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EFFECT OF NANOSILVER PAINTING ON CONTROL OF HOSPITAL AIR-TRANSMITTED MICROORGANISMS

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ABSTRACT
Microorganisms, including bacteria and fungi, are among air-transmitted infectious agents at hospitals, which in addition to patients, can afflict hospital employees and visitors, and may result in economic burden and impact on human health. Although application of physical and chemical methods for control of microbial growth is not a new subject, but the use of nanotechnology and especially nanosilver painting is a new method applied in this area. This study was aimed to assess antibacterial and antifungal effects of nano-silver painting. Three rooms were selected in an infectious diseases unit of a university-based tertiary referral hospital affiliated to Tehran University of Medical Sciences. One of the rooms was painted with ordinary paint having no nano-particle (as control room) and the other two rooms were painted with two different 2% nanosilver paints (one locally produced and other provided from abroad) provided from two different companies (as case rooms). Air sampling was carried out using a portable air pump (Quick Take 30 with constant rate between 10 and 30 L/min from 1 to 999 minutes) at pre-planned schedule. Each sampling was done in two minutes with the rate of 28.3 L/min. Samples were transferred on Blood agar (for total bacterial growth), EMB agar (for Gram negative bacterial growth) and Sabouraud>s Dextrose agar (for fungi detection) medias to study the culture results and Colony Forming Unit (CFU) count. Results, tested by ANOVAs and Kruskal-Wallis methods, indicated that there was no statistically significant reduction in the bacterial and fungal bio- burden between the control and case rooms and also between two types of paints by active sampling method. Moreover, there was no selective statistically significant change in bacterial and fungal species CFUs collected from the painted rooms by the above mentioned method. Study also revealed that there is no time trend change in bacterial bio- burden of the under study case and control rooms except for the first time zone (one month) of study duration.

Key words: Nano-silver; Air-transmitted microorganisms; Nosocomial Infections

INTRODUCTION
Microorganisms are agents of hospital infections and some of them are transmitted through air. Hospital infections are referred to infections acquired in hospital or other health care facilities. These infections may occur in the hospital or after discharge from hospital (Majid Pour and Habib Zadeh, 2001; Pittet and Alleranzi, 2005; Farr, 2005; Krishna Prakash, 2005; Pratta *et al*., 2007).

Air biologic contaminants known as aerosols include bacteria, fungi, viruses and pollens (Torbati and Hekmat Yazdi, 2007). Bacteria which may cause disease under specific conditions in those whose immune systems are compromised, are referred to opportunist pathogens (Soleimani *et al*., 2003). Fungal infections were known

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since about two hundred years ago and reports of fungal infections, geographical dissemination, and infection outbreaks have existed since 1890. In addition to infections caused by pathogenic fungi, many fungal infections are induced by opportunist agents and saprophytes which can bypass hosts immunity, threatening the patient's health. Also, a number of fungal agents are the natural inhabitants of human body and some others try to achieve symbiosis, probably inducing no inflammatory reaction of hosts against them. When the natural barriers of the body is diminished or interrupted, such fungi are able to induce infection and this is why there are called opportunist fungi (Imandel, 1996; Dvorak, 2005).

Through proper control and improvement of the air quality and disinfection and sterilization of medical instruments, hospital infections can be prevented significantly. Physical and chemical methods used in disinfection in human life are not a new phenomenon and have few of century's experience (Kyung-Hwan, 2005). Along with recent revolutions in human life, nanotechnology has widely developed.

Nanotechnologists have become familiar with new properties related to nano-particles which may have great influence in the future of medicine. Silver in greater dimensions is a metal with low reactivity, but when it is converted to small dimensions in nano-level, its antimicrobial property increases over 99%, so that it can be used to heal injuries and infections in a more effective way.

Features of nanosilver properties include quick effect with low toxicity, tolerance against different conditions and environmental feasibility, significant antibacterial, antifungal, and even antiviral effects.

Economic nano-silver polymer applications may include plastic dishes (for food and drugs), household appliances (refrigerator, ventilators and humidifiers), cleaners and detergents, weaving products and clothes.

This study was aimed to examine the effect of nano-silver particles on the control of air-transmitted microorganisms to determine their effects on microbial burden of hospital environment.

MATERIALS AND METHODS

Three rooms were selected in an infectious diseases unit of a university-based tertiary referral hospital affiliated to Tehran University of Medical Sciences, with identical conditions from the viewpoint of room surface, light, temperature, ventilator conditions, number of beds (each room had two beds) and patients and frequency of room cleaning.

One of the rooms was painted with ordinary paint having no nano-particle (as control room), and the other two rooms with two different (one locally produced and the other provided from abroad) 2% nano-silver paints provided from two different companies (as case rooms) to examine the effect of nano-silver paintings on decreasing the microbial burden in the hospital indoor air.

Sampling was conducted by a sampler pump (Quick take 30). The pump flow was calibrated on 28.3 L/min and the sampling time was adjusted at 2 minutes. Samples were transferred on Blood Agar (for total bacteria), EMB agar (for Gram. negative bacteria) and Sabouraud's Dextrose Agar (for fungi) cultures. Sampler pump was located with a distance of about 1.2 m to 1.5 m from patient's respiratory area or any other barriers. Before each sampling episode, ethanol (70%) was used to disinfect the mesh cap of the system. Doors and windows were closed during sampling. After disinfection, the cap of the related plate system was located inside the system and then it was placed in a greater plate to prevent any possible pollution. Then the sampler was turned on and sampling was done after time setting. Sampling was conducted over three months (mid June to mid November).

Fig. 1 shows the sampling intervals and time schedule for sampling during three months study duration.

The bacteria specific plates were closed after sampling and were transferred to laboratory and kept in incubators for 48 h under temperature of 35ºC. The fungi-specific plates were clogged after sampling and sealed by stick paper (one cm was gapped for air exchange). Samples were kept in the laboratory condition and were transferred to fungi laboratory for quantification and identification of the microorganisms based on Colony Forming Unit (CFU). Findings were registered in data sheets during each phase of the study.

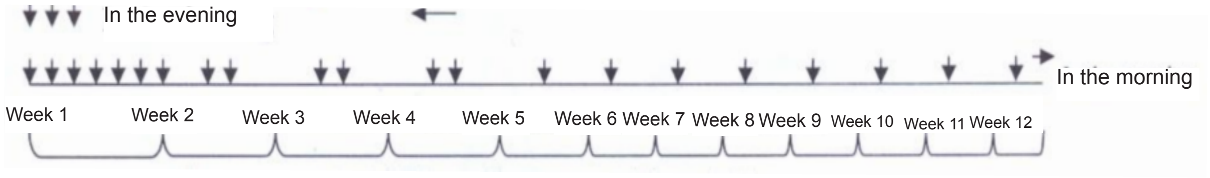

Fig .1: Study sampling strategy and time schedule

To analyze the effect of time trend on the efficacy of nanosilver paints on decreasing the bio-burden in hospital air, 21 samples were prepared in 90 sampling days from the rooms painted and with nanosilver and conventional paints.

RESULTS

Results of fungal study indicated the presence of fungi in the air of infectious diseases unit and effect of nanosilver on microbial agents in the hospital indoor air. Data shows that nanosilver paints had no statistically significant effect in decreasing the fungal burden in comparison with conventional paint by active sampling method implemented in this study, despite using three types of data categorization to evaluate this effect ($P= 0.47$ for both case rooms 1 and 2 compared to control room in sampling method in Fig. 2, $P= 0.44$ for both case rooms 1 and 2 compared to control room in sampling method in Fig. 3, $P\geq 0.05$ for both case rooms 1 and 2 compared to control room in sampling method in Fig. 4) (Figs 2, 3, and 4).

Data also indicates that both types of nanosilver paints have affected on penicillium CFUs ($P= 0.02$ both for case room 1 and case room 2 compared to control room respectively), however, this effect as mentioned previously is not significant for total fungal counts (Fig. 5).

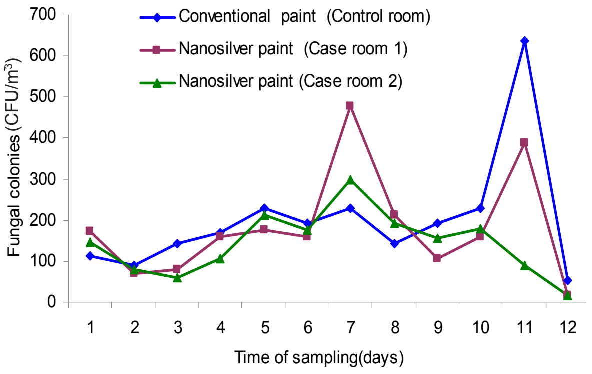

Fig. 3: Comparing the effects of nanosilver paints and conventional control paint on fungal burden (using the average CFUs of sundays and thursdays samplings for comparison)

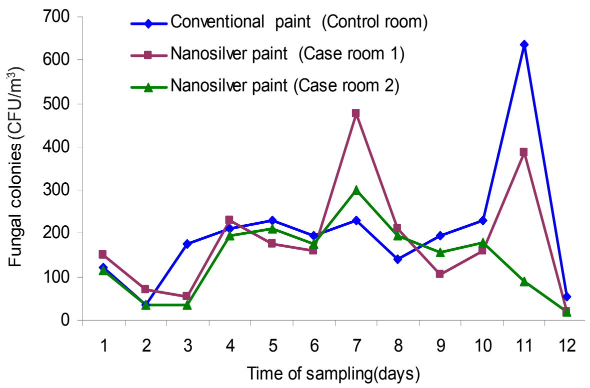

Fig. 2: Comparing the effects of nanosilver paints and conventional control paint on fungal burden (using the average CFUs of sunday's samplings for comparison)

Results of the bacterial study showed that both nanosilver containing paints had no statistically effect on burden of bacterial contamination both in total CFUs despite using three types of data categorization to evaluate this effect ($P= 0.916$ for both case rooms 1 and 2 compared to control room in sampling method in Fig. 6 , $P= 0.605$ for both case rooms 1 and 2 compared to control room in sampling method in Fig. 7 , and $P\geq 0.05$ for both case rooms 1 and 2 compared to control room in sampling method in Fig. 8), or by species compared with conventional paint for all species ($p\geq 0.5$ for both case rooms 1 and 2 compared to control room) (Figs. 6, 7, 8, and 9).

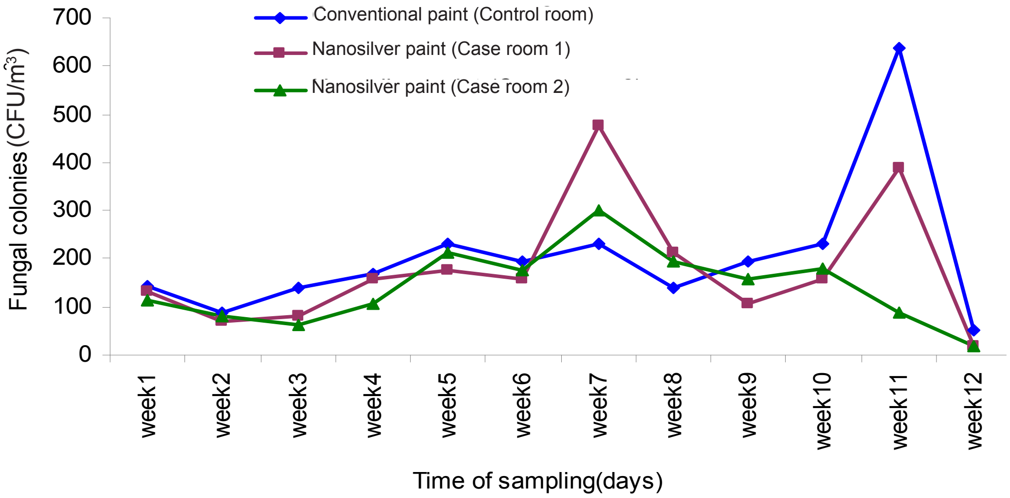

Fig. 4: Comparing the effects of nano- silver paints and their conventional control paint on fungal burden (Using the average CFUs of each month of samplings for comparison)

In comparing the persisting effect of nanosilver paints over time zones of the study, analysis showed borderline effects of case room 1 paint regarding to control room over time ($P= 0.053$ and $P= 0.603$ for fungal and bacterial burden, respectively; however, this effect was more prominent with case room 2 paint on fungal burden ($P= 0.01$) and not on bacterial burden ($P= 0.896$) compared to control room over time zones.

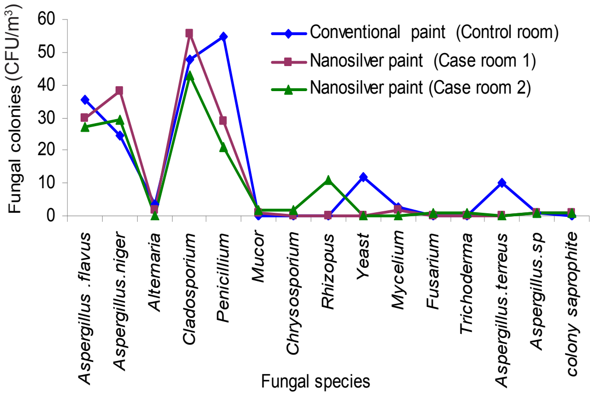

Fig. 5: Effects of nanosilver paints on specific fungal species based on CFUs

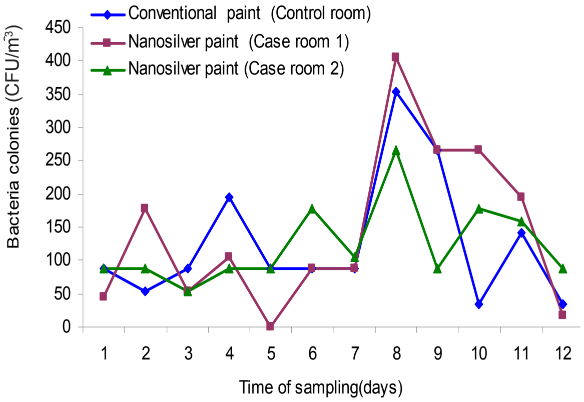

Fig. 6: Comparing the effects of nanosilver paints and conventional control paint on bacterial burden (using the average CFUs of sunday's samplings for comparison)

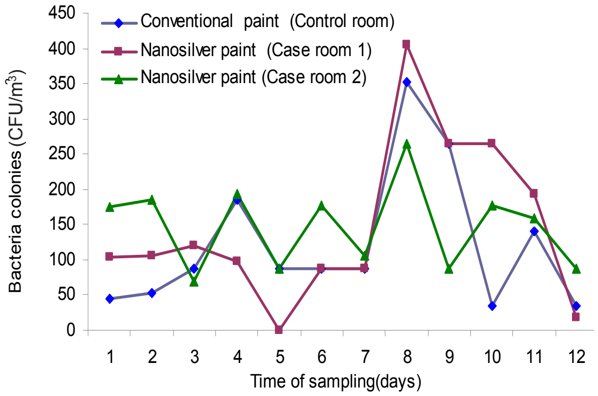

Fig. 7: Comparing the effects of nanosilver paints and conventional control paint on bacteria burden (using the average CFUs of sundays and thursdays' samplings for comparison)

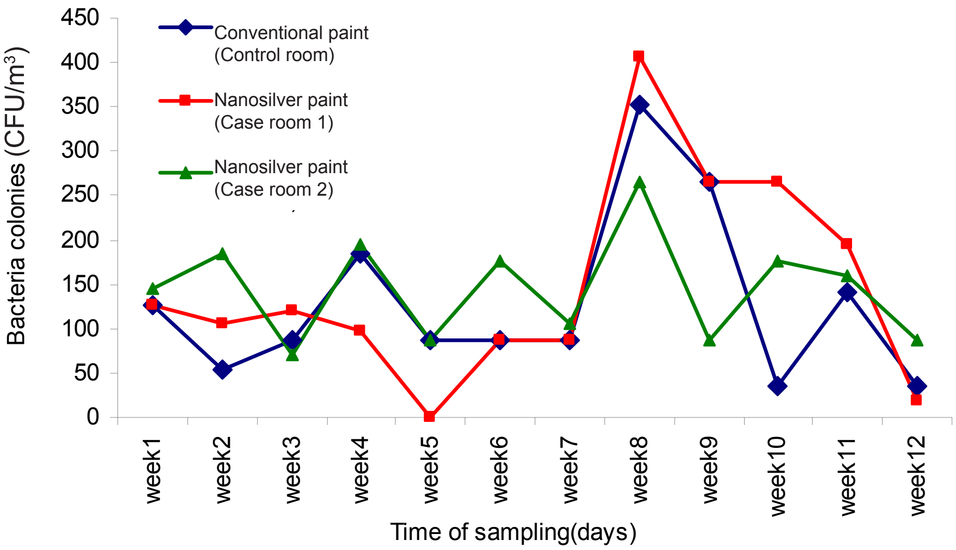

Fig. 8: Comparing the effects of nanosilver paints and conventional control paint on bacterial burden (using the average CFUs of each month of samplings for comparison)

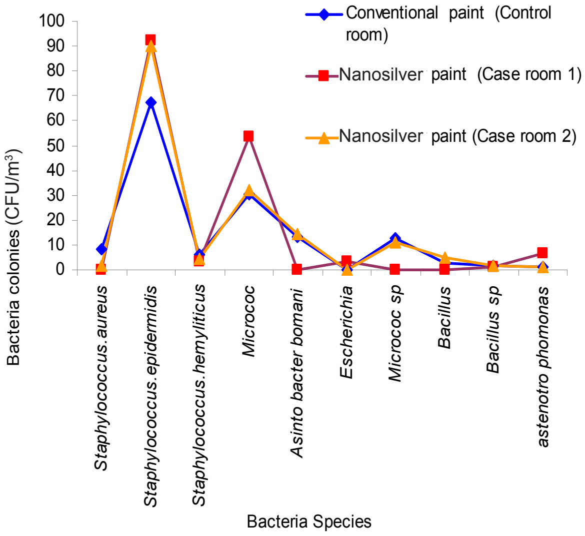

Fig. 9: Effects of nanosilver paints on specific bacterial species based on CFUs

DISCUSSION

To the best of our knowledge by searching in electronic databases, there was no similar study to be compared with the results of this study; however, the authors of this study have performed similar study with different methods of sample collection (Azizifar, 2008). The mentioned study was aimed to measure the fungal contamination in units of Qom Kamkar hospital and to evaluate the effect of nanosilver painting on decreasing fungal burden using Passive sampling method with open plate in the air and also by surface swab cultures from the hospital wards walls.

Results had indicated the effect of the same nanosilver paint used in case room 2 of the present study in decreasing the fungal burden of the rooms' air and walls. Present study failed to show similar statistically significant effect from the application of the nanosilver paints in decreasing fungal and bacterial burden of the painted rooms. This difference is probably resulted from the type of the sampling methods which has been used in these two studies. Hence, it seems that passive sampling methods are more sensitive to detect the changes produced by these types of paints in evaluating bio-burden. However, this assumption needs further studies to be confirmed.

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