

Halil YAZGI<sup>1</sup>  
M. Hamidullah UYANIK<sup>1</sup>  
Mustafa ERTEK<sup>2</sup>  
Ayse Esin AKTAŞ<sup>1</sup>  
Hakan İGAN<sup>1</sup>  
Ahmet AYYILDIZ<sup>1</sup>

<sup>1</sup> Department of Microbiology and  
Clinical Microbiology,  
Faculty of Medicine,  
Atatürk University,  
Erzurum - TURKEY  
<sup>2</sup> Refik Saydam National Hygiene  
Center, Ankara - TURKEY

## Survival of certain nosocomial infectious agents on the surfaces of various covering materials

**Aim:** The aim of the present study was to investigate the survival time of some nosocomial infectious agents on the surface of various covering materials.

**Materials and Methods:** Four kinds of flooring materials (vinyl and ceramic tile as floor covering material; and laminate and inox sheet as bench covering material) were experimentally contaminated with *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus* and vancomycin-resistant (VR) *Enterococcus faecalis*, which were frequently encountered in nosocomial infections. The survival periods of representative agents on the tested flooring materials were detected by culturing from the surfaces.

**Results:** It was found that the survival periods were shorter for all the tested bacteria on the vinyl surfaces, as compared to the ceramic surfaces; the difference was significant ( $P < 0.05$ ). On the other hand, all the test bacteria survived shorter on the inox sheet than on the laminate surfaces ( $P < 0.05$ ). On all of the 4 covering materials tested gram-positive bacteria were found to survive longer than the gram-negative ones.

**Conclusions:** It was concluded that vinyl as flooring material and inox sheet as surface material for benches and laboratory tables may be preferred in order to reduce bacterial colonisation in the hospital environment.

**Key words:** Surface covering materials, nosocomial infection, *Staphylococcus aureus*, *Enterococcus faecalis*, *Escherichia coli*, *Pseudomonas aeruginosa*

## Hastane infeksiyonu etkeni olarak sıklıkla karşılaşılan bazı bakterilerin çeşitli yüzey kaplama maddelerindeki yaşam sürelerinin değerlendirilmesi

**Amaç:** Bu çalışmada hastane infeksiyonu etkeni olarak sıklıkla karşılaşılan bazı bakterilerin çeşitli yüzey kaplama maddelerindeki yaşam süreleri araştırıldı.

**Yöntem ve Gereç:** Zemin kaplama maddesi olarak kullanılan seramik ve vinil ile tezgah yüzeylerinde kullanılan laminat ve inox yüzeyler, hastane infeksiyonlarında sıklıkla etken olarak karşılaşılan *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, ve vankomisine dirençli *Enterococcus faecalis*, gibi bakteriler kullanılarak deneysel olarak kontamine edildi. Çalışmaya alınan bakterilerin test edilen yüzeylerdeki yaşam süreleri bakteriyolojik kültür yöntemi ile saptandı.

**Bulgular:** Çalışma kapsamındaki tüm bakterilerin vinil yüzeylerde seramik yüzeylere göre; inox yüzeylerde ise laminat yüzeylere göre daha kısa süre canlı kaldıkları görüldü ( $P < 0.05$ ). Test edilen tüm yüzeylerde gram pozitif bakterilerin gram negatiflere göre daha uzun süre yaşadıkları saptandı.

**Sonuç:** Hastane ortamında bakteri kolonizasyonunu azaltmak için zemin kaplama maddesi olarak vinilin, tezgah ve laboratuvar masalarında yüzey maddesi olarak inoxun tercih edilebileceği sonucuna varıldı.

**Anahtar sözcükler:** Yüzey kaplama maddeleri, hastane infeksiyonu, *Staphylococcus aureus*, *Enterococcus faecalis*, *Escherichia coli*, *Pseudomonas aeruginosa*

Received: May 12, 2008  
Accepted: March 10, 2009

### Correspondence

Halil YAZGI  
Department of Microbiology and  
Clinical Microbiology,  
Faculty of Medicine,  
Atatürk University,  
Erzurum - TURKEY  
hyazgi@hotmail.com

## Introduction

Persistence of nosocomial infections (NI) have been increasing causing a major health problem since the nineteenth century. While these infections are encountered in at least 5% of the hospitalized patients in the USA, this rate has been reported to be up to 27% in developing countries. It has been stressed that each year NI in the USA cause deaths of 88,000 individuals and an approximately 4.5 billion dollars increase in healthcare costs (1,2).

Both the significant morbidity and mortality and increased treatment costs NI cause, more intensive studies and practices have been performed in recent years for its control. Beside the high costs of treating these infections, the high-spectrum antibiotics that are used may also cause the development of new resistant species. Therefore, efforts towards prevention of NI become more important. One of these measures is the implementation of covering materials that do not allow bacterial colonization on the floor and workbenches in patient wards, clinics, intensive care units, and operating rooms.

The aim of the present study was to investigate the survival period of some nosocomial infectious agents on the surface of various covering materials. For this purpose, 4 kinds of flooring materials (vinyl and ceramic tile as floor covering material, and laminate and inox sheet as bench covering material) were experimentally contaminated with *E. coli*, *P. aeruginosa*, *S. aureus*, and VR *E. faecalis*, which were frequently encountered in NI, and then the survival periods of the representative agents on the tested materials were detected.

## Methods

In the study, standard strains of *E. coli* (ATCC 25922), *P. aeruginosa* (ATCC 27853), *S. aureus* (ATCC 25923), and VR *E. faecalis* (ATCC 51299) were used as the test microorganisms. The covering materials (ceramic tile, laminate, inox sheet, and vinyl) were prepared as sets of coupons sized 9 cm<sup>2</sup>. Each set consisted of 60 coupons. In order to repeat the experiments 5 times with the same bacteria and same materials simultaneously, 5 groups of 60 coupons sets were prepared.

Ceramic tile, laminate, and inox sheet coupons were sterilized by autoclaving. However vinyl flooring material coupons was sterilized by ethylene oxide.

Meanwhile, the strains of the test bacteria were grown on the blood agar medium as a pure culture. Bacterial suspensions from the colonies were prepared in sterile saline equal to Mc Farland 1 turbidity. The test coupons were contaminated by placing on them approximately 20 microliter volume of the bacterial suspension, and the inoculum allowed to outspread and dry itself in closed Petri dishes under sterile conditions. Then the petri dishes within the coupons were kept at room temperature (18-23 °C), under an approximately 823.0 mb of atmospheric pressure, and 70% humidity, while being protected from sunlight. Beginning from the third day, culture was taken from 1 coupon of 60-piece set using sterile swab soaked with sterile saline and inoculated onto blood agar plate. The plate was incubated for 18-24 h at 35 °C. The sampled coupon was then discharged, and the process was repeated every other day with a new coupon from the same set. When the bacterial growth was observed, the grown bacteria was re-identified by conventional methods in order to confirm whether it was identical with the test strain. Culturing process was terminated in the case of no growth was detected 3 times consequently. The process as described above for 1 set was simultaneously repeated 5 times with the same bacteria and same materials. Statistical differences between the groups were evaluated by one-way analysis of variance (ANOVA). All data were analyzed with SPSS 11.5 software.

## Results

On the tested surfaces, *S. aureus* was found to survive longest, and the *E. coli* was found shortest. The shortest and longest survival periods for VR *E. faecalis* were 42.6 days on inox sheet and 67.8 days on ceramic tile. The shortest and longest survival periods for *P. aeruginosa* were 6.6 days on inox sheet and 30.6 days on ceramic tile. The survival periods of bacteria on the surface materials tested are displayed in Tables 1 and 2. As seen in Table 1, the survival periods were shorter for all the tested bacteria on the vinyl surfaces, as compared to the ceramic surfaces. This difference was statistically significant ( $P < 0.05$ ). On the other hand, all the test bacteria survived shorter on inox sheet than on laminate surfaces (Table 2). This difference was found statistically significant ( $P < 0.05$ ). It was observed that gram-positive bacteria survived longer than gram-negative ones on all of the 4 covering materials tested in the present study.

Table 1. Survival duration (days) of the bacteria on floor covering materials.

Surfaces	<i>S. aureus</i> Mean $\pm$ SD	VR <i>E. faecalis</i> Mean $\pm$ SD	<i>P. aeruginosa</i> Mean $\pm$ SD	<i>E. coli</i> Mean $\pm$ SD
Vinyl flooring	63.40 $\pm$ 3.58	47.80 $\pm$ 3.03	11.40 $\pm$ 1.67	4.60 $\pm$ 0.89
Ceramic tile	73.80 $\pm$ 3.63	67.80 $\pm$ 2.68	30.60 $\pm$ 1.67	6.60 $\pm$ 0.89

SD: standart deviation  
Values are mean  $\pm$  SD

Table 2. Survival duration (days) of the bacteria on workbench covering materials.

Surfaces	<i>S. aureus</i> Mean $\pm$ SD	VR <i>E. faecalis</i> Mean $\pm$ SD	<i>P. aeruginosa</i> Mean $\pm$ SD	<i>E. coli</i> Mean $\pm$ SD
Laminate	75.4 $\pm$ 2.61	65.40 $\pm$ 2.61	25.40 $\pm$ 2.19	7.00 $\pm$ 0.00
Inox sheet	68.20 $\pm$ 2.28	42.60 $\pm$ 2.61	6.60 $\pm$ 0.89	4.60 $\pm$ 0.89

SD: standart deviation

## Discussion

One important factor in microorganism transmission to a person from another person or the environment is the ability of microorganism to survive on an environmental surface. Contamination and colonization of surfaces are important in transmission of nosocomial infections, particularly for methicillin-resistant *S. aureus* and vancomycin-resistant Enterococci (VRE).

Different floor covering materials have been used in recent years in the intensive care units, operating rooms, clinics, and laboratories of hospitals in order to reduce microorganism colonization. These materials include vinyl reinforced with polyurethane in their chemical composition. Since these coverings have wider surfaces, they are easier to disinfect and require fewer disinfectants and water during cleaning (3).

Staphylococci are among the most resistant non-spore forming bacteria, and they can survive at various environmental conditions. They can be cultured from dried clinical material even several months later (4). In the present study, *S. aureus* survived on laminate and inox sheet for 75.4 days and 68.2 days, respectively, whereas these survival days were 73.8 days on ceramic tile and 63.4 days on vinyl flooring.

In USA, Enterococci are the second most common nosocomial pathogens associated with either endogenous colonization or patient-to-patient transmission. Today, VRE is one of the principal microorganisms implicated in NI (5). There is growing evidence that inanimate surfaces may play a significant role in transmission of VRE. Jawad et al. (6) have demonstrated that Enterococci may survive up to 45 days on a dry surface when suspended with organic materials. In a study conducted in a rehabilitation unit with 146 patient beds, the patient rooms and common-use areas were investigated from the viewpoint of VRE colonization, and VRE colonization was detected in 10% of the 319 samples (7). It has been reported that the Enterococci are significant causes of morbidity due to their ability to survive for long periods on inorganic surfaces in hospital environments (8). Likewise, we found that VR *E. faecalis* survived on various surfaces for long periods. The survival days were varied from 42.6 to 67.8 on the tested surfaces for VR *E. faecalis*.

In the study conducted by Neely and Maley (9), the survival of several clinical and environmental staphylococcal and enterococcal isolates on fabrics and plastic commonly used in hospitals were examined systematically. They found the survival

period of *S. aureus* strains 4 to more than 90 days on various surfaces, whereas it was 18 to more than 80 days for Enterococci. In our study, the average survival ranges for *S. aureus* and VR *E. faecalis* strains on the test surfaces were 63.4 to 75.4 days and 42.6 to 67.8 days, respectively. Depending on the results of both studies, we can propose that the tested covering materials have significant influences on the survival periods of bacteria. Neely (10) who investigated the survival periods of several gram-negative bacteria (*P. aeruginosa*, *E. coli*, *Klebsiella pneumoniae*, *Serratia marcescens*, *Proteus mirabilis*, *Acinetobacter* species, and *Enterobacter* species) on the surfaces of various textiles, nylon, polyvinyl, polyurethane, and polyester, found that the survival periods of the tested bacteria varied depending on the test surface, the bacterial species, and the inoculum size of bacteria. Similarly,

we found that the survival periods of *E. coli* and *P. aeruginosa* varied depending on different materials. In both studies, survival periods of the bacteria on test surfaces appeared to depend on the surface material and the bacterial species inoculated. Because we found no previous studies in the literature conducted with the same materials we used, our data could not be compared and discussed.

In conclusion, the data of this study indicate that Staphylococci and Enterococci can survive for long periods on surface materials. Among the 4 flooring materials, inox sheet seemed to be the most unsuitable one for the bacteria to survive for a long period of time. This material may be preferred for covering benches and laboratory tables. As for the covering of the floors, vinyl seemed better than ceramic tile.

## References

1. Edmond MB, Wenzell RP. Organization for infection control. In: Mandell GL, Bennet JE, Dolin R, editors. *Principles and Practice of Infectious Diseases*, New York: Churchill Livingstone Inc; 2000, p. 2988-91.
2. Rosenthal VD, Guzman S, Orellano PW. Nosocomial infections in medical-surgical intensive care units in Argentina: Attributable mortality and length of stay. *Am J Infect Control* 2003; 31: 291-5.
3. Available at: "<http://www.vinylinfo.org>" Accessed May 02, 2008.
4. Waldvogel FA. *Staphylococcus aureus* (Including Staphylococcal toxic shock) In: Mandell GL, Bennet JE, Dolin R, editors. *Principles and Practice of Infectious Diseases*, New York, : Churchill Livingstone Inc; 2000: p. 2069-92.
5. Furtado GH, Martins ST, Coutinho AP, Soares GM, Wey SB, Medeiros EA. Incidence of vancomycin-resistant Enterococcus at a university hospital in Brazil. *Rev Saude Publica* 2005; 39: 41-6.
6. Jawad A, Heritage J, Snelling AM, Gascoyne-Binzi DM, Hawkey PM. Influence of relative humidity and suspending menstrua on survival of *Acinetobacter* spp. on dry surfaces. *J Clin Microbiol* 1996; 34: 2881-7.
7. Trick WE, Temple RS, Chen D, Wright MO, Solomon SL, Peterson LR. Patient colonization and environmental contamination by Vancomycin-Resistant Enterococci in a rehabilitation facility. *Arch Phys Med Rehabil* 2002; 83: 899-902.
8. Eliopoulos GM. Vancomycin-resistant enterococci. Mechanism and clinical relevance. *Infect Dis Clin North Am* 1997; 11: 851-65.
9. Neely AN, Maley MP. Survival of enterococci and staphylococci on hospital fabrics and plastic. *J Clin Microbiol* 2000; 38: 724-6.
10. Neely AN. A survey of gram-negative bacteria survival on hospital fabrics and plastics. *J Burn Care Rehabil* 2000; 21: 523-7.