

RESEARCH PAPER

Microbiological analysis of inanimate surfaces in an Intensive Care Unit and patient safety

Análise microbiológica de superfícies inanimadas de uma Unidade de Terapia Intensiva e a segurança do paciente

Análisis microbiológico de superficies inanimadas en una Unidad de Cuidados Intensivos y la seguridad del paciente

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Abstract

Theoretical framework: The hospital has close links with hospital infections due to the fact that inanimate surfaces can harbor microorganisms of epidemiological importance.

Objectives: To microbiologically analyze inanimate surfaces in an Intensive Care Unit (ICU), as well as the resistance and sensitivity pattern of gram-negative bacteria found in these surfaces.

Methodology: Cross-sectional, exploratory, prospective study with a quantitative approach. Sample composed of equipment/materials and furniture in direct contact with patients and professionals at the ICU. Data were statistically analyzed using the *Statistical Package for the Social Sciences* (SPSS) software, version 17. Of the 49 samples analyzed, 24.4% were positive for multidrug-resistant *Acinetobacter baumannii*.

Results: The following equipment/materials and furniture tested positive: respirator, infusion pump, stethoscope, bed rails and clinical outcome table. Bacterial isolates were 100% resistant to cephalosporins, carbapenems, quinolones, and nitrofurans, and 100% sensitive to polymyxins, glycolylcine and aminoglycosides.

Conclusion: Inanimate surfaces in ICUs are sources of pathogens with high antimicrobial resistance and represent a challenge in ensuring patient safety.

Keywords: drug resistance; Intensive Care Unit; hospital-acquired infection.

Resumo

Enquadramento: O ambiente hospitalar tem estreita ligação com as infeções hospitalares devido ao fato das superfícies inanimadas poderem abrigar micro-organismos de importância epidemiológica.

Objetivos: Analisar microbiologicamente as superfícies inanimadas numa Unidade de Terapia Intensiva (UTI), bem como o padrão de resistência e sensibilidade de bactérias Gram-Negativas encontradas nessas superfícies.

Metodologia: Estudo transversal, exploratório, prospectivo com abordagem quantitativa. Amostra composta por equipamentos/materiais e mobiliários de maior contacto com os pacientes e profissionais na Unidade de Terapia Intensiva. Dados analisados estatisticamente pelo *Statistical Package for the Social Sciences* (SPSS), versão 17. Das 49 amostras analisadas, 24,4% foram positivas para *Acinetobacter baumannii* multirresistente.

Resultados: Os equipamentos/materiais e mobiliário que obtiveram positividade foram: respirador, bomba de infusão, estetoscópio, grades da cama e mesa de evolução clínica. As bactérias isoladas apresentaram 100% de resistência aos grupos das cefalosporinas, carbamazepênico, quinolonas e nitrofuranos, com 100% de sensibilidade a Polimixina, Gliciliclina e aminoglicosídeo.

Conclusão: Superfícies inanimadas em UTI são fontes de patógenos com alta resistência antimicrobiana e representam um desafio na garantia da segurança do paciente.

Palavras-chave: resistência a fármacos; Unidade de Terapia Intensiva; infecção hospitalar.

Resumen

Marco Contextual: El ambiente hospitalario tiene una estrecha relación con las infecciones hospitalarias, debido al hecho de que las superficies inanimadas pueden albergar microorganismos de importancia epidemiológica.

Objetivo: Analizar microbiológicamente las superficies inanimadas en una Unidad de Cuidados Intensivos, así como el patrón de resistencia y sensibilidad de las bacterias Gram negativas encontrado en estas áreas.

Metodología: Estudio transversal, exploratorio, prospectivo y con enfoque cuantitativo. La muestra estuvo formada por los equipos / materiales y mobiliario con los que más contacto tienen los pacientes y los profesionales de la unidad de cuidados intensivos. Los datos se analizaron estadísticamente mediante el Paquete Estadístico para Ciencias Sociales (SPSS), versión 17. De las 49 muestras analizadas, el 24,4 % fue positivo para *Acinetobacter baumannii* multirresistente.

Resultados: Los equipos / materiales y mobiliario que dieron positivo fueron respirador, bomba de infusión, estetoscopio, barandillas de la cama y mesa de resultados clínicos. Las bacterias aisladas mostraron una resistencia del 100 % a los grupos de las cefalosporinas, carbamazepinas, quinolonas y nitrofuranos, con un 100 % de sensibilidad a la polimixina, gliciliclina y aminoglucósidos.

Conclusión: Las superficies inanimadas en la UCI son una fuente de patógenos con alta resistencia antimicrobiana y representan un desafío para garantizar la seguridad del paciente.

Palabras clave: resistencia a medicamentos; Unidades de Cuidados Intensivos; infección hospitalaria.

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Introduction

Considered epicenters of bacterial resistance, Intensive Care Units (ICUs) are the main source of upsurges in multidrug-resistant bacteria, which are responsible for a large number of health care-associated infections. Over the years, these microorganisms have become increasingly resistant to common antibiotics and even impenetrable to new therapies, raising the concern of the scientific community with the issue of bacterial resistance (Oliveira & Silva, 2008).

There has been an increase in the rate of nosocomial infections associated to antibiotic resistant bacteria worldwide. In the United States, more than 70% of bacteria isolates in hospitals are resistant to at least one common antibiotic used to treat such infection. Microorganisms are generally transmitted to patients via the hands of health care professionals or through the patients' direct contact with contaminated material or environment (Oliveira, Silva, Díaz, & Iquiapaza, 2010).

In this context, patient safety emerges as a structural component and a key variable of quality in health care. It is, thus, of paramount importance to study the role of hospital environment in the transmission of pathogens, as it may clarify some of the issues involving the triad *microorganism - susceptible - environment*, as well as help reflect on the actions of health care professionals in the work environment, taking into account their role in the transmission of infections. This study aimed to microbiologically analyze inanimate surfaces in an Intensive Care Unit, as well as the pattern of resistance and sensitivity of gram-negative bacteria found in these surfaces.

Background

The Brazilian Health Surveillance Agency (2010) defines multidrug-resistant microorganisms as microorganisms resistant to different classes of antimicrobials tested microbiologically and pandrug-resistant microorganisms with proven *in vitro* resistance to all antimicrobials tested microbiologically. The international scientific community considers them to be multidrug-resistant pathogens causing health care-associated infections/colonizations: Glycopeptide-resistant *Enterococcus* spp., Vancomycin-intermediate and Vancomycin-resistant *Staphylococcus* spp., *Pseudomonas*

aeruginosa, *Acinetobacter baumannii* and Carbapenem-resistant *Enterobacteriaceae* (ertapenem, meropenem or imipenem).

The mechanism of antimicrobial resistance in bacteria means naturally resisting to a class of antimicrobial agents, which is called intrinsic resistance. In addition, there is the mechanism of acquired resistance, in which initially susceptible populations of bacteria become resistant to a antimicrobial agent through mutation and selection or via the acquisition of resistance codifying genes from other bacteria (Tenover, 2006).

Damasceno (2010) and Kramer, Schwelbke and Kampf (2006) argue that equipment and inanimate surfaces close to the patient, which are often touched by health care professionals, as well as solutions and water may become contaminated and a reservoir for multidrug-resistant pathogens. Due to the lack of studies on this topic, the authors highlight that further studies are needed to identify the epidemiological characteristics of microorganisms clinically important for the service since the profile of infections varies between institutions when microorganisms are present on surfaces, solutions and equipment and the patient's cultures possibly present similar positive results. A single incidence of hand contact with a contaminated surface results in a variable degree of pathogen transfer. Contaminated hands can also be the source of recontamination of the surface.

It is important to reflect on a principle of the World Health Organization (WHO) which establishes patient safety as a priority in health care services, taking into account the need for a *clean* care provision, free of contamination. There is a probable relationship between the presence of resistant pathogens on hospital surfaces and equipment and the frequency with which they are cleaned, how they are cleaned, the proper use of disinfectants and the proper disinfecting technique (Oliveira & Damasceno, 2010). Despite its high cost, the microbiological assessment of hospital surfaces is recommended for outbreak investigations whenever environmental sources are epidemiologically related to the spread of infections (Centers for Disease Control and Prevention, 2003). Patient safety is defined as the absence of accident or preventable injury during the health care process. It includes all actions, structural elements, processes, tools and methodologies consistent with the scientific

evidence which are carried out in order to minimize the risk of an adverse event and its damages during health care provision, thus complying with the high safety standards (Fernandes & Queirós, 2011). According to the WHO, safety is a fundamental principle of patient care and a critical component of quality management. Its improvement demands a complex system-wide effort, involving a wide range of measures to improve risk management, performance and environmental safety.

Methodology

A cross-sectional, descriptive, exploratory, prospective study was carried out with a quantitative approach. The study was conducted at the adult ICU of the Hospital da Restauração in the city of Recife, Pernambuco, Brazil. This Unit consisted of 28 beds. The sample was composed of all equipment/materials and furniture of the ICU with which patients and health care professionals had greater contact. The following were selected: mechanical respirators, infusion pumps, heart rate monitors, stethoscopes, bed rails, inner handle of the entry and exit door, bedside table handle, clinical outcome table and phone.

Data were collected during June 2012, after analysis and approval by the Research Ethics Committee of the selected institution (CAAE no. 0056.0.102.000-

11). The materials/equipment for data collection were divided into two different groups, using a convenience sampling: Group 1 was composed of patients isolated from contact with multidrug-resistant *Acinetobacter baumannii*, while Group 2 was composed of non-isolated patients. For a pairwise composition of the 1st and 2nd groups, patient beds were randomly selected: group 1 was composed of beds 5, 6, 7 and 10, while group 2 consisted of beds 3, 9, 12 and 18.

The samples were collected during the 8 a.m. shift by the researcher before the daytime cleaning of the equipment, without prior notice, by swabbing the surfaces of the selected sites. No disinfectant neutralizers were used after sample collection, nor were the site sizes standardized for sample collection. To clean the surfaces, the ICU uses a disinfectant with bactericidal, virucidal, fungicidal, tuberculocidal, and sporicidal characteristics. According to the CDCP (2003), the collection of environmental samples should follow an aseptic technique and surfaces should be visibly clean. The sample collection site in each equipment/materials and furniture are presented in Table 1. After being used, the swabs were then placed into a 1 ml tube of buffered and sterile saline solution and transported to the laboratory, where the superficial seeding and spreading in Petri plates containing the blood agar culture medium were performed. After being identified, the samples were placed in a greenhouse at 35 °C for 24 hours.

Table 1
Collection sites of the equipment/materials and furniture in the ICU (Hospital da Restauração-Recife, 2011)

Equipment/materials	Collection sites
Mechanical respirator in each bed - when being used	Y connection to the airway device
Infusion pumps	Panel (command buttons)
Heart rate monitor	Left-hand panel (command buttons)
Bed rails - on both sides	Central area of the top, middle and bottom rails
Stethoscope	Diaphragm (surface in contact with the patient)
Clinical outcome table	Upper surface of the table
Bedside table in each bed	Bedside table drawer handles
Inner exit door handles of the Unit	Central external area
Phone	Phone hook and buttons

The bacterial colonies were macroscopically analyzed, with a focus on the search for gram-negative bacteria, which is the group of the multidrug-resistant pathogens of epidemiological importance for the service. Then, these colonies were isolated using a

platinum loop and seeded using the *bioMerieux CPS chromogenic culture media* (Marcy L'Etoile, France). Microbial growth was not measured. After 24 hours, they were diluted in sterile saline according to the 0.5 McFarland standard for automated reading using

the bioMérieux Vitek 2 Compact (Marcy L'Etoile, France). Bacteria were identified and the antibiogram was performed. The following antimicrobials used at the service were tested: Aminoglycosides (Amikacin, Gentamicin), B-lactams (Ampicillin, Cefepime, Cephalothin, Cefotaxime, Ceftazidime, Imipenem, Meropenem, Piperacillin, Amoxicillin), Quinolones (Ciprofloxacin, Levofloxacin, Naladixic acid), Polymyxin (Colistin), Glycylcyclines (Tigecycline), Nitrofurans (Nitrofuraz).

Data were analyzed using descriptive statistical techniques through absolute and percentage distributions. Pearson's Chi-square test was used as a method of inferential statistics. The margin of error used in the decision of the statistical tests was 5%. The

statistical software used to insert the data and obtain statistical results was the *Statistical Package for the Social Sciences* (SPSS), version 17.

Results

A total of 49 samples were collected: 46 samples relate to equipment/materials (mechanical respirators, infusion pumps, heart rate monitors, stethoscopes and bed rails) and 3 samples relate to furniture (clinical outcome table, phone and door handles) as shown in Table 2. Twelve samples were positive for multidrug-resistant *Acinetobacter baumannii*, corresponding to 24.4% of the total sample.

Table 2

Frequency of the presence of the multidrug-resistant Acinetobacter baumannii in the surfaces of equipment/materials and furniture, according to the group of contact isolated and non-isolated patients at the ICU (Hospital da Restauração-Recife, 2011)

Site	Groups		Total
	Group 1: Contact isolated n1/n2	Group 2: Non-isolated n1/n2	
Respirator ⁽¹⁾	2/2	3/4	5/6
Infusion Pump	1/4	2/4	3/8
Monitor	0/4	0/4	0/8
Bed rail	0/4	1/4	1/8
Stethoscope	2/4	0/4	2/8
Bedside Table	0/4	0/4	0/8
Total	5/22	6/24	11/46

(1): The test was not performed in two patients of group 1 in the aforementioned site due to use of another airway device.

n1/n2: n1 number of samples positive for *Acinetobacter* and n2 number of analyzed samples.

After assessing the frequencies of the presence of the multidrug-resistant *Acinetobacter baumannii* bacterium in the surfaces of equipment/materials and furniture, considering the group of contact isolated and non-isolated patients at the ICU, Table 3 shows that the multidrug-resistant *Acinetobacter baumannii* bacterium was present in 83% (5/6) of the respirators, followed by 37.5% (3/8) of the infusion pumps, 25% (2/8) of the stethoscopes and 12.5% (1/8) of the bed rails. Table 3 also shows the frequency of the presence of the multidrug-

resistant *Acinetobacter baumannii* bacterium in the equipment/materials according to the group of contact isolated and non-isolated patients at the ICU. It was observed that the contamination in group 1 (isolated patients) was 22.7% positive for the multidrug-resistant *Acinetobacter baumannii* bacterium in equipment/materials. In group 2 (non-isolated patients), it was 25% positive for the multidrug-resistant *Acinetobacter baumannii* bacterium in equipment/materials. In this case there was no statistically significant difference.

Table 3

Frequency of the presence of the multidrug-resistant *Acinetobacter baumannii* bacterium, according to the group of contact isolated and non-isolated patients at the ICU (Hospital da Restauração-Recife, 2011)

Patient Condition							
Multidrug-resistant <i>Acinetobacter baumannii</i>	Group 1: contact isolated		Group 2: Non-isolated		Total		p value
	n	%	n	%	n	%	
Present	5	22.7	6	25.0	11	23.9	p ⁽¹⁾ = 0.857
Absent	17	77.3	18	75.0	35	76.1	
Total	22	100.0	24	100.0	46	100.0	

(1): Using Pearson's Chi-square test.

Table 4 showed the pattern of resistance and susceptibility to antimicrobial agents of the strains of multidrug-resistant *Acinetobacter baumannii* in the samples of inanimate surfaces in the ICU. It evidenced that all samples were resistant to

cephalosporin, carbapenems, B-lactams, nitrofurans and sulfonamides and showed sensitivity to Amikacin (aminoglycoside), Colistin (polymyxin) and Tigecycline (Glycylcyclines).

Table 4

Patterns of resistance and sensitivity to antimicrobials of the multidrug-resistant *Acinetobacter baumannii* in samples of inanimate surfaces at the ICU. (Hospital da Restauração-Recife, 2011)

Resistance			Sensitivity		
Cephalosporins	Cefepime	100%	Polymyxin	Colistin	
	Cefotaxime				
	Ceftazidime				
Carbapenems	Imipenem	100%	Glycylcycline	Tigecycline	
	Meropenem			100%	
Quinolone	Ciprofloxacin		Aminoglycoside	Amikacin	
	Levofloxacin				
	Nalidixic acid				
Nitrofurans	Nitrofuraz				

Discussion

The predominant microbial growth of multidrug-resistant *Acinetobacter baumannii* in the surfaces of materials and equipment studied shows the relevance of this pathogen in hospital settings, since strains of *Acinetobacter baumannii* have the ability to survive on dry surfaces for a long time, while maintaining their ability to multiply and infect (Menezes, 2007).

Health care professionals can also become colonized. However, immunocompromised patients, who have been submitted to a large number of invasive procedures and treated with broad-spectrum antibiotics, such as ICU patients, are

more susceptible to becoming infected with *Acinetobacter baumannii*, which is a common cause of nosocomial pneumonia. The literature also mentions a growing concern with the increase of the resistance of *Acinetobacter baumannii* to antimicrobial agents in every continent (Allen & Hartman, 2005).

As the reason for contact isolation in the group of infected patients was the *Acinetobacter baumannii*, there was a high probability of inanimate surfaces in the area surrounding the bed becoming contaminated by the same microorganism through the frequent touch of health care professionals. Consistently with our results, a study is cited in which, during an outbreak of *Acinetobacter baumannii* at

a neurosurgical ICU, a direct correlation was found between the number of environmental isolates and the number of patients who were colonized or infected with the same strain during the analyzed period. In this case, the environment can play a significant role in the transmission of nosocomial pathogens during outbreaks. In our study, there was a 100% phenotypic similarity between the result of environmental cultures and the cultures of isolated patients, in which the selected surfaces tested positive for *Acinetobacter baumannii* (Kramer et al., 2006). The evidence indicates that the most effective measure in the fight against hospital infections is hand washing. This practice is essential to reduce the spread of bacterial resistance. The most recent official recommendation on hand washing was proposed in 2002 by the CDC, and made official in Brazil by the Brazilian Health Surveillance Agency (2010). It recommends that hands should be washed with an antiseptic soap (PVP-I or 2% chlorhexidine) before and after the provision of care to patients isolated due to infection by resistant microorganisms.

This measure is essentially based on the fact that health care professionals may often spread bacterial resistance through apparently innocuous actions, such as touching the intact skin of a colonized patient, resting their hand on the patient's bed or even on the handle, medical chart or phone, thus leading to contamination (Oliveira & Silva, 2008).

There is the possibility of resistant microorganisms persisting in the hands, inanimate objects, surfaces/ environments and being transmitted from one patient to another or to surfaces and environments when health care professionals do not perform their hand hygiene, thereby perpetuating the transmission chain (Oliveira et al., 2010).

In addition, the least contaminated equipment were the multi-parameter monitors, in which all samples were negative. This finding may reflect the less frequent touch of the monitor's buttons by health care professionals, since the measurement of vital signs can be automatically programmed at regular intervals.

As for the presence of bacteria in samples of surfaces of materials and equipment near the bed in group 1 (isolated patients) and group 2 (non-isolated patients), it was observed that there was no statistical significance between the results ($p>0.5$). The

Acinetobacter baumannii was present in 22.7% of the samples of surfaces in group 1 (isolated patients) and in 25% of the samples in group 2 (non-isolated patients). These data show that surfaces may be contaminated, regardless of whether the patient is infected or not.

Therefore, the contamination can be associated with cross-contamination, in which, if there is insufficient hand washing when providing care to isolated patients, objects and surfaces surrounding other patients will be touched, contaminated and become a source of infection for susceptible patients. Nursing professionals' unawareness of the role of environmental surfaces as major reservoirs for the dissemination of multidrug-resistant bacteria (MDRB) is alarming, with an impact on the possibility of exposure to such factors, without the proper precautions, and, consequently, to the risk of contamination and spread of these MDRB (Panhotra, Saxena, & Abdulrahman, 2005).

The impact of environmental contamination and inadequate hand washing by health care professionals in the spread of *Acinetobacter baumannii* increases the number of colonized patients and, consequently, the degree of environmental contamination.

Health care professionals with poor adherence to hand hygiene contaminate the environment and susceptible patients more often. When there is an association between the variables *environment*, *patient* and *infective agent*, there is a correlation between inadequate hand hygiene and environmental contamination (Moura & Gir, 2007). All aspects concerning surface cleaning and disinfection procedures, along with hand hygiene, contribute effectively to avoid and/or minimize the emergence of environmental reservoirs, which are sources of infection for critically ill patients.

The CDC (Centers for Disease Control and Prevention, 2003) recommends the frequent and routine cleaning and decontamination of surfaces during hospitalization and after patient discharge in a supervised way in order to eliminate the possibility of becoming a reservoir. The adequacy of the duration, frequency and specific care in surface cleaning requires greater attention as the removal of dirt is important to reduce biofilms. The spread of pathogens may be prevented with an increase in thorough cleaning techniques of surfaces and equipment surrounding the patient, as well as the

proper use of hospital disinfectants (Wisplinghoff, Schmitt, & Wöhrmann, 2007).

In 2010, bearing in mind the importance of the hospital environment in nosocomial infections, the Brazilian Ministry of Health drew up a guide with surface cleaning and disinfection recommendations designed to help the institutions ensure patient safety, a clean place and an environment with less potential for contamination, thus contributing to reduce the possibility of transmission of infection from inanimate sources.

The implementation of a safety culture in health care organizations has become one of the pillars of the movement for patient safety. Patient safety means the absence of preventable patient damage during the process of health care provision. It is estimated that 1 in every 10 patients is harmed while receiving hospital care. Based on this principle, the WHO, through the establishment of an International Alliance in 2004, has been supporting the campaign *Clean Care is Safer Care* in order to establish global rules and standards to support the efforts of countries to develop patient safety policies and practices, thus reducing the social and health consequences of adverse events resulting from unsafe health care (Pittet & Donalson, 2005).

The treatment of *Acinetobacter baumannii* infections has been extremely difficult due to the phenotype of multiple resistance to antibiotics of most clinical isolates. This remarkable phenotype of resistance can also be explained by the ability of clinical strains of the *Acinetobacter baumannii* to form biofilms on abiotic surfaces (Pier, Francesco, Maria, Maria, & Raffaele, 2011). Due to the resistance to carbapenems (Imipenem, Meropenem), the treatment is limited to polymyxins, such as colistin (Pier et al., 2011). This corroborates the findings of this study, where 100% of the samples positive for multidrug-resistant *Acinetobacter baumannii* were sensitive to colistin. On the other hand, a study found a level of sensitivity of 52-68% of the *Acinetobacter baumannii* to carbapenems in blood cultures (Aguirre, Mijangos, Zavala, Coronado, & Amaya, 2009). The difference in the results between these studies may be associated with characteristics of bacterial strains existing in each hospital unit. Nowadays, it is not common to identify *Acinetobacter baumannii* sensitive to carbapenems. Studies with bacterial genome showed that genes are involved in drug resistance mechanisms, as well as encode membrane proteins, such as OmpA,

which plays a key role in the formation of biofilm. Multidrug resistance is a key feature of *Acinetobacter baumannii*, and several genes are connected to the establishment of a multidrug-resistant phenotype. The ability of *Acinetobacter baumannii* to adhere and persist in surfaces such as biofilms may be key to its pathogenicity, which may explain its ability to survive in hospital environments, causing device-related infections in immunocompromised patients (Gaddy, Tomaras & Actis, 2009).

Acinetobacter baumannii was also detected in the clinical outcome table, which shows limitations in the professionals' actual adherence to hand washing. As this space is intended for and available to all professionals, direct contamination can come from the individual itself after contact with the patient and function as the pathogen's reservoir. Another professional who might use and rest at the table, even if for a short period of time and even without direct contact with any patient, may become colonized and, consequently, spread multidrug-resistant strains to other sectors of the institution or even take them to other hospitals or their own home through their personal contaminated objects.

Although the CDC does not recommend the routine collection of environmental samples, it argues that such action can help determine the effectiveness of cleaning and disinfection procedures, with the supervision of the hospital's infection control committee and Microbiology Laboratory. The CDC highlights that surface sampling may be useful for quality assurance purposes. As a research tool, surface sampling has been used to determine the potential of environmental reservoirs for the survival of pathogens, identify microorganisms on the surfaces and, consequently, identify the contamination sources.

Conclusion

There was a predominance of multidrug-resistant *Acinetobacter baumannii* in mechanical respirators, infusion pumps, stethoscopes and bed rails. There was no statistical significance ($p=0.857>0.5$) between the groups of isolated and non-isolated patients. The strains of *Acinetobacter baumannii* showed resistance to cephalosporins, carbapenems, B-lactams, nitrofurans, and sulfas and sensitivity to

Amikacin (Aminoglycoside), Colistin (Polymyxin) and Tigecycline (Glycylcyclines).

The prevention of the occurrence and transmission of multidrug-resistant pathogens requires a comprehensive multidisciplinary collaboration. Both the adoption of administrative/institutional measures and continuing education should promote safe practices for the provision of care to critically ill patients, by offering a microbiologically safe environment that reflects the excellence of care.

The study showed some limitations such as the convenience sample and the lack of a genotyping method to confirm the similarity between the strains in the surfaces of isolated and non-isolated patients, thus, the existence of cross-contamination.

Understanding the contamination of inanimate surfaces and how to eliminate it promotes quality of care and patient safety. Future studies with genotyping of isolated and non-isolated patients should assess the team's accountability in spreading the infection.

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