Review

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The contribution of surface disinfection to prevent health care acquired infections

Summary

While an increasing body of evidence has been published on the relevance of surface disinfection to prevent healthcare acquired infections (HAIs), execution is still poor in many cases. This short review summarizes recent publications on the contamination of inanimate surfaces in healthcare and the relevance in the spread of infection. In addition to reports of infections caused by Gram-positive bacteria, infections caused by Gram-negative bacteria and viruses are increasingly reported. The relevance of surface disinfection in the prevention of spread of infection is well proven in international literature. Improvement in surface disinfection decreases infection rates and can be achieved by monitoring the disinfection process and feedback to cleaning staff, rather than reporting a level of contamination or a score of cleanliness.
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Introduction

This overview is an update of a publication from 2010 [1]. A large amount of evidence on the contribution of surface disinfection to prevent HCAIs has been published, allowing an updated evaluation. In 2007, the relevance of surface disinfection was judged to be negligible, except in the outbreak situations [2]. In recent literature, microbial contamination of inanimate surfaces is seen as the cause of a significant number of HCAIs [3]. In 2004, Dettenkofer et al. concluded that there is no evidence for routine surface disinfection [4]. In 2013, Donskey concludes that a growing body of evidence exists which suggests that an improvement of surface disinfection can prevent transmission of pathogens [5].

Current practice and opportunities for optimization

Given the existence of this evidence, there is still a lack of implementation of surface disinfection reported in the literature. Latham and Cooper, for example, report a compliance rate of only 47 % in the disinfection of rehabilitation equipment in an acute care hospital [6]. By systematically introducing disinfectant wipes alone, this rate increased to 74 %. In two large studies, Carling et al. report compliance rates of only 48–49 % in cleaning and disinfection of frequently touched surfaces [7, 8]. Hence, there is still a need for improvement.

Contamination of surfaces in practice

For Gram-positive bacteria, a high tenacity is generally described [9]. Vancomycin resistant *Enterococcus faecium* was detected by culture more than two years after drying onto surfaces [10]. It is therefore not surprising that Meticillin Resistant *Staphylococcus aureus* (MRSA) have been found in practice on 3.3 % to 5 % of the examined surfaces [11, 12]. It is also not surprising that contamination of surfaces with *S. aureus* correlates with nasal colonization of patients [13]. *Clostridium difficile* was found on 34 % of surfaces in hospital rooms and in rooms occupied by colonized/infected patients, was found on 48 % of surfaces [14]. Fair et al. found MRSA and *C. difficile* on 11.8 % and 2.4 % of surfaces respectively in three Canadian hospitals [15].

In recent years, Gram-negative bacteria were increasingly reported to be found on inanimate surfaces. For example, *Acinetobacter baumannii* was detected on 48 % of the examined surfaces [16]. Rose et al.

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studied the occurrence of multi-resistant gram-negative bacteria on frequent hand contact surfaces (e.g. doors) in the vicinity of hospitals [17]. Multi-resistant *Enterobacteriaceae* were detected in about 1 % of the samples. This corresponds to the demonstrated stability of *Enterobacteriaceae* over 19 days on dry surfaces [18]. In 4.5 % of the samples within 0.5 miles, *A. baumannii* with clonal relation to hospital isolates was detected. At a distance of > 0.6 miles these pathogens were not found [17].

Viruses were also found on inanimate surfaces. In an assessment of surfaces close to toilets in a hospital, 78 % were positive for Adenovirus by PCR, 48% for Torque Teno Virus and 1% for Norovirus [19]. D'Arcy et al. found genetic material of Adenovirus, Cytomegalovirus, Norovirus, Rotavirus and Torque Teno virus on surfaces in a pediatric hospital outpatient waiting area [20]. It should be noted, however, that due to the PCR methodology used, this is no proof of the presence of infectious particles. Therefore, the findings in the case of viruses indicate only a potential risk of infection. In a similar study to detect these types of viruses, no correlation between virus detection and the presence of hemoglobin and bacterial contamination was found [21]. Classic methods for the detection of hygienic cleanliness of surfaces are therefore not meaningful for viral contamination.

Relevance of inanimate surfaces and their disinfection in transmission of infection

Donskey concludes in his review that the improvement of surface disinfection leads to a reduction of HAIs [5]. Stiefel et al. showed that contamination of the hands with *S. aureus* after direct contact with colonized patients and after contact of typical hand contact surfaces in patient rooms was equally likely. They conclude that surfaces play an important role in the transmission of MRSA [22]. The same was also found for *C. difficile* [23]. Accordingly, it could be shown that a daily disinfection of hand contact surfaces reduces the contamination on the hands of staff with MRSA or *C. difficile* in isolation rooms [24]. The role of inanimate surfaces in the transmission of pathogens is also clearly demonstrated by the fact that previous occupation of a hospital room by a colonized or infected patient is a risk factor for acquiring the same infection, when admitted to the same room [25]. This was demonstrated for both Gram-positive and Gram-negative bacteria.

In addition to the role of surfaces in patient rooms in transmission of infection, the role of surfaces in operating rooms is considered critically in the literature. As well as surgical site infections, outbreaks can originate in operating rooms and spread into other areas of the hospital [26].

One problem in proving the direct influence of surface disinfection on infection rates or the termination of outbreaks, is that during outbreaks usually several interventions are implemented in parallel as a bundle. For example, a *Klebsiella pneumoniae* outbreak could be terminated by introducing a bundle of surface disinfection, patient screening, improved staff training and improved communication [27]. A similar bundle was successful long-term with vancomycin-resistant *Enterococcus faecium* (VRE) [28]. However, some studies also clearly show the influence of surface cleaning alone. Employing only one additional person dealing with surface cleaning per ward resulted in a significant reduction of microbial contamination of surfaces and the MRSA infection rate [29]. Taking into account the costs associated with infections, this measure is rated as a cost-saving. Mahamat et al. describe the reduction of MRSA rate by gradually introducing a package of measures incl. surface disinfection [30]. After ceasing surface disinfection while maintaining all other measures, the MRSA rate rose again to its previous value. By introducing sporicidal instead of just bactericidal surface disinfection, the rate of *C. difficile*-associated diarrhea was significantly reduced. Returning to bactericidal surface disinfection, the rate rose to its former value [31]. The introduction of additional room disinfection after discharge of patients with *C. difficile* infection could further reduce the rate of infection [32]. Hughes et al. demonstrated that amongst various measures, an improvement in surface disinfection is the most likely to reduce *C. difficile* infection rates [33]. Weber et al. consider the role of inanimate surfaces in the transmission of *C. difficile* and surface disinfection to avoid transmission as uncontroversial [34].

In the meantime a first study was published demonstrating a significant decrease in MRSA, VRE and *C. difficile* infection rates upon change from mere cleaning of frequent touch surfaces in all patient rooms to disinfection [35]. In this study also the compliance in daily disinfection was monitored. The significant effect on MRSA and *C. difficile* rates could only be demonstrated at a compliance of at least 80 %.

Assessing adequacy of surface disinfection in practice and optimization

To help reduce the rate of infection, surface disinfection must be done correctly. In addition to the appropriate efficacy spectrum of the chosen disinfectant, ensuring surfaces are completely wet with sufficient amount of liquid and a mechanical wiping of the surfaces is vital [36, 37]. To verify the success of surface disinfection, microbiological methods to assess the microbial load of surfaces are considered to be gold standard. Galvin et al. point out the need for a standardization of test methods and evaluation criteria to assess success of surface disinfection [38]. One problem is that for the detection of different microbial groups, different methods have different sensitivity. It has been shown that for the detection of Gram-positive cocci, contact plates have a higher sensitivity than swabs. In contrast, for Gram-negative rods, swabs are favorable [39]. Due to non-standardized mechanical action during sampling, contact plates and swabs can only be regarded semi-quantitative in the recovery of infectious agents from surfaces. An option for quantitative recovery by a wet/dry procedure using two swabs is described in EN 16615 [40]. However, the problem of detecting viable but non-culturable forms of microbes still remains unsolved. Viruses are not detectable using these methods and they are suitable for anaerobes, only if additional anaerobic cultures are performed. Also, evaluation criteria for the inspection of surfaces with microbiological methods are not clearly defined. The discussed acceptable contamination of 2.5 to 5 colony forming units per cm2 appears to be relatively high [41]. Since contamination with viruses does not necessarily correlate with bacterial contamination, the value of such tests to assess infection risks is limited [21]. Another approach to assess the thoroughness of surface disinfection is to assess the disinfection process itself. This can be achieved by assessing the removal of invisible fluorescent markers [42]. By feedback to cleaning staff and appropriate training, a significant improvement can be achieved [8, 43]. It was shown that this kind of process evaluation correlates with evaluation of surface disinfection by microbiological methods [44]. In contrast for the evaluation by ATP measurement, this was not the case. Corresponding improvement programs are recommended by the US Centers for Disease Control and Prevention [45].

Conclusion

The importance of surface disinfection, particularly disinfection of hand contact surfaces to prevent infection in health care can be regarded as proven. An improvement in surface disinfection helps to reduce the transmission of infection. This improvement can be achieved by a review of the disinfection process, corresponding feedback and training of cleaning staff. Additionally, the choice of a disinfectant with an appropriate efficacy spectrum is crucial.

Conflict of interest

The authors are employees of Ecolab, manufacturer and distributor of disinfectants.

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