Journal of Nursing
Revista de Enfermagem
UFPE On Line
ISSN: 1981-8963

ORIGINAL ARTICLE

ETHYL ALCOHOL: AN ANALYSIS OF ITS DISINFECTING ACTION ON YEAST FOUND IN HOSPITAL MATTRESSES

ÁLCOOL ETÍLICO: ANÁLISE DA AÇÃO DESINFETANTE SOBRE LEVEDURAS PRESENTES EM COLCHÕES HOSPITALARES

ALCOHOL ETÍLICO: ANÁLISIS DE SU ACCIÓN DESINFECTANTE EN LEVADURAS PRESENTES EN COLCHONES HOSPITALARIOS

Francine da Silva e Lima de Fernando[1], Adriano Menis Ferreira[2], Tatiana Elias Colombo[3], Marcelo Alessandro Rigotti[4], Fernando Gôngora Rubio[5], Margarete Gottardo de Teresa Almeida[6]

ABSTRACT

Objective: to evaluate the effectiveness of 70% (w/v) alcohol for disinfecting yeast in hospital mattresses. **Methods:** a cross-sectional study conducted between August 2009 and October 2011 in which swab samples were collected from 74 mattresses used by patients with Candidemia from different units and after terminal cleaning procedures. Isolated yeast samples were identified by their macroscopic, microscopic and physiological characteristics. ***Results:*** a total of 28 (38.2%) mattresses presented yeast contamination, out of which 19 (67.8 %) and 9 (32.1%) corresponded, respectively, to samples taken before and after cleaning/disinfection with 70% (w/v) alcohol. The most common species were *Trichosporon asahii* and *Candida parapsilosis*. ***Conclusion:*** considering that 47.7% of mattresses were still contaminated after terminal cleaning/disinfection, we can infer the risk of these mattresses acting as secondary reservoirs in the infection chain and the ineffectiveness of their terminal cleaning/disinfection procedure. ***Keywords:*** Beds; 2-Propanol; Yeasts; Candida; Disinfection; Hospital Infection.

RESUMO

Objetivo: avaliar a ação do álcool etílico a 70% (p/v) como desinfetante sobre leveduras presentes em colchões hospitalares. ***Método:*** estudo transversal realizado no período de agosto de 2009 a outubro de 2011, onde foram coletadas amostras com swabs de 74 colchões, utilizados por pacientes com Candidemia, de diferentes unidades, e que receberam limpeza terminal. As leveduras foram isoladas e identificadas pelas características macroscópicas, microscópicas e fisiológicas. ***Resultados:*** totalizou-se 28 (38,2%) colchões contaminados com leveduras, dos quais 19 (67,9%) e nove (32,1%) corresponderam, respectivamente, à coleta antes e após a limpeza/desinfecção com álcool etílico a 70% (p/v). As espécies mais frequentes foram *Trichosporon asahii* e *Candida parapsilosis*. ***Conclusão:*** considerando que 47,4% dos colchões permaneceram contaminados após o processo de limpeza/desinfecção terminal, pode-se inferir sobre o risco destes atuarem como reservatório secundário na cadeia de infecção, apontando para a ineficiência no procedimento de limpeza/desinfecção terminal dos colchões avaliados. ***Descritores:*** Leitos; 2-Propanol; Leveduras; Candida; Desinfecção; Infecção Hospitalar.

RESUMEN

Objetivo: evaluar la acción del alcohol etílico al 70% (p/v) como desinfectante en levaduras presentes en colchones hospitalarios. ***Método***: estudio transversal, realizado entre agosto 2009 y octubre 2011, recolectándose las muestras con swabs de 74 colchones utilizados por pacientes con candidemia, de diferentes unidades y que recibieron limpieza terminal. Las levaduras fueron aisladas e identificadas según características macroscópicas, microscópicas y fisiológicas. ***Resultados***: Se contaron 28 (38,2%) colchones contaminados con levaduras, de los que 19 (67,9%) y 9 (32,1%) correspondieron, respectivamente, a la recolección antes y después de la limpieza/desinfección con alcohol etílico a 70% (p/v). Las especies más frecuentes fueron Trichosporon asahii y Candida parapsilosis. ***Conclusión***: considerando que 47,4% de colchones continuaron contaminados luego del proceso de limpieza/desinfección terminal, puede inferirse el riesgo de que estos actúen como reservorio secundario en la cadena infecciosa, y se toma nota de la ineficiencia del procedimiento de limpieza/desinfección de los colchones evaluados. ***Descriptores***: Lechos; Propanolol; Levaduras; Candida; Desinfección; Infección Hospitalaria.

[1]Master's in Nursing. Professor of Biotechnology, Undergraduate Nursing Program, São José do Rio Preto University Center (UNIRP). São José do Rio Preto (SP), Brazil. E-mail: francineslfernando@gmail.com; [2]Doctor of Nursing with Post-Doctoral studies. Professor in Nursing, Federal University of Mato Grosso do Sul (UFMS), Três Lagoas Campus; Member, Graduate Faculties in Nursing and Health and Development in the Central-West Region, UFMS, Campo Grande Campus. Três Lagoas (MS), Brazil. E-mail: a.amr@ig.com.br; [3]Biomedicine degree from Western São Paulo University Center, São José do Rio Preto, (SP), Brasil. E-mail: taty_ec@hotmail.com; [4]Master's in Science. Professor of Nursing, Undergraduate Nursing Program, Federal University of Mato Grosso do Sul (UFMS), Três Lagoas Campus. Três Lagoas (MS), Brazil. E-mail: marcelosaude@hotmail.com; [5]Doctor of Infectious Diseases. Department of Dermatology and Infectious and Parasitic Diseases, São José do Rio Preto Medical School (FAMERP). São José do Rio Preto (SP), Brazil. E-mail: gongora@famerp.br; [6]Doctor of Biology. Professor of Biology, Department of Dermatology and Infectious and Parasitic Diseases, São José do Rio Preto Medical School (FAMERP); Member, Graduate Faculty in Health Sciences, FAMERP, and Graduate Faculty in Microbiology, São Paulo State University. São José do Rio Preto (SP), Brazil. E-mail: margarete@famerp.br

INTRODUCTION

Literature provides circumstantial evidence indicating that environmental surfaces contaminated with microorganisms, including Vancomycin-resistant *enterococci* (VRE), Methicillin-resistant *Staphylococcus aureus* (MRSA), *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, Norovirus and *Clostridium difficile* can contribute to transmitting these agents in the context of health care services. All of these agents have been shown to persist in environments for hours, days and, in some cases, months. They frequently contaminate the surfaces of the rooms of infected or colonized patients and, thus, temporarily colonize the hands of the health care team members, who disseminate them to other surfaces and other patients, sometimes even leading to outbreaks. These surfaces play a significant role in the occurrence of cross-transmission, acting as constant secondary sources of contamination. In this sense, studies demonstrate that occupying an environment with patients infected or colonized with the abovementioned microorganisms is a risk factor for the colonization and infection of patients who will later occupy the same environment. This suggests that the cleaning and disinfection of such surfaces was not satisfactory.[1-2]

Thus, to minimize this reality, more attention should be given to the terminal cleaning and disinfection process. Terminal cleaning is defined as that which is carried out in all components surrounding the patient and which were used, directly or indirectly, to assist in his/her care. It should be done as soon as a bed is no longer occupied due to patient discharge, death, transferal, or hospitalization period longer than seven days, as well as at the end of an isolation period. Many different agents may be used to this end, such as water and soap/detergent, disinfectant and detergent/disinfectant.[1-6]

The environment and objects surrounding the patient are contaminated with bacteria, including the multi-resistant kind. Out of all of the objects close to the patient, the mattress makes the most contact with his/her body and serves as a possible place for the deposit of organic and/or inorganic dirt and microorganisms responsible for infections. Therefore, the mattress is a reservoir element for these bacteria.[3-5] On the other hand, studies evaluating the action of disinfectants on mattress microbiology emphasize their action on bacteria[3,5,7-8,4,9] and not fungi, which represent an equal threat of dissemination.

The number of fungal diseases has increased, and in this sense, blood stream infection caused by fungi (candidemia) is considered the fourth leading cause of sepsis, according to data provided by the *Nosocomial Infection Surveillance System*. Most of these infections are caused by species of yeast of the genus *Candida* spp. and result in substantial morbidity and mortality.[10]

The incidence of candidemia has risen over the last two decades in several parts of the world and in different health care environments, especially due to the increased use of aggressive therapeutic practices. These include, for example, the use of intensive chemotherapy to treat hematologic malignancies, transplants and Intensive Care Unit (ICU) hospitalization; it is also important to point out a change in the frequency of isolation of each species of *Candida* spp. found in the bloodstream.[10]

Disinfection is the most widely recommended procedure for reducing microbial loads. Disinfection is defined as the physical or chemical process of destroying microorganisms in their vegetative but not necessarily sporulated form. Disinfection should be carried out on previously cleaned inert surfaces (hospital material, equipment and fixed surfaces).[11] Among the existing arsenal of disinfectants, 70% alcohol (m/v) tends to be most readily available and used (ethyl alcohol as well as 2-propanol), mainly because it costs less than other products.[12] According to the *Center of Diseases Control and Prevention* (CDC)[12] classification, it is an intermediate-level germicide.

Considering that the microbiological assessment of a mattress after terminal cleaning can supply data about the possibility of it serving as a reservoir for microorganisms and, especially, establish the effectiveness of the cleaning/disinfection process with ethyl alcohol, this study aims to:

- Evaluate the effectiveness of 70% ethyl alcohol (m/v) for disinfecting yeast found in hospital mattresses.

METHOD

This is a cross-sectional quantitative study carried out in a general tertiary, public and high-complexity hospital located in the State of São Paulo in the Southeast region of Brazil. Permission to conduct the study was granted by the hospital administration. Samples were taken from different hospital areas, such as Wards, the General Intensive Care Unit, Pediatrics and Neonatal Care.

Samples were collected from the mattresses of patients who presented fungal

bloodstream infections (Candidemia) and were screened by the Hospital Infection Committee and confirmed through blood cultures using an automatic system (Becton Dickinson BACTEC™ 9240). In the period between August 2009 and October 2011, samples were collected from 74 mattresses made of polyurethane foam and covered in impermeable nappa leather, before and after undergoing terminal cleaning. The mattress measured 188188x88x12cm. The mattresses in the selected hospital areas were cleaned by both the nursing team (nursing assistants and technicians) and the Health Care Surfaces Cleaning and Disinfection Services. This activity depended on the imminent need for a hospital bed and the availability of both teams.

Immediately after a bed was vacated, samples were collected using sterile swabs moistened in a 0.85% sterilized saline solution by rolling them over five quadrants in three different areas (upper, middle and lower) of the surface that had made contact with the patient. They were then immediately deposited in a bottle containing Sabouraud Dextrose Broth (DIFCO™). Ten minutes elapsed between mattress disinfection and the gathering of samples.

It is important to note that the mattresses in this study were not cleaned with water and soap/detergent before applying the disinfectant. Thus, hydrated 70% (w/v) ethyl alcohol was applied directly. This disinfectant is used in health services by rubbing it on surfaces or objects three consecutive times. Between each application, the alcohol must be given time to dry. It acts as a bactericide, virucide, fungicide and tuberculicide, but not a sporicide, and it is easy to use and appropriate for immediate action.[6,12]

Surgical compresses were used to disinfect each mattress. These compresses were first used in surgical procedures and were then sent to the hospital laundry. Those that presented no gross organic material were then selected, after which they were washed and disinfected to prepare them for use to clean/disinfect mattress surfaces. The compresses, according to their manufacturer, possess the following characteristics: made of 100% cotton fabric; soft and extra-absorbent and four-layered; 45x50 cm; contain no greasy substances, amide or optical bleach. These compresses were moistened with 70% (m/v) ethyl alcohol solution using wash bottles. After cleaning/disinfection of surfaces, they were sent back to the hospital laundry, submitted to the triage and washing/disinfection process, and later used again for the same purpose. It was not possible to control the number of times they underwent this process. Hospital routine established that mattress cleaning/disinfection be done in a unidirectional fashion, beginning at the upper part and ending at the lower part of the mattress, allowing it to dry naturally.

The Microbiology laboratory immediately processed the collected material by seeding it in Saboaurad Dextrose Agar (DIFCO™) and CHROMagar™ Candida (CHROMagar, Paris, France) plates. They were kept in a heat sterilizer at 30°C for an average of 96 hours.

The yeasts were isolated and identified by their macroscopic, microscopic and physiological characteristics, according to standard methodology.[14]

The data was recorded and analyzed using descriptive statistics and absolute and relative frequency calculations with the help of *Microsoft Excel*® 2007.

RESULTS

Analyses showed that, of the 74 mattresses, there was yeast growth in 28 (38.2%). Out of these, 19 (67.9%) were from before and 9 (32.1%) from after cleaning and disinfection. Table 1 shows that fungi were still present in all of the studied units after cleaning, except in the Neonatal Intensive Care Unit. This demonstrates that the cleaning and disinfection procedure used by the Institution was not effective for eliminating these agents.

Table 1. Frequencies of positive and negative results from mattress cultures before and after disinfection. São José do Rio Preto, SP, Brazil, 2009-2011.

Unit	Positive		Negative		Total	
	Before n (%)	After n (%)	Before n (%)	After n (%)	Before n (%)	After n (%)
Wards	2(2.7)	1(1.3)	5(6.8)	6(8.1)	7(9.5)	**7(9.4)**
General ICU	11(14.9)	5(6.8)	30(40.5)	36(48.6)	41(55.4)	**41(55.4)**
Neo ICU	4(5.4)	0(0)	5(6.8)	9(122)	9(12,2)	**9(12.2)**
Ped. ICU	2(2.7)	3(4)	15(20.2)	14(19)	17(22,9)	**17(23)**
Total	**19(25.7)**	**9(12.1)**	**55 (74.3)**	**65 (87.8)**	**74(100)**	**74(100)**

General ICU: General Intensive Care Unit; Neo ICU: Neonatal Unit of Intensive Care; Ped ICU; Pediatric Intensive Care Unit

Still considering Table 1, out of the 74 mattresses evaluated before disinfection, the General Intensive Care Unit displayed the largest quantity of mattresses contaminated with yeast (11, 14.9%), followed by the Neonatal Intensive Care Unit with 4 (5.4%). In all units, contamination was reduced after cleaning, except for the Neonatal Intensive Care Unit, where no yeast recovery took place, and the Pediatric Intensive Care Unit, which presented an increase in the quantity of contaminated mattresses.

According to Table 2, it is possible to see that the *Candida albicans*, non-*albicans* and yeast species of other genera were isolated to 28 mattresses.

Table 2. Distribution of isolated yeast species from mattresses in different hospital units before and after disinfection. São José do Rio Preto, SP, Brazil, 2009-2011.

	Wards		General ICU		Neo ICU		Ped ICU		Total	
Species	Before n (%)	**After** n (%)	Before n (%)	**After** n (%)	Before n (%)	**After** n (%)	Before n (%)	**After** n (%)	Before n (%)	**After** n (%)
C. albicans	2(10.6)	0(0)	1(5.3)	1(11.1)	0(0)	0(0)	0(0)	0(0)	3(15.8)	**1(11.1)**
C.guilliermondii	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	1(5.2)	0(0)	1(5.2)	**0(0)**
C. parapsilosis	0(0)	0(0)	2(10.6)	2(22.2)	4(21)	0(0)	0(0)	0(0)	6(31.6)	**2(22.2)**
C. tropicalis	0(0)	0(0)	3(15.8)	0(0)	0(0)	0(0)	0(0)	0(0)	3(15.8)	**0(0)**
T. asahii	0(0)	1(11.1)	5(26.3)	2(22.2)	0(0)	0(0)	1(5.2)	3(33.4)	6(31.6)	**6(66.7)**
Total	**2(10.6)**	**1(11.1)**	**11(58)**	**5(55.5)**	**4(21)**	**0(0)**	**2(10.4)**	**3(33.4)**	**19(100)**	**9(100)**

C.= Candida; T.= Trichosporon; General ICU: General Intensive Care Unit; Neo ICU: Neonatal Intensive Care Unit; Ped ICU; Pediatric Intensive Care Unit.

We emphasize that, after disinfection, nine (47.4%) mattresses were still contaminated with some type of yeast.

Ten mattresses presented negative results after disinfection: two from the Ward (*C. albicans*), one from the Pediatric Intensive Care Unit (*C. guilliermondii*), four from the Neonatal Intensive Care Unit (*C. parapsilosis*) and three from the General Intensive Care Unit (*C. tropicalis*). For the remaining mattresses in all units, the level of contamination was either reduced or maintained. Curiously, *T. asahii,* which had previously displayed negative results, presented recovery in one mattress from the Ward and two from the Pediatric Intensive Unit (Table 2).

The prevalent species were *T. asahii* and *C. parapsilosis*, respectively.

DISCUSSION

Hospital-acquired yeast infections have become greatly significant over the last few years, both for their progressive increase and for their elevated morbidity and mortality rates.[14]

Despite the controversy surrounding the appropriate treatment of inanimate surfaces in the hospital setting in order to prevent pathogen transmission, there is evidence of the presence and survival of *C. albicans* on inert surfaces for extended periods due to the presence of albumin and the environment's low temperature and high humidity. Thus, *C. albicans* can survive on surfaces for up to four months. Other yeasts survived for similar periods, such as *Torulopsis glabrata* (up to five months), or for shorter ones, such as *Candida parapsilosis* (up to 14 days).[15]

Several studies have made contributions to the comprehension of the effectiveness of cleaning and/or disinfection of hospital mattresses and their potential as secondary reservoirs for epidemiologically important microorganisms. One study[5] evaluated the microbiological conditions of hospital mattresses before and after their cleaning by manual friction associated with a synthetic Phenol detergent-disinfectant solution. The study evaluated 52 mattresses, producing a total of 520 plates. Of these, 514 (98.8%) resulted in positive cultures; 259 were from before the cleaning and 255 after. We must stress the striking presence of fungi before and after cleaning procedures. The results showed that the cleaning routine using Phenol caused the microbial load to be dislocated

instead of reducing it. It also proved to be ineffective against fungi, although the authors did not identify their genus and species.

A study on *Staphylococcus aureus* was conducted at a Teaching Hospital[7] using samples from 50 mattresses. Its objective was to evaluate the effectiveness of the cleaning procedure using water and soap and disinfection together with 70% alcohol. The samples were gathered and seeded for biochemical identification in two culture mediums (blood agar and mannitol salt agar) followed by catalase and coagulase tests. Of the 600 plates, 94 (15.6%) presented growth; 82 (87.2%) of these were from before cleaning and disinfection and 12 (12.8%) after. The results reflected and brought attention to the failure of the hospital mattress cleaning and disinfection procedure, displaying similar data as the present study. However, we must state that the genus researched in this study was not a fungal species; nonetheless, it clearly demonstrated that microorganisms persist even after cleaning and disinfection procedures.

In one particular hospital unit, researchers[14] monitored and identified anemophilous fungi and yeasts of biotic and abiotic origins. They collected samples monthly during two periods in the Surgical Center and Adult and Neonatal Intensive Care Units. Anemophilous fungi were collected using a single stage Andersen sampler. The yeast was collected from the hands and the oral-pharynx cavities of health professionals as well as from the surfaces of hospital beds and doorknobs of critical areas. Thirty-two genera of anemophilous fungi were recovered from the Surgical Center and 31 from the Intensive Care Units. The most commonly isolated genera were *Cladophialophora* spp., *Fusarium* spp., *Penicillium* spp., *Chrysosporium* spp. and *Aspergillus* spp. Yeasts were found on 39.4% of health professionals. In 44% of the furniture samples, *Candida* (*C. albicans, C. guilliermondii, C. parapsilosis* and *C. lusitaniae*) predominated, followed by *Trichosporon* spp. A relatively high number of anemophilous fungi (potentially pathogenic) were found in special areas as well as expressive levels of yeast from biotic and abiotic sources. In a way, these results corroborate the findings of the present study, for the General Intensive Care Unit contained the mattresses with the highest fungal distribution following cleaning and disinfection.

Other researchers[8] carried out a study to assess the microbiologic conditions of hospital mattresses before and after cleaning and disinfection. A clean white cloth, moist with distilled water, was used for cleaning and applied to the surface through circular motions. Afterwards, using the same moist cloth - now with 70% alcohol - each region (upper, middle and lower) was rubbed clean once. The microbiological samples were gathered from different areas of the mattress using contact plates (*Rodac Plate*™) filled with nutrient agar and brain and heart infusion agar (BHI). The microbiological analysis conducted with the nutrient agar before and after disinfection showed a reduction of the number of colony-forming units in only 28.5% of the mattresses. With the BHI agar, 37.5% suffered a reduction. Considering that the samples were taken from different regions of the mattress, the results obtained indicate that the disinfection procedure was only dislocating the microbial load to other locations instead of reducing them. Such findings confirm that the cleaning and disinfection procedure was not completely efficient, as observed in this study.

One study[9] compared two techniques for hospital mattress disinfection using 70% alcohol, seeking to test their effectiveness in reducing microorganisms. Of the seven hospital beds that were analyzed using technique 01 (unidirectional cleaning, from the cleanest region to the most contaminated), four presented contamination following cleaning. Contamination was reduced in two (50%) of the investigated mattresses. Technique 02, on the other hand (circular motions independent of contamination levels), presented microbial reduction in all six (100%) of the analyzed mattresses. The study detected the presence of *Staphylococcus aureus* before and after disinfection. Although technique 02 displayed greater reduction of microbial count, further studies must be conducted with a greater number of mattresses and also related to the products used and honing of new techniques.

We emphasize that, in the previous study, the authors mentioned that they conducted cleaning from the "area of lowest to highest contamination." However, this practice has been perpetuated in nursing for decades, and the naked eye obviously cannot determine the more or less contaminated areas of surfaces that seem to be evenly "clean." We must also note that, at times, the authors of the previous studies did not clearly describe the techniques used for mattress cleaning and disinfection procedures, or such procedures diverge considerably from one another. Thus, the results of these studies and of this present

paper indicate that the procedures were not effective.

It is also important to note that the studies presented biases, such as the lack of description of some of the cleaning/disinfection processes; the type of cloth used; the frequency of cloth replacement; the method of application, friction and how long the product kept contact with the surface; detergent and/or soap dilution, as well as their substitution; microbiological collection methods; sample processing and culture mediums utilized.

Considering all 74 (100%) of the mattresses assessed in this present study, 28 (38.2%) tested positive for yeast (Table 2) -among them, *Candida albicans*, non-*albicans Candida* and yeasts not associated to species of *Candidas*, with the prevalence of *Trichosporon asahii* and *Candida parapsilosisi*. One study[14] investigating the presence of yeast on hospital furniture surfaces (doorknobs, bed and telephone devices) in the Surgical Center and General and Neonatal Intensive Care Units found that the genus *Candida* predominated, followed by *Trichosporon* spp. and *Candida guilliermondii*.

Regarding the *Candida* species responsible for causing infection, studies indicate that *Candida albicans* continues to be the most common pathogen agent, responsible for about 50-60% of cases. However, the prevalence of other species such as *Candida glabrata, parapsilosis, tropicalis* and *krusei* has been increasing in several countries around the world. This is of particular importance because of the resistance originating from previous use of wide-spectrum antimicrobials such as fluconazole. In fact, the extensive use of such agents has caused a rise in non-*albicans* species. The dissemination of these species is relative to the patient's age. Thus, *Candida parapsilosis* is normally found in the pediatric population, while the incidence of *Candida glabrata* increases with age.[11,16-17]

Studies conducted in Brazil reveal that the most prevalent species are *C. albicans, C. parapsilosis* and *C. Tropicali*.[16,18] In a way, such results corroborate those found in the present study in which 22.2% of hospital mattresses remained contaminated with *Candida parapsilosis* after the cleaning and disinfection process. On the other hand, *Trichosporon asahii* was present in most mattresses (66.7%) after the process (Table 2).

The *C. parapsilosis* species is often found on skin and is transmitted mainly exogenously, especially through the hands of health professionals. Its occurrence is also elevated among children and premature newborns hospitalized in Intensive Care Units.[16,18] Characteristically, *C. parapsilosis* proliferates in solutions containing glucose and has a great capacity for producing biofilm. Several studies have clearly established an association between the use of central venous access catheters and a higher occurrence of fungemia due to *C. parapislosis*.[19]

Fungal infections not associated with the *Candidas* species have risen significantly over the last two decades. Among these, infections due to *Trichosporon asahii* yeast can present in a great variety of clinical manifestations, from superficial cutaneous cases to severe sepsis in immunocompromised patients. It can be found colonizing humans but can also cause superficial and deep infections. The microorganism in question is traditionally described as causing opportunistic infections, leading to cases disseminated among neutropenic and immunocompromised patients. The main infection sites for *Trichosporonose* are the respiratory, gastrointestinal and urinary tracts, which are known as places of frequent colonization and subsequent hematological dissemination. [20]

The classic and consensual recommendation for a safe surface disinfection method consists of previously cleaning the locale followed by disinfection with a microbiocide agent.[6,11] Exception is made when a sanitizer is used, which cleans and disinfects in one single step. However, in this study, cleaning with water and soap/detergent was not carried out as it was not an established practice in the investigated units unless visible dirt was present. In fact, in health care practices, the direct application of alcohol on surfaces with no prior cleaning is observed relatively frequently.[13] Still, we must not disregard the reality of Brazilian hospitals, which do not perform this mattress cleaning procedure due to high turnover and scarcity of beds that must be occupied immediately after vacancy.[3]

A Brazilian experimental, randomized and single-blind laboratory study assessed the effectiveness of 70% (w/v) alcohol in disinfecting surfaces using friction (circular movements) for 30", with no prior cleaning, as a concurrent disinfection procedure. The samples came from enameled surfaces, intentionally contaminated with *Serratia marcescens* microorganisms ATCC 14756 10^6 CFU/mL, plus 10% of human saliva, and submitted to disinfection preceded by cleaning with water and detergent, through friction (circular movements) for 30". There

was a six-logarithm reduction in the initial microbial population in both groups, with and without prior cleaning (p = 0.440), and a residual microbial load ≤ 10^2 CFU/mL. These demonstrate that there was no difference between the disinfection effectiveness of 70% (w/v) alcohol under friction when applied with or without prior cleaning of contaminated surfaces. Another interesting finding in this study was the visual inspection of alcohol's cleaning properties.

Although the previous investigation demonstrated the safety of health care practices using alcohol 70% (w/v) directly on contaminated surfaces, it did not test such practice on fungi found on environmental surfaces and which increase risk of cross-transmission. Although there are products on the market known as spray-wipes that, when applied directly on contaminated surfaces, clean and disinfect in one single step, day-to-day Brazilian reality makes it so that 70% (w/v) alcohol is the most available and utilized agent in health care services, especially due to its lesser cost when compared to these new products. [13]

Studies[21] done in 69 (61%; 95% CI, 52-70%) American hospitals found that only 16 (9%; 95% CI, 4-18%) reported washing mattresses after using disinfectant. The majority of the investigated hospitals did not follow the manufacturer's recommendations regarding proper mattress cleaning and disinfection. These errors may result in inadequate cleaning and can damage mattress surfaces and lead to their colonization.

In the present study, we used clean and disinfected surgical compresses moistened with 70% (w/v) alcohol. Although the mattresses had not been previously cleaned with water and soap/detergent, further research is needed to clarify the efficiency and effectiveness of direct application of alcohol on fungi-contaminated surfaces.

According to the Brazilian Ministry of Health and other international agencies, alcohols are classified as an intermediate-level effective disinfectant. Their antimicrobial action is linked to protein denaturation. They are indicated for object and surface disinfection with a ten-minute exposure time using a 77% volume-volume concentration, which corresponds to 70% in weight. The alcohol must be applied and rubbed until dry. This procedure must be repeated three times. However, some disadvantages limit the use of alcohols: volatility, the fact that they are flammable and do not present residual activity, and quick evaporation, as well as being inactivated in the presence of organic material.[6,12]

Regarding the abovementioned practice of disinfection used in the hospital in question, the actual contact duration versus the time recommended by government entities may not have been followed. A ten-minute action time is not always practical in health care, especially in Intensive Care Units and other units with high patient turnover. Thus, frequently, a germicide that is highly effective after 10 minutes may in reality remain on the surface no longer than a minute, for the surface may be needed immediately to provide care. In this context, we must analyze other factors that contribute to the inadequate reduction of *Candida* spp. and yeast after mattress terminal cleaning and disinfection procedures.[5,22] Furthermore, considering how the procedure was executed, it is possible to infer that several factors may have interfered in the final result.

Besides the fact that mattresses were not cleaned before disinfection, other aspects may have contributed to the final results obtained. These aspects range from the correct use of surgical compresses (named furniture cloth), how many times they were cleaned and reutilized, how the compress was folded during the process in order to expose the other clean sides while rubbing it in different parts of the surface, the amount of alcohol used to moisten the compress, possible evaporation of the alcohol in the wash bottles and even the force of friction used to apply the alcohol on the mattress surface during the disinfection process. Therefore, taking these different variables into consideration, we cannot claim that the permanence of *Candida* spp. and yeast on the mattresses was due to the ineffectiveness of alcohol.

Although there are several Microfiber (MF) cleaning cloths on the market that promise greater efficiency for removing microorganisms from environmental surfaces, research shows that different types of MF have different capacities for microorganism removal from different surfaces. They are also capable of transferring microorganisms to other surfaces.[23] Even before such technologies such as MF, the use of cotton cloths (for example, surgical compresses) is still observed. One study[23] found that the use of moist MF for the first time was more effective for removing *Stappylococcus aureus* and *Escherichia coli* from ceramic tiles. However, after 20 reprocessings (90ºC for 5 minutes), moistened cotton cloths presented better effectiveness for microorganism

removal. The recommendation is for the cleaning and disinfection process to be conducted with moist cloths, which was the procedure in the present study. However, other factors may have influenced the results when we take into consideration the use of these surgical compresses, as we previously described. We emphasize that the tests conducted on these cleaning cloths are sometimes carried out on surfaces that do not represent the reality of most existing surfaces in a hospital ward setting.

Practices regarding the cleaning and substitution of used cloths for surface hygiene are crucial, for if they are not washed, dried and discarded frequently, they can most surely contribute to the ineffectiveness of surface cleaning and disinfection as well as causing cross-contamination of microorganisms. Prior studies evaluating the microbiologic condition of mattresses corroborate the results of the present study, for they also found remaining microorganisms after cleaning/disinfection.[5,7-9] Aside from the previously described intervening factors, the fact that contamination persisted after the evaluated mattresses were disinfected may have been due to *Candida* spp. and yeast dislocation at the moment the disinfection procedure was conducted, from the upper to the lower part of the mattress. However, we do not expect for there to be no microorganisms after the surface disinfection process; lower microbial density after the procedure implies higher microbiological safety.

We note that the permanence of *Candida* spp. and yeast in 47.4% of the mattresses following disinfection is cause for concern, for terminal cleaning implies that other patients will occupy the beds, and we cannot discard the possibility of these patients being colonized and/or infected with fungi left on these surfaces, especially if we consider that such microorganisms can survive on surfaces for reasonable periods of time.[15]

Although most *Candida* infections are probably from endogenous sources (result of patient colonization), molecular typology studies of yeasts recovered from patients, health care staff's hands and environmental surfaces suggest that the latter may play a role in the dissemination of *Candida albicans*, *Candida glabrata* and *Candida parapsilosis* among patients submitted to bone marrow transplants. The types of *Candida* CEPAS acquired by these patients were identical to those found on the hospital surfaces of the rooms they occupied before acquiring the infection.[24]

It is important to state that, in the institution in question, the terminal cleaning of mattresses was conducted by nursing professionals as well as by members of the Surface Cleaning and Disinfection Service. Since two different categories of professionals were involved in the process, cleaning different components with no clear definition of these professionals' duties and responsibilities, they may not have been aware of the risks associated with improper mattress cleaning/disinfection. In addition, perhaps not every mattress was cleaned/disinfected, for the professional thought that another person would do so.[4] This important issue was investigated in another literature review study, which pointed to the reduced number of compiled articles that specified the professional category responsible for carrying out hospital mattress cleaning and disinfection. [3]

We cannot disregard that the little importance given to the qualification of the Health Care Surfaces Cleaning and Disinfection Services is a detrimental element in the process. The Hospital Infection Control Committees should be deeply involved with Cleaning Services and promote joint activities regarding hygiene protocols, training and team supervision.[22]

This study, however, presents some limitations, for it was conducted only on mattresses that were used by patients with candidemia; the professionals involved knew the objective of the study, which could have led them to be more rigorous in their cleaning/disinfection procedure (the Hawthorne effect). Lost samples cannot be ruled out, for the mattress microbiological sample gathering depended on a nurse from each unit communicating an available mattress to the researchers; thus, cases may have been underestimated. Colony-forming units were not quantified before and after alcohol application, which limited result interpretation. We cannot claim that the fungi found on the mattresses were the same as those on the patients and vice-versa, for genotyping tests were not carried out, and, finally, we cannot guarantee that the mattresses were equally cleaned/disinfected according the established routine, especially because more than one professional category conducted this procedure.

CONCLUSION

The present study demonstrated the occurrence of *Candida* spp. and yeast on mattresses from different hospital units occupied by patients carrying Candidemia.

The prevalent species was *Candida parapsilosis*. After disinfection, we verified the persistence of *Candida* spp. and yeast in 47.4% of mattresses. Therefore, we can confirm that they can act as reservoirs or sources for potentially pathogenic fungi and represent a risk for cross infection of patients as well as professionals.

It is necessary to reevaluate the mattress disinfection technique, such as the implementation of prior cleaning or the use of a detergent/disinfectant that acts as a cleaning and disinfecting agent in one single step, as well as role definition, investment in training, products and supervision of both the Health Care Service Surface Cleaning and Disinfection Services and the nursing team. Such reevaluation would be an attempt to reduce the prevalence of our findings, thus guaranteeing a safe environment from a microbiological standpoint.

REFERENCES

1. Otter JA, Yezli S, French GL. The role played by contaminated surfaces in the transmission of nosocomial pathogens. Infect Control Hosp Epidemiol [Internet]. 2011 Jul [cited 2013 Sept 18];32(7):687-99. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21666400.

2. Rutala WA, Weber DJ. Are room decontamination units needed to prevent transmission of environmental pathogens? Infect Control Hosp Epidemiol [Internet]. 2011 Aug [cited 2013 Sept 18];32(8): 743-47. Available from: http://www.tru-d.com/docs/are_room_decontamination_units_needed_to_prevent_transmission_of_environmental_pathogens_rutala_phd-weber_md-iche_2011.pdf.

3. Oliveira AC, Viana RElH, Damasceno QS. Contamination of hospital mattresses by microorganisms of epidemiological relevance: an integrative review. Rev Enferm UFPE on line [Internet]. 2010 Jan [cited 2013 Sept 20]; 7(1):236-45. Available from: http://www.revista.ufpe.br/revistaenfermagem/index.php/revista/article/view/3049. 4. Creamer E, Humphreys H. The contribution of beds to healthcare-associated infection: the importance of adequate decontamination. J Hosp Infect [Internet]. [cited 2013 Sept 14];2008;69(1):8-23. Available from: http://www.ncbi.nlm.nih.gov/pubmed/18355943

5. Andrade D, Angerami ELS, Padovani CR. Condição microbiológica dos leitos hospitalares antes e depois de sua limpeza. Rev Saúde Pública [Internet]. 2000 [cited 2013 Apr 13];34(2):163-9. Available from: http://www.scielo.br/scielo.php?pid=S0034-89102000000200010&script=sci_arttext.

6. Brasil. Agência Nacional de Vigilância Sanitária. Segurança do paciente em serviços de saúde: limpeza e desinfecção de superfícies. Agência Nacional de Vigilância Sanitária. Brasília: Anvisa; 2010. 116p.

7. Mundim GJ, Dezena RA, Oliveira ACS, Silva PR, Cardoso M, Pereira GA, et al. Avaliação da presença de *Staphylococcus aureus* nos leitos do centro de terapia intensiva do hospital escola da faculdade de medicina do Triângulo Mineiro, em relação à posição no colchão antes e após a limpeza. Rev Soc Bras Med Trop [Internet]. 2003 [cited 2013 Apr 13];36(6):685-88. Available from: http://www.scielo.br/scielo.php?pid=S0037-86822003000600007&script=sci_arttext.

8. Zanconato RV, Pereira WKV, Abegg MA. Condição microbiológica de colchões hospitalares antes e após sua desinfecção. Rev Prática Hospitalar. 2007;52:68-72.

9. Silva NO, Ferraz PC, Silva ALT, Malvezzi CK, Poveda VB. Avaliação da técnica de desinfecção dos colchões de uma unidade de atendimento a saúde. Rev Min Enferm [internet]. 2011 [cited 2012 Apr-June 16];15(2): 242-47. Available from: http://www.enf.ufmg.br/site_novo/modules/mastop_publish/files/files_4e662b005a6b3.pdf.

10. Falagas ME, Roussos N, Vardakas KZ. Relative frequency of *albicans* and the various non-*albicans Candida* spp among candidemia isolates from inpatients in various parts of the world: a systematic review. Int J Infect Dis [internet]. 2010 [cited 2013 June 16];14:e954-66. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20797887.

11. CDC-Center of Diseases Control and Prevention. Guideline for Environmental Infection Control in Health-Care Facilities: Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). MMWR. [Internet]. 2003; [cited 2013 July 26]; 52(RR-10):1-48. Available from: http://www.cdc.gov/ncidod/hip/enviro/guide.htm.

12. Healthcare Infection Control Practices Advisory Committee (HICPAC). Guideline for disinfection and sterilization in healthcare facilities. Atlanta, 2008. Available from: http://www.cdc.gov/ncidod/dhqp/pdf/guidelines/Disinfection_Nov_2008.pdf.

13. Graziano MU, Graziano KU, Pinto FMG, Bruna CQM, Queiroz RQ. Lascala CA.

Effectiveness of disinfection with alcohol 70% (w/v) of contaminated surfaces not previously cleaned. Rev. Latino-Am. Enfermagem [Internet]. 2013 Mar-Abr [cited 2013 May 24]; 21(2): 618-23 Available from: http://dx.doi.org/10.1590/S0104-11692013000200020.

14. Martins-Diniz JN, Silva RAM, Miranda ET, Mendes-Giannini MJS. Monitoramento de fungos anemófilos e de leveduras em unidade hospitalar. Rev Saúde Publica [Internet]. 2005; 39(3): 398-405. Available from: http://www.scielo.br/scielo.php?pid=S0034-89102005000300010&script=sci_arttext.

15. Kramer A, Schwebke I, Kampf G. How long do nosocomial pathogens persist on inanimate surfaces? A systematic review. BMC Infect Dis [internet]. 2006 [cited 2012 Oct.18]; 6:130. Available from: http://www.biomedcentral.com/content/pdf/1471-2334-6-130.pdf.

16. França JCB, Ribeiro CEL, Queiroz-Telles F. Candidemia em um hospital terciário brasileiro: incidência, freqüência das diferentes espécies, fatores de risco e suscetibilidade aos antifúngicos. Rev Soc Bras Med Trop [internet]. 2008 [cited 2013 Feb 20]; 41(1):23-8. Available from: http://www.scielo.br/pdf/rsbmt/v41n1/a05v41n1.pdf.

17. Dhillon RH, Clark J. Fungal infections in the critically ill. Trends in Anaesthesia and Critical Care. 2011;4:210-18.

18. Maluche ME, Santos JI. *Candida* sp. e infecções hospitalares: aspectos epidemiológicos e laboratoriais. Rev bras anal clin [internet]. 2008 [cited 2013 Feb 20]; 40: 65-7. Available from: http://www.sbac.org.br/pt/pdfs/rbac/rbac_40_01/13.pdf.

19. Colombo AL, Guimarães T. Epidemiologia das infecções hematogênicas por *Candida* spp. Rev Soc Bras Med Trop [internet]. 2003 [cited 2013 Feb 20]; 36(5):599-607. Available from: http://www.scielo.br/pdf/rsbmt/v36n5/a10v36n5.pdf.

20. Júnior AA, Carvalho RT, Focaccia R, Fernandez JG, Araújo HBN, Strabelli TMV et al. Emergência de infecção por *Trichosporon Asahii* em pacientes portadores de insuficiência cardíaca em unidade de terapia intensiva cardiológica. Relato de caso e revisão da literatura. Rev bras ter intensiva [internet]. 2008 [cited 2013 Feb 22];20(1):106-9. Available from: http://www.scielo.br/pdf/rbti/v20n1/a18v20n1.pdf.

21. Hooker E, Jones KL. Cleaning practices for hospital mattresses in top US adult hospitals. Am J Infect Control. 2012;40(5): e43. DOI: 10.1016/j.ajic.2012.04.073.

22. Padoveze MC. O papel do ambiente na transmissão de infecções: atualidades. Rev Prática Hospitalar. 2011;74:26-31.

23. Diab-Elschahawi M, Assadian O, Blacky A, Stadler M, Pernicka E, Berger J. Evaluation of the decontamination efficacy of new and reprocessed microfiber cleaning cloth compared with other commonly used cleaning cloths in the hospital. Am J Infect Control [internet]. 2010 [cited 2013 Apr 25];38:289-92. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20123151.

24. Hota B. Contamination, disinfection, and cross-colonization: are the hospital surface reservoirs for nosocomial infection? Clin Inf Dis [internet]. 2004 [cited 2013 Apr 25];39(8):1182-89. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20123151.

Submission: 2013/11/21
Accepted: 2014/04/01
Publishing: 2014/05/01

Corresponding Address

Profa. Dra. Margarete Teresa Gottardo de Almeida
Programa de Pós-graduação em Ciências da Saúde/Faculdade de Medicina de São José do Rio Preto/FAMERP
Av. Brigadeiro Faria Lima, 5641
CEP: 15090000 — São José do Rio Preto (SP), Brazil