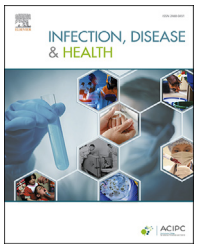
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Discussion paper

Sustainability and novel technologies to improve environmental cleaning in healthcare — Implications and considerations

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Abstract Along with emerging technologies electrolysed water (EW) systems have been proposed for cleaning and/or disinfection in clinical areas. There is evidence for the use of EW in food-handling and the dairy industry however there is lack of evidence for EW as an effective cleaning and disinfecting agent in a clinical setting. Existing publications mostly are either laboratory based or from non-clinical settings. This is in direct contrast to other approaches used in healthcare cleaning. The aim of this paper is to provide infection prevention and control professionals with a risk assessment checklist using an evaluation of electrolysed water as an example of the analysis and consideration required prior to the introduction of any new technology and, in particular, the inclusion of sustainability.
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Highlights

- Emerging technologies are being proposed for environmental cleaning in clinical areas to promote sustainability.
- The evidence for the use of some of these technologies in a clinical setting is scarce.
- Infection Prevention and Control professionals are mostly quested on the most suitable approach.

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- Ensuring sustainability is vital, but should not compromise provision of safe, quality care.
- A risk assessment should be conducted before the introduction of novel cleaning and disinfection technologies within clinical settings.

Introduction

Effective environmental cleaning along with standard and transmission-based precautions are essential components of any successful infection prevention and control (IPAC) programs aimed at providing safe, high-quality healthcare for patients and a safe working environment for health workers (IPAC PD NSW Health 2023) [1]. Regular and meticulous cleaning and disinfection of environmental surfaces is an important component of removing microorganisms and disrupting biofilm formation in the environment to prevent transmission of healthcare associated infections (HAIs) [2,3].

Most health facilities follow a conventional two step cleaning and disinfection approach. The first step is to clean with a neutral detergent to remove adherent organic material. This is allowed to dry before the second step of disinfection with an appropriately approved product or process to reduce the number of microorganisms to a level thought not to be harmful. The other method is to use a 2-in-1 product which both cleans and disinfects in one step. Both methods have disadvantages including the need for contact times to achieve advertised microorganism reduction and the impact of disposal of both the disinfectant and their containers on the environment [4].

Environmental cleaning consumes vast quantities of plastics and cleaning agents and although reducing consumption of these is on the surface an easy fix, this may negatively impact on the contamination levels of healthcare environments, whilst noting that reuse also comes at an environmental cost. Standard healthcare cleaning is resource intensive and in practice, often not rigorously monitored. Furthermore, balancing sustainability against the provision of safe healthcare is challenging. IPAC professionals are mostly quested on the most suitable approach to achieve effective environmental cleaning to ensure safety of health workers and the environment.

Ensuring sustainability is vital, but should not compromise provision of safe, quality care. Nor should it entail reverting to an era where HAIs were considered an expected consequence of healthcare. There is a complex interplay between priorities in IPAC and sustainable health and environmental systems [5]. Contemplating sustainability throughout the entire life cycle of a product ensures that any potential social, economic, and environmental impacts are considered. This is particularly pertinent for environmental cleaning. Leveraging technology to improve efficiency and effectiveness while reducing waste is a worthy aim.

There are a range of novel liquid disinfectants and non-touch technologies currently available and evidence in this area continues to evolve. This paper aims to discuss the clinical application of one of these, electrolysed water as an alternative sustainable cleaner/disinfectant in healthcare settings as a case study for the need to consider both benefits and potential harms of adopting new approaches.

Discussion

Electrolysed Water (EW) also known as electrolysed oxidising water is widely used in the food, aquaculture, and agriculture industries [2]. EW is generated by electrolysis of dilute salt solutions (sodium chloride), in an electrolytic chamber [6]. There are at least three forms of electrolysed water available: acid water, alkaline water, and neutral water, classified according to their pH values [7]. Some authors have proposed EW as an environmentally friendly alternative disinfectant to chlorine-based products [8]. However, most studies do not differentiate between routine cleaning and pre-cleaning for processes requiring disinfection as a subsequent step. There is no differentiation between surfactant use to remove organic soil and a disinfection approach. The removal of organic material is critically important to the effectiveness of any subsequent or combined disinfectant approach. Furthermore, most existing studies providing evidence for EW are laboratory-based or derive from the food-handling industries, not healthcare settings [9,10]. The setting in which environmental cleaning studies are performed is particularly important in the context of relevancy of pathogens and at-risk population groups, two (of a few) critical factors in determining the appropriateness of an environmental cleaning approach [11].

The literature review conducted by National Health Service Scotland version 2.0 [12] concluded that there is a very limited evidence base for EW, the product has very short shelf life, very limited high-quality evidence of direct clinical benefit. Based on the current evidence it is difficult to recommend this product for clinical application. It is not widely used in healthcare settings except a few hospital kitchens and the test organisms and methodologies used by existing studies often vary, making direct comparison problematic. Evidence generated from three studies [13—15] evaluating the efficacy of EW in clinical settings cannot be generalised due to variation in methodologies, sample size, lack of details on product used, cleaning standards and potential funding bias [12,16]. A recent study Krishnan (2023) concluded that "impact of storage conditions, anti-Candida biofilm efficacy and mechanism of action against yeasts, long-term effects on denture materials and cost-effectiveness is required to establish the suitability of EW as a multipurpose biocide for dental healthcare" [17]. Like any change in IPAC practices or processes, there are also other important considerations, including whether the change is likely to complicate processes or practice, thus reducing compliance (human factors component). Not further discussed here but many such

Table 1 Risk assessment checklist for introduction of novel cleaning and disinfection technology.

No.	Item	YES	NO
1	Is there sufficient evidence from well-designed non-inferiority studies that the approach or change is not inferior to the existing cleaning method/s?	☐	☐
2	Have any potential unintended consequences of the approach or change been considered and evaluated?	☐	☐
	• Are there any storage requirements for products that may have shorter shelf-life?	☐	☐
	• Are there any waste disposal implications?	☐	☐
	• Is there a risk of resistance developing?	☐	☐
	• Is there a risk of skin or other allergic reactions in staff?	☐	☐
	• Will any changes in personal protective equipment be required?	☐	☐
	• Will overall costs rise, including is the system more requiring of staff time?	☐	☐
	• Is the required contact time for efficacy achievable in normal use?	☐	☐
	• Are there any material compatibility issues?	☐	☐
	• Do manufacturers of products approve the use of the product on materials used in healthcare?	☐	☐
	• Are there any potential reactions with other chemicals?	☐	☐
	• Does the product meet all regulatory requirements?	☐	☐
3	Is additional infection prevention and control education or training required for individuals who will be utilising this product?	☐	☐
4	Have human behavioural considerations been taken into account?	☐	☐
	• Will this change increase or complicate workflow?	☐	☐
	• Will this change increase or complicate compliance?	☐	☐
5	Has the carbon cost of the product been considered?	☐	☐
6	Has a Life Cycle Assessment (LCA) of the product been undertaken?	☐	☐
7	Has the LCA been independently verified?	☐	☐
8	Are additional actions required to reduce the carbon emissions and associated waste[a] from the product?	☐	☐
10	Does it include a net zero target?	☐	☐
	What is the target?		
	Comment: …. …		
	What demonstrable actions are underway to meet your target?		
	Comment: …. …		

[a] NB: Waste may include pharmaceuticals, chemical waste, heavy metals, pressurized containers, radioactive waste, and nonhazardous/general waste.

solutions like EW should not ignore the chemical composition (hypochlorous acid and oxidation—reduction potential or the free chlorine) during the risk assessment [2].

One of the emerging challenges currently being faced by healthcare globally, is that of antimicrobial resistance, particularly with Gram negative bacteria. Water and sinks are commonly and increasingly being implicated in outbreaks and transmission of highly resistant pathogens [18—20]. As a result, there have been moves to reduce water outlets and sinks in hospitals, to combat these challenges [21]. Given the relatively fast loss of activity of EW, multiple water outlets may be required to generate adequate supplies of EW for clinical use [22].

A trip around the exhibition at any IPAC-related conference demonstrates that industry see cleaning and disinfection of healthcare environments as a potentially lucrative market, which has resulted in technologies such as aerosol and vaporised hydrogen peroxide, ultraviolet-C light (UV—C), and electrolysed water entering the market. While these technologies demonstrate some effectiveness, there are disadvantages such as lack of well-designed studies including effectiveness and cost-effectiveness studies, the presence of chemical residues, product stability and a short shelf-life, and adverse effects on human skin [2]. Some of these technologies and bundled environmental strategies have been tested in clinical trials in healthcare to determine superiority to other approaches [23—25]. These trials have subsequently synthesised and evaluated using established processes when developing evidence-based guidelines [26]. At present, no such trials for EW have been conducted, including as a minimum, non-inferiority to existing practice. In the checklist below (Table 1 Risk assessment checklist for introduction of novel cleaning and disinfection technology) the first requirement is evidence. At this point the assessment on a new product such as EW would be concluded because the very first criterion on the checklist was not achieved. If a health organisation decided to consider EW (or similar technology) for clinical application the following risk assessment checklist should be considered.

Conclusion

New products will continue to develop and will always be required; however, their introduction and adoption should always be part of a managed process in which evidence plays a significant role. Current systems that use chemicals and plastics may seem to be the low-hanging fruit when looking to adopt a more sustainable approach to healthcare delivery, however we should remember that we also must sustain the use of our dwindling antibiotic resource. Should

infection rates rise because of using systems that do not have a robust evidence base, that would not, to these authors, be a sustainable approach.

Ethical considerations

Ethics approval not required as this is a discussion paper.

Authorship statement

Jain S and Dempsey K conducted conceptualization, investigation, and draft writing. Clezy K, Mitchell B G and Kiernan M.A contributed to revising drafts and Mitchell B G and Kiernan M.A provided expertise on environmental cleaning. All authors contributed to the development of the paper, provided critical input, and approved final version of the manuscript.

Declaration of competing interest

Authors on this paper have an editorial affiliation with the journal but played no role at all in the peer review or decision-making process for this paper.

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