Surfaces of the hospital environment as possible deposits of resistant bacteria: a review

SUPERFÍCIES DO AMBIENTE HOSPITALAR COMO POSSÍVEIS RESERVATÓRIOS DE BACTÉRIAS RESISTENTES: UMA REVISÃO

SUPERFICIES INANIMADAS DEL AMBIENTE HOSPITALARIO COMO POSIBLES RESERVORIOS DE BACTERIAS RESISTENTES: UNA REVISIÓN

Adriana Cristina de Oliveira[1], **Quésia Souza Damasceno**[2]

ABSTRACT

The main objective of this study is to identify, in the literature, articles about the occurrence of contamination from inanimate surfaces and a possible dissemination of resistant bacteria in the hospital environment. A bibliographic survey was performed with articles published in the databases LILACS, MEDLINE, Science Direct, SCOPUS and ISI Web of Knowledge, between 2000 and 2008. Twenty-one articles were selected and analyzed. The analyzed studies highlighted the presence of bacteria on monitors, bed grids, tables, faucets, telephones, keyboards and other objects. There was a prevalence of Staphylococcus aureus resistant to methicillin, Clostridium difficile, Acinetobacter baumannii and Enterococcus resistant to vancomycin, being the predictive factor the previous occupation of patients colonized by these microorganisms. There was a similarity observed among the isolated strains of colonized and/or infected patients and the strains of the environment by molecular typification. These evidences reinforce the need for knowledge and control of the sources of pathogens in the hospital environment.

KEY WORDS
Cross infection.
Contamination.
Drug resistance, bacterial.

RESUMO

O principal objetivo deste estudo é identificar, na literatura, artigos sobre a ocorrência de contaminação das superfícies inanimadas e uma possível disseminação de bactérias resistentes no ambiente hospitalar. Realizou-se um levantamento bibliográfico de artigos publicados nas bases de dados LILACS, MEDLINE, Science Direct, SCOPUS e ISI Web of Knowledge, entre 2000 e 2008. Foram selecionados e analisados vinte e um artigos. Nos estudos analisados, realçou-se a presença de bactérias em monitores, grades de cama, mesas, torneiras, telefones, teclados de computador e outros objetos. Houve predominância de Staphylococcus aureus resistente à meticilina, Clostridium difficile, Acinetobacter baumannii e Enterococcus resistentes à vancomicina, sendo fator preditivo a ocupação prévia por pacientes colonizados por tais microrganismos. Verificou-se semelhança entre as cepas isoladas de pacientes colonizados e/ou infectados e as cepas do ambiente por tipificação molecular. Essas evidências reforçam a necessidade de conhecimento e controle de fontes de patógenos no ambiente hospitalar.

DESCRITORES
Infecção hospitalar.
Contaminação.
Farmacorresistência bacteriana

RESUMEN

Se objetivó identificar en la literatura artículos sobre la ocurrencia de contaminación de superficies inanimadas y la posible diseminación de bacterias resistentes en el ambiente hospitalario. Se realizó una investigación bibliográfica en las bases de datos LLILACS, MEDLINE, Science Direct, SCOPUS e ISI Web of Knowledge acerca de artículos publicados entre 2000 y 2008. Fueron seleccionados veintiún artículos. En los estudios analizados, se puso de manifiesto la presencia de bacterias en monitores, barandas de camas, mesas, canillas, teléfonos, teclados de computadora y otras. Existió predominancia de Staphylococcus aureus resistente a la meticilina, Clostridium difficile, Acinetobacter baumannii y Enterococcus resistentes a la vancomicina, resultando como factor predictivo el uso previo por parte de pacientes colonizados por tales microorganismos. Se verificó semejanza en las cepas aisladas de pacientes colonizados y/o infectados y del ambiente por tipificación molecular. Esas evidencias refuerzan la necesidad de conocimiento y control de fuentes de patógenos en el ambiente hospitalario.

DESCRIPTORES
Infección hospitalaria.
Contaminación.
Farmacorresistencia bacteriana.

INTRODUCTION

The dissemination of health-care associated infections (HAI) often originates from cross contamination. The most common means of pathogen transference occurs between the hands of health professionals and patients[1].

However, the hospital environment may contribute with the dissemination of pathogens. Environments occupied by colonized and/or infected patients generally can become contaminated[1]. The presence of bacteria is common in inanimate surfaces and equipment[2].

It was identified that in the USA there is frequent contamination of surfaces by vancomycin-resistant *Enterococcus* (VRE) and methicillin-resistant *Staphylococcus aureus* (MRSA). Although the microorganisms survive in the environment, the role that surfaces play in the dissemination remains unclear[3-4].

The definition of the role that the environment has on the acquisition of HAI is highlighted by the need for multiple strategies to control the dissemination of antibiotic-resistant bacteria; a global issue that increases the length of stay, costs and morbi-mortality[5]. Therefore, it is important to evaluate the role of the environment regarding infections to propose strategies that would reduce contamination and dissemination by pathogens[6].

It is observed that the environment may have a greater effect on intensive care units (ICU) because of the severe an unstable clinical conditions of patients who require intensive care, in addition to factors such as cleaning, disinfection, physical structure, amount of equipments and surfaces in certain units[7].

The dissemination of health-care associated infections is complex and has multifactor causes. In this sense, addressing the environment in bacteria dissemination aims at achieving a better understanding of HAI control, defining policies for control and building awareness about the subject among health professionals[8].

OBJECTIVE

The objective was to identify in literature articles about the occurrence of inanimate surface contamination and possible dissemination of resistant bacteria in the hospital environment.

> ...it is important to evaluate the role of the environment regarding infections to propose strategies that would reduce contamination and dissemination by pathogens.

METHOD

A literature review was performed of journals published in English, from 2000 to 2008, on the following data bases: Medical Literature (MEDLINE), Latin-American and Caribbean Center on Health Sciences Information (LILACS), Science Direct, SCOPUS (Database of research literature) and the Isi Web of Knowledge virtual research platform. This period was considered because the subject has not been much addressed and has been gaining the attention of researchers. The following keywords were used: *cross infection, transmission, environment* and *bacterial drug resistance.*

The inclusion criteria were the following: original articles presenting surface contamination associated with hospital infection and bacterial resistance, in adult patient units, using laboratory tests (biochemical and/or molecular) and statistical. A total 348 articles were found. Those that were not related with the subject (327) were excluded, and, thus, 21 articles were analyzed.

RESULTS

It was found that, in endemic and outbreak situations, there is environment contamination and bacterial transferring between patients and the environment (Chart1). In these studies, the bacterial species were identified using biochemical tests (gram staining, coagulase, oxidase, pyruvate and others). The profile of bacterial isolates was verified by antimicrobial susceptibility test by disk diffusion or determining the minimal inhibitory concentration (MIC) by the E-test[1-21].

The clonal relationship of bacterial isolates was often verified using pulsed-field electrophoresis (PFGE); a technique of high discriminatory power, broad application to the several species, and which permits to compare the similarity between strains[17-21].

In the endemic observation there was a greater prevalence of MRSA and VRE with a risk of patients acquiring infections in a contaminated environment. In outbreaks there were mostly gram negative bacteria; carbapenem-resistant *P. aeruginosa* and *A. baumanni*. Environment contamination by *C. difficile* was observed in both endemic and outbreak situations[1-14,16-18,20-21]. Despite the involvement of the environment in outbreaks in some studies the environment cultures were negative or, when positive, there was no strand similarity, suggesting other sources of dissemination[22-23].

Surfaces of the hospital environment as
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Oliveira AC, Damasceno QS

Rev Esc Enferm USP
2010; 44(4):1112-7
www.ee.usp.br/reeusp/

1113

Chart 1 - Studies using biochemical and/or molecular analysis of surface contamination and possible dissemination of resistant bacteria in ICU in endemic and outbreak situations, USA, France, Ireland, United Kingdom, Germany, Switzerland, Turkey, Canada, Spain, Belgium - 2000 - 2008

Observations in endemic situations		
Bacterial species	**Study design**	**Bacterial dissemination**
VRE[1,3,5,11-12]	1) Cultures of the environment and patients of two ICU. Determined the risk factors for being infected by VRE [1,11]. * 2) Culture of patients and room surfaces before and after routine cleaning in 27 episodes[3]. 3) Phases: 1- baseline, 2- educational intervention, 3- no intervention and 4- Hand washing. Samples were obtained from the hands of the workers, environment, and patients[5]. 4) Culture of patients, surfaces and from workers' hands and/or gloves before and after procedures[12].	1) High risk of being infected by VRE in the admission to rooms that were occupied one week before by a colonized individual (RR: 3.1; 95% CI, 1.6–5.8) or contaminated after cleaning (P<0.02)[1,11]. 2) Correlation between the ratio of positive culture per patient or environment and for workers' hands with or without gloves (r= 0.59; P=0.008)[3]. 3) The increase in cleaning time was associated with the reduction of VRE in environment cultures (P<0.0001)[5]. 4) The VRE transference rate was 10.6% between surfaces and patients[12].
MRSA[4,8]	5) Culture of patient rooms. Comparison of isolates from environment and patients[4,8].	5) MRSA isolates were identical or related in patients and environment in 70% of cases (25.4%)[4,8].
Pseudomonas aeruginosa[7,13]	8) Cultures of patients, room taps and workers' hands[7]. 9) Cultures of samples from the inside of taps in nine occasions (1997 – 2000)[13].	8) Possibility of transmitting strands from contaminated taps. After applying the measures there was a reduction in the colonization or infection rate by the pathogen (P<0.01)[7,13].
MRSA and VRE[9]	10) Cultures of patients to search for MRSA and VRE in 8 ICU of the hospital[9]. *	10) High chance of being infected by MRSA (odds ratio, 1.4; P=.04) and VRE (odds ratio, 1.4; *P*=.02) in rooms that were previously occupied by a colonized individual[9].
MRSA and VRE and gram negative[10,14]	11) Culture of the environment at ICU in the hospital for positive routine patient cultures (1997- 1999)[10]. 12) Culture of computer keyboards and taps of an ICU in eight episodes (two months)[14].	11) Environment contamination, especially with multi-resistant gram positive bacteria - MRSA and VRE (P<0.00001)[10]. 12) Contamination of computer keyboards and taps, especially with MRSA - (P<0,01)[14].
Clostridium difficile[15]	13) Culture of the environment of six health facilities from a metropolitan area[15].	13) The environment of patients with *C. difficile* was more probable of having microorganism isolation – (P<0.01)[15].
Observations in outbreak situations		
Bacterial species	**Study design**	**Bacterial dissemination**
Acinet obacter baumannii Strands resistant to carbapenems and cephalosporins[16-17].	1) Comparison of isolates from cultures of patients, environment and workers' hands[16]. * 2) Cultures of patients, surfaces and equipment from two ICUs of the hospital[17]. 3) Culture of patients, environment (surfaces, equipment and solutions) and workers' hands[18].	1) Identical strands in secretions, environment and workers' hands[16]. 2) Identical strand in patients and surfaces and dissemination of the strand between the ICUs[17]. 3) A multi-resistant strand was recovered from surfaces and patients[18].
C. difficile Strands resistant to fluoroquinolone[19].	4) Identification of patients with *C. difficile* before and after the outbreak. Culture of the environment[19].	4) Fluoroquinolone-resistant strands on surfaces, colonized individual and patient[19].
P. aeruginosa Strands resistant to trimethropin-sulfamethaxazole, gentamicins and carbapenems[2,6,20].	5) Investigation of postoperative infections and culture of the environment[2]. ** 6) Culture of blood and wound secretions, environment and tap water[6]. 7) Cultures of patients, environment, cytoscopy equipment and disinfection solution[20]. ** 8) Culture of rectal swab samples, workers' hands, solutions and environment[21].	5) Identical isolate from patients and instruments[2]. 6) Dissemination of the pathogen associated with the contamination of cleaning materials (RR = 3.9; P<0.01)[6]. 7) Single isolate clone from several patients, environment and instruments[20]. 8) Single multi-resistant clone in patients, taps and surfaces[21].

* Studies in which only biochemical tests were applied.
** Studies performed outside the ICU.

Hospital environment surfaces and recovered bacterial species

The following were often analyzed: bed, tap, computer and monitor (Figure 1)[3-4,6-14].
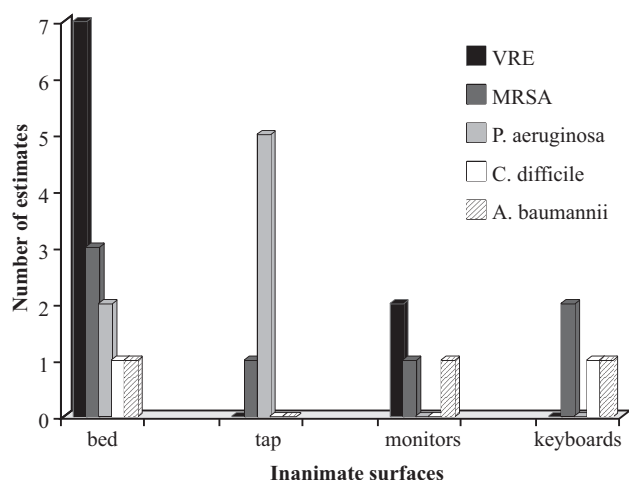

Figure 1 - Analyzed surfaces and the bacteria recovered from the hospital environment, USA, France, Ireland, United Kingdom, Switzerland, Germany, Hawaii, Katar, Mexico, Japan - 2000-2008

The following were recovered from bed surfaces: VRE, *P. aeruginosa*, *C.difficile, A. baumannii* and MRSA. The latter was the most frequent and was also found on handles, chairs, toilet seats, and table[1,3,7-11,14-16]. The most prevalent on taps was *P. aeruginosa;* common to humid places[13].

In a study in which the length of cleaning was increased to comply with an institutional protocol, there was no bacterial recovery compared to before, when bacteria was detected on telephones, taps and infusion pumps[11]. However, there have been reports on the persistence of VRE in the environment likely due to the incomplete removal of the pathogen in the cleaning[1]. Recontamination was verified a few weeks after exchanging the contaminated taps, in an outbreak by *P. aeruginosa,* possibly because of the formation of biofilm[13].

DISCUSSION

The hospital environment was highlighted as a potential reservoir of MRSA, VRE, *P. aeruginosa*, *C. difficile* and *A. baumannii*[1,8,10-13,16-21]. The higher contamination rate in ICU is coherent with the physical structure, high number of equipments and the conditions of intensive care patients, who tend to have more risk factors and higher infection rates. In this environment the risk of being infected by MRSA and VRE may increase in the presence of colonized patients or if the length of stay exceeds the average of 15 days, as stated by the guideline on the management of multidrug-resistant organisms in health care settings, 2006 [9,24].

The contamination of monitors and computers corroborated the hypothesis that surfaces that are touched often become more contaminated[5,8]. That premise reinforces the idea that it is often for professions to go by without washing their hands after touching a patient and return to their activities without being aware of the possibility of disseminating microorganisms.

The similarity of strands added to other evidence permits to draw more precise considerations about the origin of an outbreak so as to favor the implementation of effective control measures[2,17-21]. Molecular tests consist of an important aid in verifying the similarity of strands. Nevertheless, those tests are still not easily accessible to hospital laboratories, due to their limited financial resources which often make them unfeasible[4].

The circulation of a single clone in outbreaks evinces the involvement of the environment in HAIs. However, surface contamination may differ between outbreak and endemic periods[1]. During outbreaks, environment contamination may be higher. Nonetheless, in endemic situations, it was also registered that surfaces were contaminated with strands similar to those of patients and the contaminated environment was the predictive factor in the acquisition of VRE and MRSA[1,8-9,11].

The contamination of apparently clean locations reinforces the possibility of pathogen dissemination. Places considered *clean* surfaces, without any apparent dirtiness, often make effective cleaning measures to go ignored. The traffic of people; health team and visitors, in the unit and their consequent contact with different patients, objects and surfaces imply possibilities of pathogen dissemination if the necessary precautions are not observed, especially hand washing. However, other means may be involved in the transference of pathogens[22-23].

The transference of MRSA and VRE from surfaces and equipment was reinforced in the guideline for environment infection control in health-care facilities as a probable means of dissemination. Some highlights of the study were: surface contamination by VRE was higher in clinical areas of patients colonized in multiple body regions, with diarrhea and failures in workers using gloves or patients, relatives and visitors washing their hands[24]. Permanent education of workers and providing orientations to patients, relatives and visitors about measures to control HAI are an important aspect to be addressed at health services.

Surface contamination could be reduced with the act of washing hands before and after being in contact with the patients and the various surfaces. However, health professionals' adherence to this practice has been reported to be less than 50% in general health facilities[12,15]. Several aspects permeate the effective use of HAI control measures. It has been observed, according to the guideline about the control of multi-resistant organisms in health facilities that professionals are more receptive to control measures when the leaders also participate[25].

The clarification of the role that surfaces have in the dissemination of HAI could provide support to increase adherence to control measures and reviewing policies, besides

Surfaces of the hospital environment as
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Oliveira AC, Damasceno QS

Rev Esc Enferm USP
2010; 44(4):1112-7
www.ee.usp.br/reeusp/

1115

notifying about the means of dissemination that are still underestimated.

Intensifying the cleaning routine reduces the dissemination of pathogens. More attention should be given to the adequacy of the length, the frequency and specific care when cleaning surfaces, because removing dirtiness is important to reduce biofilms. The dissemination of pathogens could be prevented by using engineering and environment control strategies, i.e., by organizing the patient unit to make it easier to clean and taken care of [26].

FINAL CONSIDERATIONS

The contamination of surfaces in the ICU environment associated to a higher risk of being infected by MRSA and VRE was frequent in endemic situations, while in and outbreaks the more prevalent were carbapenem-resistant *A. baumannii* and *P. aeruginosa*. In both situations it was observed there was similarity between strands found in patients and isolated strands from environment surfaces. The molecular methods were the most used in analyses of the dissemination of HAI.

ICUs call for more attention because of their physical feature that favors the dissemination of pathogens in addition to the presence of patients in intensive care with a higher risk of acquiring infections. The organization of the space between beds and equipments, as well as the application of cleaning protocols for those surfaces according to the specificities of the sector, in addition to providing orientation to patients, relatives and visitors about washing their hands, and permanent education of workers may reduce dissemination in the environment and the acquisition of pathogens.

Taking into consideration the observations regarding the dissemination of pathogens in the hospital environment, there is a need for more knowledge, better control of sources, disseminating means and resources to help implement techniques to identify and compare pathogens more accurately in hospital laboratories. It should also be highlighted that it is important to look at the quality of environment cleaning, execution methods, products, the workers' degree of knowledge about the important of those aspects and the relation with the reduction of HAI dissemination.

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Surfaces of the hospital environment as
possible deposits of resistant bacteria: a review
Oliveira AC, Damasceno QS

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Correspondence addressed to: Quésia Souza Damasceno
Rua Paraíba, 100 - Morro das Bicas
CEP 34400-000 - Raposos, MG, Brazil