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Disinfectant Use in the Hospital Environment for Microorganisms Control

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Abstract

Studies indicate that the hospital has an important role in transmission of various pathogens. To minimize the spread of these microorganisms in hospitals, they proposed various forms of disinfection, however diversity and effectiveness of these methods are varied. Thus, this study aimed to understand the associations and approaches that have been reported in recent years on microorganisms control by disinfectants in the hospital environment, thus enabling the search for new strategies and/or implementation of conducts already performed in other hospitals. In this article they performed a systematic review on the topic, in accordance with the preferred reporting items for systematic reviews and meta-analyzes-PRISMA. Articles were selected published between the years 2012-2016 present in the PubMed database. The data demonstrate that reviews many conventional methods may be flawed (10%), or may not be able to reduce the number of microorganisms (30%). The most frequently related microorganisms were *Clostridium difficile* (20%), methicillin-resistant *Staphylococcus aureus* (40%), or *Enterococcus* resistant to vancomycin (20%). There was no evidence statistical differences for a tendency to exchange the conventional methods, however the management was highlighted by 50% of the disinfection process. But our approach has enabled better understanding of mechanisms linked to environmental disinfection process of pathogenic microorganisms, thus pointing to coherent strategies in disinfection processes, which have benefits with the reduction of major causative agents of nosocomial infections and thus with decreasing nosocomial diseases.

Keywords: Disinfectants; Hospitals; Microorganisms

Introduction

Hospital infections are one of the major cause of morbidity and mortality worldwide, and their treatment becomes increasingly difficult due to increased bacterial resistance [1]. Studies indicate that the hospital environment plays an important role in the transmission of several pathogens, including methicillin-resistant *Staphylococcus aureus*, Vancomycin-resistant *Enterococcus faecalis*, *Clostridium difficile*, *Acinetobacter baumannii*, among other important agents causing human infections [2,3]. In addition, agents that cause hospital infections are related to resistance to antibacterial treatments, resulting in higher mortality rates associated with hospital infections [4-6]. A series of factors are related to the decreased efficacy of antibacterial treatments, including self-medication, lack of adherence to the patient's treatment, repetitive infections, as well as bacterial biological characteristics that allow the development and selection of bacteria resistant to the various treatments [7,8].

In this way, measures are carried out with the purpose of containing the dissemination of multi resistant bacteria, as well as making it possible to reduce the proliferation of new multi resistant strains, and it is necessary to take measures that prevent evolution and the spread of antibiotic resistance [9]. Simple measures are taken, such as hand washing or even cleaning and proper disinfection in the hospital routine, and these can contribute substantially to minimize the spread of microorganisms [10,11]. However, some limitations are associated with these measures, such as the adherence of the executors and professionals of the area [12], to efficient methods that can contemplate the adequate process of hospital disinfection [13]. Considering these limitations some reports demonstrate efforts, where through different methods seek excellence in hospital disinfection [1,2].

However, with these possibilities for variations in the effectiveness of disinfection processes, new approaches must be undertaken to understand the best applications, as well as to indicate new strategies that can reduce this serious public health problem of the 21st century. Thus, the objective of this study was to understand the associations and approaches that have been reported in recent years on the control of microorganisms through disinfectants in the hospital environment, thus enabling the search for new strategies and/or the implementation

of successful behaviors already performed in other hospital environments.

Methods

Kind of study

This study is about a systematic review. Selection, evaluation, exposition and conclusions of the data were conducted in agreement with the preferred reporting items for systematic reviews and meta-analyses-PRISMA [14].

Extraction of data and inclusion and exclusion criteria

To select the data, we used the PubMed database (www.ncbi.nlm.nih.gov/pubmed) for the last five years (up to 09/02/2016). The terms extracted from Mesh (Medical Subject Headings): "Disinfectants", "hospitals", "environmental" and "microbiology" were used together. Within the objectives of this study, the following items were addressed: Authors+year, Objectives, Substances+Methods, Study Outcome. Articles that were included in reviews, without correlations with descriptors, articles that did not use solid disinfection processes, non-hospital disinfection processes and the non-use of disinfection processes were not considered for this study.

Statistical analysis

A descriptive analysis of the data was performed. Frequencies were compared by the Fisher's extract test and correlations were performed by the Spearman test after verifying the non-Gaussian distribution of the data. Statistically significant differences were considered when $p<0.05$ [15].

Results

In the search of the entire database collection using "PubMed", we found 152 articles after referring the descriptors. Of these, 46 articles were selected in the period established for this study, where 10 of these papers were separated for evaluation. The remaining articles were excluded for this approach because they did not follow the inclusion criteria (1-Revisions, 2-No correlation with descriptors, 2-without use of solid disinfection, 3-non-hospital disinfection processes and 4-non-use of Disinfection processes (Figure 1).

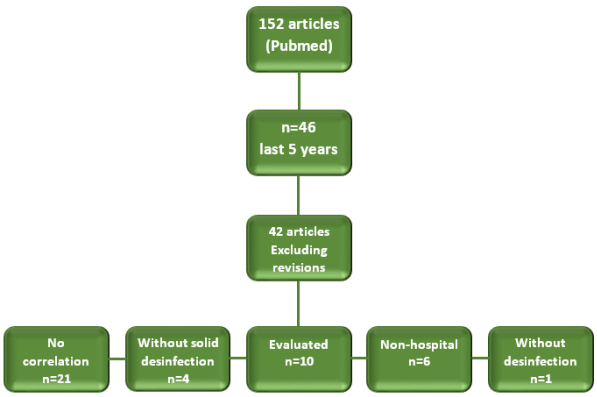

Figure 1: Selection of articles for evaluation.

The evaluated papers were described according to the authors and year of publication, as well as objectives, substances, methods used and results, as described in Table 1. In the last 5 years, we have shown an average of two articles per year, with 40% of these in the year of 2013. Regarding the objectives, it is notable the concern to verify the efficiency of methods and products already used (80%), as well as to propose the use of new products for the hospital disinfection process (20%).

Author	Objectives	Substance and methods	Study outcome
Perez et al. [16]	To evaluate and quantify the microbiological risk associated with the use of a single antimicrobial agent in the hospital surface treatment.	Disinfectant of 5% quaternary Ammonia, with residual antimicrobial effect. Samples were collected for microbiological culture before and after cleaning and after disinfectant use.	The total number of bacteria remained unchanged, but there was a reduction of gram-negative bacteria and *Staphylococcus aureus*, resulting in a lower risk of hospital infections.
Alfa et al. [17]	To assess prospectively whether daily hospital-based disinfectant use in place of a cleaner could significantly reduce hospital infection rates for methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant *Enterococcus* and *Clostridium difficile*.	Disinfectant and cleaner based on hydrogen peroxide, in a disposable wipes container (1x daily use). Cleaning service compliance rates were assessed by monitoring with an ultraviolet-visible marker and rates of hospital infection by methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant *Enterococcus* and *Clostridium difficile* were calculated by isolating these agents in infections.	There was a significant reduction in hospital-acquired infections due to methicillin-resistant *Staphylococcus aureus*, Vancomycin-resistant *Enterococcus* and *Clostridium difficile*.
Monk et al. [18]	Demonstrate the efficacy of two solid surfaces embedded with copper oxide in eliminating various pathogens according to previously approved protocols.	Two benches with and without copper oxide were compared by the activity of residual disinfectant and continuous bacterial reduction.	The two test benches passed all US Environmental Protection Agency acceptance criteria (>99.9% of deaths within 2 h exposure) by killing a range of bacterial pathogens even after repeated exposure to the pathogen and several cycles of wet and dry abrasion.

Seenama et al. [19]	Determine the effectiveness of Virusolve® disinfectant wipes and PAL® disinfectant wipes for the disinfection of inoculated bacteria in the hospital environment and medical equipment surfaces.	Extensively resistant methicillin-resistant *Staphylococcus aureus* and *Acinetobacter baumannii* were inoculated in various hospital equipment. The surface was then cleaned with one of four treatments: water; Water and detergent; Virusolve® disinfectant wipes; PAL disinfectant wipes. After cleaning, samples were collected for bacterial culture.	Extensively resistant methicillin-resistant *Staphylococcus aureus* and *Acinetobacter baumannii* were recovered from all surfaces cleaned with water; Water and detergent; PAL disinfectant wipes. However, the amount of bacteria recovered was lower in each treatment. Only the cleaned surfaces with disinfectant wipes (Virusolve®) did not recover the inoculated bacteria.
Sigler e Hensley [20]	Evaluate disinfectant activity after use of quaternary ammonia products.	The distribution of staphylococci on hospital room surfaces was evaluated before and after daily disinfection with quaternary ammonia products.	*Staphylococcal* markers were found on all surfaces evaluated.
Apisarnthanarak et al. [21]	To evaluate the use of fumigation with a combined quaternary ammonium compound and two alcohols after detecting large amounts of bacteria and fungi in the air.	Performed in a hospital in Thailand after flooding of contaminated water, where after protocol failure for decontamination with the use of hydrogen peroxide vapor or a quaternary ammonium-based compound, some parts of the hospital were instituted fumigation with solution of 2,5% quaternary ammonium salt with isopropyl alcohol, benzalkonium chloride and tridecyl acetate alcohol.	After the first protocol, the microbial load of air from bacteria and fungi resulted in more than 500 CFU/ m^3. After the second protocol, even after 14 days, the microbial load was less than 500 CFU/m^3.
Friedman et al. [22]	To compare a single-stage hospital disinfection protocol with a traditional three-stage hospital disinfection protocol, and eradication of vancomycin-resistant *Enterococcus* sp.	Environmental surface collections were performed randomly prior to disinfection and 1 hour after disinfection. Using Sodium Dichloroisocyanurate (three stages), or Benzalkonium (single stage). Colonization of vancomycin-resistant *Enterococcus* was evaluated.	Both protocols were able to decrease colonization by vancomycin-resistant *Enterococcus,* but the single-stage protocol resulted in lower colonization.
Doan et al. [23]	To compare the clinical efficacy and cost of eight environmental disinfection methods for the cleaning of hospital rooms contaminated with *Clostridium difficile* spores.	A randomized prospective study was conducted in three phases. Each empty hospital room was disinfected, contaminated with *C. difficile* spores, again disinfected with one of eight disinfection products and then samples were collected: hydrogen peroxide vapor; Dry ozone; Chlorine-releasing agent; Wipes with and without a chlorine-releasing agent; Dry atomized high temperature steam and sanitizing solution; Steam cleaning; Tissues with peracetic acid.	Three of the effective products were statistically significant, including hydrogen peroxide, chlorine releasing agent and wipes with peracetic acid.
Oie et al. [24]	Report bacterial contamination of a widely used environmental cleaning cloth (cloth), soaked in a low-level disinfectant.	172 samples were cultured during bacterial contamination. Pulsed field gel electrophoresis was used to compare the DNA found with the disease responsible and the samples collected.	Open packs of cloths soaked in 0.2% of alkyl amino ethyl glycine hydrochloride, used for environmental cleaning, have been shown to be contaminated with various strains (eg *Pseudomonas fluorescens* and *Pseudomonas aeruginosa*).
Schmidt et al. [25]	To characterize the microbial load (MC) associated with commonly touched objects, with and without copper in the intensive care unit (ICU), in order to understand the risk that CM can represent and the benefit that a perpetually active copper material can offer.	Sampling of six objects in 16 rooms in the ICU of three hospitals. Copper surfaces, with antimicrobial properties, were installed in six monitored objects in 8 of the 16 rooms.	Copper caused a significant reduction (83%) in CM found in objects compared to controls (no copper coating).

Table 1: Descriptive association of objectives, substances, methods, and results of descriptors: hospital disinfectants and environmental microbiology.

The data also demonstrate that conventional methods such as the use of tissues (cloths), soaked with disinfectants can be flawed, and carriers of microorganisms (10%). Commonly used products such as ammonia may result in failure of the disinfection process (10%), or even though methods may be effective in eliminating some related agents to develop nosocomial infections, they may not decrease the number of microorganisms (30%). On the other hand, studies show that product association and management can present an efficiency of up to 100% in environmental disinfection. In most of the works, the targets of the disinfectants were specific bacteria. The most frequently related microorganisms were *Clostridium difficile* (20%), Methicillin resistant *Staphylococcus aureus* (40%) or Vancomycin resistant *Enterococcus* (20%).

Although we demonstrated the application of new methods, we did not find statistically significant differences for a tendency to change conventional methods (Figure 2a); on the other hand, management

was highlighted with 50% of pipeline investigations in disinfection processes (Figure 2b).

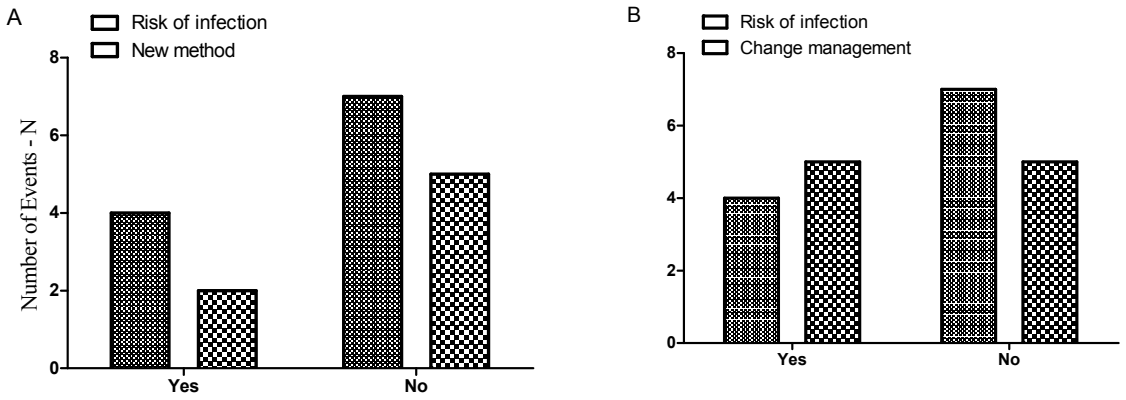

Figure 2: Comparative study of hospital infection risk. In A, it shows the comparison between risk of infection and the use of new methods. In B, the relationship between risk of infection and management change. Data compared by Fisher's extract test.

We still found a positive correlation ($p<0.05$) on the efficiency of disinfection techniques when handling, disinfection time and specific products (Spearman correlation).

Discussion

Hospital infections are major causes of complications in hospital settings, followed by increased mortality rates due to the ability to escape for conventional antibiotic treatments and/or even hospital settings. In this way, a search for conduits and applications can minimize the damage caused by these organisms. The process of environmental disinfection is an ally in combating the spread and development of hospital infections, given the variety of protocols that diversify not only chemicals but also management. Thus, we verified in this study the relationship between environmental disinfectant, hospital and microbiology. Our approach can demonstrate the association between the descriptors in the last years, to understand also that there are factors linked to the risk of infection by conventional methods, mainly given by the way of managing the execution of the protocols. Although some recent and innovative methods have high levels of satisfaction, the association of methods already incorporated can be extremely efficient if correctly executed.

Currently, a variety of disinfection methods are used in hospitals, only chemical disinfectants proposed in the Centers for Disease Control (CDC) guidelines for disinfection and sterilization of health facilities. Ten substances are described as base, whereas for sterilization three more substances are described [26].

The most accepted disinfection and sterilization guidelines emphasize the use of initial cleaning as a way of guaranteeing the effectiveness of disinfection and sterilization [26]. This approach is demonstrated in our approach as an effective method of environmental disinfection control. On the other hand, this efficient management is directly related to the chemical products used, as highlighted in some studies that presented good results with single-stage disinfection protocols, in which cleaning and disinfection are done in the same procedure [17,22].

We also showed a disinfection process for specific microorganisms, where protocols aimed at minimizing or even eliminating bacteria such as *Clostridium difficile* [17,23], methicillin-resistant *Staphylococcus aureus* [17-19,25] vancomycin-resistant *Enterococcus* [17,22] of which are often associated with hospital infections, with increased environmental resistance, have a more reserved prognosis and a difficult treatment [2,3].

Another important point is that although the association of commonly used techniques is efficient in the environmental disinfection process, inefficient daily practice in bacterial combat is still used [20], and it is not enough to use a high performance disinfectant, Association with good procedures [17] as well as the adaptation of the correct routine described in the protocols [22,27]. According to Alfa et al. [17], associated cleanliness compliance rates greater than 80% with disinfectant action resulting in lower rates of hospital infections by *Clostridium difficile*, methicillin-resistant *Staphylococcus aureus*, and vancomycin-resistant *Enterococcus*. Similar observations were made in a study by Gibert et al. [27], which even after disinfection of drug carriers, were again contaminated in less than 24 h of routine use and could serve as a carrier of pathogens to uncontaminated areas.

Also, a proposed alternative that presented good results was the use of objects impregnated by copper, which even after several cycles of wet and dry abrasion were able to kill a range of bacterial pathogens. It could also reduce the microbial load on surfaces of objects covered with this product and thus has great potential in decreasing hospital infections [18,25]. However, some factors establish and drive the adoption of protocols, such as cost, easy application and efficiency.

Conclusion

Our approach made it possible to improve the understanding of mechanisms linked to the process of environmental disinfection of pathogenic microorganisms, thus pointing to coherent strategies in the disinfection processes, where they present benefits with the reduction

of important agents causing nosocomial infections and consequently with the decrease of nosocomial diseases.

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