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Narrative Review

Hospital cleaning: considerations for designing and maintaining a successful environmental cleaning program

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ABSTRACT

Background: There are nuances and complexities associated with designing and implementing cleaning programs in hospitals and healthcare. As such, like many aspects of infection prevention and control, a multimodal approach to environmental cleaning is recommended.
Objectives: In this communication, we examine various factors that must be considered when creating a meaningful and sustainable environmental program for hospitals and healthcare.
Sources: A literature review was conducted in PubMed using terms: environmental cleaning, cleaning, hospital, healthcare, infection.
Content: In this review, considerations for the development of a hospital (healthcare) based cleaning program are discussed. Topics include differences between cleaning and disinfection, a risk assessment, cleaning procedures, product choice, implementation, evidence from randomised control trials and gaps in evidence.
Implications: The growing body of evidence highlights that environmental cleaning is a crucial, though complex, aspect of preventing healthcare-associated infections. Hospital investments in cleaning should also recognise and provide tangible support for the critical role cleaning staff play in ensuring patient safety. Ongoing investment in evidence-driven, multimodal cleaning programs is essential to reducing infections and safeguarding patients in hospital environments.

General introduction

Healthcare-associated infections (HAIs) majorly impact patients by increasing morbidity and mortality, as well as burden health services by extending length of stay and raising treatment costs [1–3]. In the European Union and European Economic Area healthcare systems report an estimated 2.6 million new cases of HAIs annually [4]. A 2022-23 HAI point prevalence survey, undertaken in 1623 European hospitals, found an average HAI prevalence of 7.1 %, with rates ranging from 3.1 to 13.5 % [5]. Preventing and controlling HAIs requires a multifaceted approach. Environmental cleaning is one strategy that aims to prevent exogenous transmission of pathogens.

Over the past 20 years, there has been a growing number of publications on environmental cleaning [6]. The evidence supporting a clean, safe environment for the prevention of infection can be supported from two perspectives, epidemiological and evidence from clinical trials. Pathogens can survive on inanimate surfaces in healthcare settings for long periods of time, sometimes for days or even months [7]. Unless these pathogens are removed or killed, they pose an ongoing risk of transmission.

Epidemiological evidence highlights the risks of prior room occupancy. A systematic review and meta-analysis identified that from 28,299 patients who were admitted into a room where the prior room occupant had any organism of interest, 651 (2.3 %) were shown to acquire the same species during their hospitalisation [8]. This compared to 981,865 patients who were admitted to a room where the prior occupant

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did not have an organism of interest, with only 3818 (0.39 %) acquiring the same organism (OR 2.45 (95 % CI: 1.53–3.93) [8]. Mathematical models also highlight the importance of contaminated surfaces in the transmission routes of important hospital pathogens [9,10]. Additionally, many environmental cleaning studies have been conducted, demonstrating that improving cleaning correlates to reductions in HAIs, [11,12] including randomised control trials [13,14].

A 2022 review evaluated the evidence for cleaning interventions and their impact on patient colonisation and HAIs, focusing on multidrug-resistant microorganisms or other epidemiologically relevant pathogens [11]. The review identified five randomised control trials with varying primary interventions, including antimicrobial surfaces, [15] hydrogen peroxide, [16] bleach wipes, [17] terminal cleaning with UV-C, [13] and a bundled cleaning approach [13–17]. These interventions focussed on terminal (discharge) cleaning, routine cleaning or a combination of both. The primary outcomes of these studies varied between infection and colonisation, as well as focusing on specific pathogens only. The quality of the four trials varied. Peters and colleagues identified three trials as the highest quality [13,14,16].

To identify papers since Peters et al. review, we conducted a new search, noting this was not systematic. Our search used the same search strategy and terms as described in Peters et al., but limited to the years from 2020 to 28th February 2025, focusing solely on randomised control trials. This updated search identified an additional four papers [18–21]. These studies explored interventions, including copper-impregnated linen and surfaces, [18] approaches to different cleaning wipes, [19] enhanced cleaning and disinfection of shared equipment, [20] and different surface-cleaning strategies [21]. Of the newer trials, some faced issues related to inadequate power, lack of blinding, methodological discrepancies or lack of detail in the statistical methods or combination of these [18,19,21].

The studies identified by Peters et al. and those identified since that review are diverse [11]. The outcomes of interest and the specific cleaning interventions vary, as does the quality of the studies [11]. This diversity highlights the nuances and complexities associated with designing and implementing cleaning programs in hospitals. Consequently, a structured multimodal approach to environmental cleaning is recommended [6,11,22]. A multimodal approach involves using a combination of strategies to influence behaviour and improve practices. For example, a successful multi-modal approach to improving hand hygiene, includes system changes, education and training, monitoring and feedback, reminders, and fostering a safety culture [23].

This paper seeks to offer a clear, concise, brief overview of hospital cleaning as well as key factors to consider when developing a meaningful and sustainable environmental program for hospitals. Topics covered include conducting a risk assessment, the differences between cleaning and disinfection, considerations when choosing a product or approach to cleaning, cleaning procedures, implementation and gaps in evidence. Each of these topics could be discussed in individual papers, however, the purpose of this paper is to provide an introductory overview. Further exploration of specific topics is assisted through supporting literature provided.

Program design

A risk-based approach to an environmental cleaning program

The first step in designing a healthcare cleaning program is to prepare a thorough risk assessment. These assessments should contain three important factors: the patient risk profile, the surface risk profile and the pathogen risk profile [24]. The vulnerability of patients to infection forms part of the patient risk assessment, while the probability of contamination informs the surface risk profile [24]. Pathogen risks refers to the persistence and presence pathogens, as well as local antibiotic resistance epidemiology [24]. As part of the risk assessment and pathogen profile, another important concept is that of “replication capacity” of pathogens [25]. Replication capacity is the degree of contamination, surface material, temperature, relative humidity, protein load, organic soil, UV-light (sunlight) exposure, and pH value [25]. A cleaning program should therefore align to organisational needs and may not be a ‘one size fits all’ approach even within an organisation.

Cleaning and disinfection – key differences

Using the risk assessment, decide whether cleaning and/or disinfection is most appropriate. Cleaning involves physically removing dirt, soils, and debris from a surface, typically using a cloth or wipe with soap or detergent [26]. Disinfection is an additional process, that aims to kill or reduce harmful pathogens on a surface to a level not thought to be harmful. Disinfection is most effective after cleaning, as residual soil can reduce efficacy. Common disinfectants include but are not limited to alcohols, chlorines, oxidative agents (e.g. peracetic acid) and quaternary ammonium compound formulations. Disinfection may also be achieved using ultraviolet-C (UV-C) or hydrogen peroxide vapour. Each approach or disinfectant product has advantages and limitations, supported by varying levels of clinical evidence [26]. Of paramount importance, a surface needs to be cleaned before disinfection or as part of the process. For example, two-in-one wipes, combine surfactants and disinfectants to streamline cleaning and disinfection procedures. Cleaning and disinfection practices vary globally and within countries, reflecting uncertainties in the evidence base [27–30]. Healthcare facilities most commonly combine cleaning and disinfection for patients with epidemiologically relevant or multidrug-resistant pathogens, in high-risk areas and during outbreaks.

Product choice and approach to cleaning

There are a number of factors to consider when choosing a product and in particular a disinfectant [31]. These include:

- Health and safety considerations, including toxicity [24,31].
- The effectiveness or “kill claims” of the product with respect to the spectrum of activity and the conformity to normative standards [32, 33].
- Contact time, which refers to the time that a disinfectant needs to stay wet (or be used for) on a surface to ensure efficacy. The contact time of products and disinfectants varies considerably, from seconds to 15 min or more [33]. The effectiveness of disinfectants and their contact time also varies depending on the active ingredient, the surface being cleaned, its application and level of contamination [34–37]. Thus, using products according to manufacturer instructions is critical. Manufacturers should provide information on the required contact times that should be consistent with efficacy standards requirements.
- Ease of use, including personal protective equipment requirements
- Economics, is the cost of product or approach worth the potential gains realised [38,39]
- Reprocessing requirements including the reuse of cloths or mops
- Environmental sustainability considerations [40,41]
- Surface compatibility should also be considered and the surface or equipment manufacturer’s guidance should be used when considering products used in order to minimise the risk of damage [42]

Wipes and cloths are frequently used in hospitals as part of cleaning practice. While this may seem like a simple product, evidence suggests that is not necessarily the case. When choosing a wipe or cloth, staff must consider the potential to transfer pathogens from one surface to another during the cleaning procedure [36,43,44]. Not all products or chemicals perform equally. For example, suggesting that all quaternary ammonium compounds are identical is like suggesting that every model of Toyota car is the same—when, in reality they vary greatly and perform very differently. Asking for scientific evidence from

manufacturers when comparing products, including transferability, may help decipher those differences.

Correct cleaning procedures

The cleaning method is crucial. One example of a common approach used for teaching cleaning procedures is that described by Dancer and colleagues, who outline four essential steps: Look, Plan, Clean, and Dry [45]. In the "Look" step, staff visually assess the area before cleaning. In "Plan," they prepare for the cleaning process. The "Clean" step involves the cleaning procedure, and "Dry" ensures surfaces are fully dry after cleaning [45].

Within the "Clean" stage, several key aspects must be considered. These include the direction of cleaning and the wiping technique. Cleaning should proceed from high to low, starting with areas closest to the patient, prioritising frequently touched surfaces, and moving from the least visibly dirty to the dirtiest areas [46,47]. For wiping, it's essential to use a single wipe or cloth per surface, unfolding it flat, wiping in one direction, and following an S-shaped motion. The principle of "one wipe, one surface, one direction" serves as a helpful reminder for these important cleaning concepts [45,48,49].

How clean is clean?

There are different approaches to evaluate environmental cleanliness and thoroughness of cleaning. These include visual audits, microbiological sampling, fluorescent markers and ultraviolet (UV) lights, and adenosine triphosphate (ATP) sampling [50–57]. Each method offers advantages and disadvantages, as previously described [58]. Visual audits are widely used but have been reported to perform poorly at identifying microbial load [58]. Regardless of the method used, there is the added complexity of choosing appropriate surfaces and locations within hospitals to evaluate. One common evaluation method uses fluorescent markers and UV lights [54–56,59]. This audit and feedback approach plays a critical role in successful cleaning programmes when integrated into training, audit and feedback programmes [14,20,54,55]. Ultimately, we do not have universally agreed standards for surface cleanliness in healthcare [60,61].

Implementation of a cleaning program

Education and training

Performing cleaning or disinfection effectively, efficiently and consistently requires skill which should be recognised and valued. Although staff and supervisors often receive training to follow specific methods, they frequently deviate from these taught procedures in practice [28,62]. There are also significant variations in approaches to environmental cleaning, including training [28]. Various factors contribute to this, including time constraints, inadequate equipment or lack of understanding of the reasoning behind the cleaning and disinfection [28,63].

Training normally focuses on specific skills and competencies required for specific tasks. It is narrow, task-oriented and 'hands-on' based aiming to achieve proficiency in tasks like surface cleaning techniques or the correct dilution of disinfectants for use. Despite this, evidence demonstrates that training alone fails to ensure consistent practices, leading to deviations in method or incorrect and unsafe dilutions of disinfectants for use in clinical areas [64]. To reinforce skills achieved during training, educators should explain the rationale behind the method. This approach helps staff understand the 'why' as well as the 'how' [65]. Integrating education into training programmes also helps staff to develop problem-solving and decision-making skills, enabling them to handle situations that cannot be simulated in classroom settings.

Table 1
Considerations of designing audit and feedback programmes to improve environmental cleaning.

Accountability of staff	It is important to define who is responsible for cleaning any given surface or piece of equipment, and how often it should be cleaned [66]. ➢ The 'clean between use' model holds all staff responsible for cleaning surfaces and equipment after use. ➢ Responsible staff may include clinical staff, environmental services and/or dedicated cleaners.
Opportunity to clean	When determining the timeframe of audits, the time allocated for cleaning should be considered [63,67]. ➢ If cleaning is assessed over a period of time, staff should have the opportunity to clean within that timeframe.
Auditing methods	There are a variety of methods available to measure environmental cleanliness [58,68,69]. The choice of auditing methods should be based on objective and evidence-based measures of cleaning performance. ➢ Visual inspection is not appropriate for frequently touched surfaces ➢ Gel-based methods are not appropriate for fabrics or upholstery ➢ The timing of any sampling, relative to when it was last cleaned, including consideration of residual effects of disinfectants.
Frequency of audits	Facilities should establish clear guidelines for the frequency of audits, based on the likelihood of contamination and risk of pathogen transmission. The frequency of audits should reflect: ➢ The frequency of contamination (i.e. frequently touched surfaces should be cleaned more than minimally touched surfaces). ➢ The risk of pathogen transmission and the consequences of infection. ➢ Increased auditing during outbreaks ➢ Auditing of surfaces/equipment before, during and after implementation of an environmental cleaning intervention
Surfaces/ equipment	Guidelines do not cover an exhaustive list of surfaces and equipment, rather provides working examples. ➢ Non-critical equipment: reusable equipment that contacts intact skin and does not involve mucus membranes (i.e. commodes, blood pressure monitors). ➢ Frequently touched surfaces: (i.e. bed rails, door handles) Note: equipment that undergoes high-level disinfection is subject to strict monitoring procedures and is outside the scope of this paper.Audits of routine and terminal patient room cleans may not cover all equipment used in patient care (i.e. equipment in storerooms) and should be assessed separately
Feedback of results	Results of cleaning audits should be promptly reported back to accountable staff, managers, Infection Prevention and Control and other relevant departments [14,20,55]. ➢ A reasonable timeframe would be the next shift of the accountable staff member ➢ Interviews with cleaning staff indicate they would prefer face-to-face feedback in addition to digital audit results (email) [20]. ➢ Avoid statements of blame. Focus on what is done well, what can be improved and understanding potential barriers, including system level changes [70].
Record of results	Long-term surveillance of environmental hygiene requires records of cleaning audits. ➢ Trends could indicate when further training and education is needed. ➢ Promotes a local culture of accountability and continuous improvement.

Audit and feedback

Audit and feedback systems cannot be overlooked when implementing sustainable and effective cleaning practices. These systems work hand-in-hand, with ongoing audits providing accountability and feedback ensuring continual improvement. Together, they enable long-term environmental surveillance, fostering a culture of cleanliness and infection prevention.

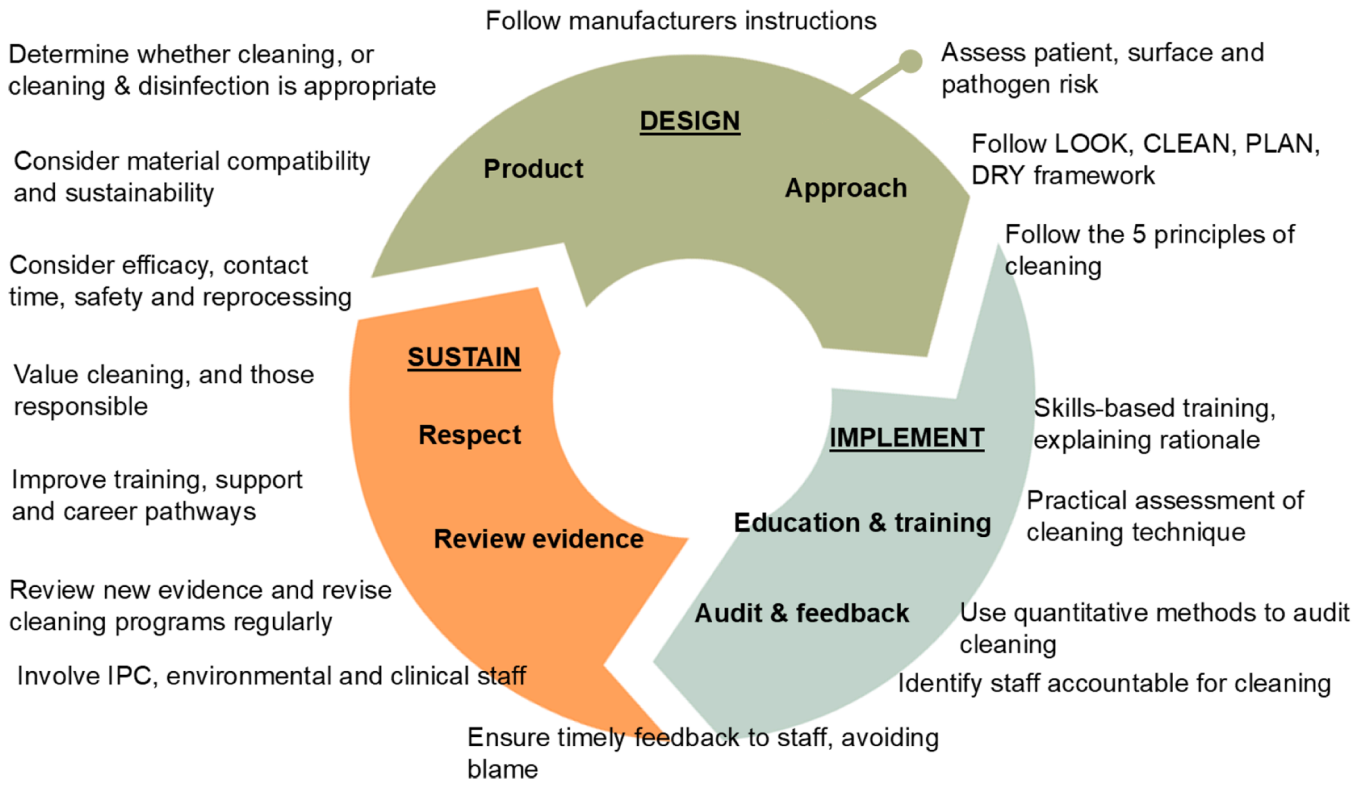


Fig. 1. Core principles to design, implement and sustain an environmental cleaning program.

To maximize their impact, facilities should design audit and feedback programmes collaboratively, engaging all relevant departments, including but not limited to Infection Prevention and Control, environmental services, and contracted cleaning services. Collaborative efforts ensure that the programme is tailored to the facility's needs and that all stakeholders are invested in its success. Table 1 outlines the key considerations for designing audit and feedback programmes aimed at improving environmental cleaning practices.

Sustainability

Valuing cleaning and those responsible for cleaning

Sustainable cleaning programs incorporate multidisciplinary teams and expertise. Hospital cleaning staff perform a highly valuable role in patient safety, yet are largely unrecognised. There is strong evidence to suggest that thorough cleaning is done well, combined with adequate support and recognition of cleaning staff, reduces the risk of HAIs [14, 20]. Despite their prevention of infection by maintaining a clean and safe environment, cleaning staff often receive limited or no training [28, 71]. There is also a lack of career progression and reflective compensation. Although cost-effectiveness analyses demonstrate cost-savings, [39] cleaning services are often the first to be cut. Recognizing and supporting cleaning staff and services is critical to maintaining and improving patient safety.

The unknowns

There are many 'unknowns' and potentially even more 'unknown unknowns' in the area of healthcare environmental cleaning. Key issues include whether to use disinfectants or detergents for routine cleaning; which disinfectant is most appropriate in any given scenario; a universal standard of surface cleanliness; the cost-effectiveness of cleaning interventions; the roles of surface biofilms in transmission and removal of pathogens; the optimal frequency of routine cleaning; and the role of air in contaminating surfaces and subsequent risk. A panel of experts recently identified priority areas for research in resource-limited countries [72,73]. These priority areas were grouped into four main themes, standards, system strengthening, behaviour change and innovation [72, 73]. Twelve priority research questions are presented, with many falling into the 'unknown' topics just described. Findings from a systematic review assessing cleaning staff training and workload, the need to evaluate the effects of training for individuals and teams was identified [74]. Research funding to support addressing these gaps is critical. As new evidence emerges, it is important to evaluate these findings, and incorporate new knowledge into practice. This involves re-evaluating cleaning programmes periodically (Fig. 1).

Conclusion

The increasing body of evidence demonstrates that environmental cleaning is an essential yet complex component for the prevention of HAI. Achieving optimal cleanliness involves consideration of multiple and interconnected factors, including risk assessments based on patient vulnerability, surface contamination potential, and pathogen persistence. Effective cleaning programs should integrate clearly defined procedures, product selection informed by efficacy, safety, ease of use, and sustainability, along with robust audit and non-punitive feedback mechanisms to those that undertake these vital roles. Recognising and addressing the challenges staff encounter through comprehensive education and ongoing training reinforces correct practices and reduces variability in implementation. Future research should aim to clarify remaining uncertainties around optimal product choice and cleaning frequencies, and cost-effectiveness of interventions. Investment in hospital cleaning must also reflect appreciation and tangible support for the vital role cleaning staff play in patient safety. Sustained investment in evidence-based, multimodal environmental cleaning programs is imperative for reducing healthcare-associated infections and protecting patients in hospital settings. It is time to ask, not whether a space is clean and ready for use, but whether it is safe for the next vulnerable occupant.

CRediT authorship contribution statement

Brett G Mitchell: Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Katrina Browne:** Writing – review & editing, Conceptualization. **Martin Kiernan:** Writing – review & editing, Writing – original draft, Conceptualization. **Pierre Parneix:** Writing – review & editing. **Philip L Russo:** Writing – review & editing, Writing – original draft.

Declaration of competing interest

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Martin Kiernan reports previous employment (2023) with GAMA Healthcare.

Katrina Browne reports no conflicts of interest.

Philip Russo reports no conflicts of interest.

Pierre Parneix reports no conflicts of interest.

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