical benefits over harm	SIGN level 2+, 3, 4, AGREE recommend
Category C	Expert opinion, these may be formed by the NIPC groups when there is no robust professional or scientific literature available to inform guidance.	SIGN level 4, or opinion of NIPC group
No recommendation	Insufficient evidence to recommend one way or another	N/A