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Microbial Contamination on Used Surgical Masks among Hospital Personnel and Microbial Air Quality in their Working Wards: A Hospital in Bangkok

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Abstract

Objective

To assess the relationship of bacterial and fungal contamination on used surgical masks worn by the hospital personnel and microbial air quality in their working wards.

Methods

This is a cross-sectional study of 230 used surgical masks collected from 214 hospital personnel, and 215 air samples collected from their working wards in the operation room and ward areas of a hospital. The study was carried out in the hospital in Bangkok, Thailand. Agar plate exposed bacterial and fungal were performed by identified by Gram's stain and lactocylphenol cotton blue. Data were analyzed using paired t-test and Pearson's correlation coefficient at the significant level of $p<0.05$.

Results

Means and standard deviation of bacterial and fungal contamination on inside area of the used masks were 47 ± 58 and 17 ± 36 cfu/cm2, and on outside area were 186 ± 199 and 34 ± 116 cfu/cm2, respectively, $p<0.001$. The bacterial and fungal contamination on used masks from hospital personnel working in male and female wards had relatively higher bacterial contamination than the other wards ($p<0.001$). The most frequently bacterial and fungal species isolated from the mask area were relatively higher than the air: which The predominant isolated bacteria and fungi contaminated on inside and outside areas of the used masks and air samples were similar (Staphylococcus spp. and Aspergillus spp., respectively). For its relationship, results found that bacterial and fungal counts in air samples showed significantly positive correlation with the microbial contamination load on outside area of the used masks, $r=0.36$, $p=0.018$ and $r=0.21$, $p=0.005$, respectively.

Conclusion

High bacterial contamination on outside area of the used masks was demonstrated, and it showed a significant correlation with microbial air quality of working wards.

Keywords: Microbial contamination, Hospital personnel, Microbial air quality

Introduction

In hospitals, the main role of infection for healthcare workers (HCWs) are the transmission from contaminated instruments or equipments and the hospital environments.[1,2] Patients and HCWs who have no symptoms of the disease or carriers of pathogens, can transmit infectious agents to other individuals or agents. The sources of infectious agent are the normal endogenous microbial flora of the patients, HCWs, or from environmental sources.[3] Surgical masks are worn by HCWs to protect themselves from splashes of blood, body fluids, secretions, or excretions.[4] Moreover, surgical masks are worn by HCWs to protect themselves from airborne disease agents exposure or indoor air pollutants, particularly in relation to allergies, asthma and respiratory diseases.[5,6,7] The airborne bacterial particles of hospital origin e.g., nurses, bacteria and fungal spores, have been associated with respiratory allergies, asthma, and several air-borne infections including influenza, tuberculosis, meningitis, and pneumonia.[8,9,10,11,12] Surgical masks have been used effectively in the hydrogic agents dispersed not only on the mass number of the inhaled particles, but also on the infectivity of agents.[13,14]

The disposable masks including surgical masks and N95 were originally developed to filter droplets from contaminated environments, and they are also used in the healthcare settings by the Occupational Organization (WHO), and National Institute for Occupational Safety and Health (NIOSH) to protect the wearer from inhaling small droplets and particles.[15,16] Surgical masks are also commonly used by considered especially the selection of a mask, should be a primary focus for infection control practices for preventing the spread of air-borne pathogens and the mask used behavior.[17,18] Hospital personnel, especially nurses are at risk as a result of exposure to infectious agents from patients and their environments. Evidences showed that the surgical mask might not be enough to protect the person from air-borne pathogens due to the size of the source of air-borne or droplet nuclei.[19,20,21] The present study was to investigate the microbial contamination on used disposable surgical masks among hospital personnel and microbial air quality in their working wards and its relationship. These are useful in developing prevention and control programs among HCWs.

Methods

A cross-sectional study was conducted to assess the bacterial and fungal contamination on 230 used surgical masks worn by 214 nurses (age 5 Fly 3.9 TAS-YH Ki Hoo) from 214 hospital personnel. The used masks were outside area of the masks were analyzed. The periadem were males and females aged 19 years, and have worked in the hospital for more than 6 months. Each mask was worn for 4 hours. Air samples were collected from their working wards in the same hospital. The study was carried out in the hospital in Bangkok, Thailand.

The Millipore Air Sotter system is based on the Andersen principle that uses a sieve with about 1,000 microperforation, which reduces the potential of microbial clumping and the subsequent destruction of the medium. The tester is small enough to be used in confined spaces, but powerful enough to sample up to 1,000 liters of air per minute (LPM). The Air Sotter is a single-stage impaction sampler that collects microorganisms from 0.25 to 6.0 mic and general range was collected in SDA plates at room temperature for 5 days with daily observation. After incubation, the bacterial and fungal colonies were counted and calculated to express as colony forming unit/m3 (cfu/m3).

Total counts (colony forming units/m3 or cfu/m3) = (Total colonies × 1000)/250

The isolated bacteria and fungi were preliminarily identified by Gram's stain and microscopic morphology of lactocylphenol cotton blue following Larone (1995).[22]

Data were analyzed using descriptive statistics including percentage, mean and standard deviation (SD) for describing bacterial and fungal counts. Paired t-test was used to compare between mean of microbial contamination on outside and inside areas of used masks. The correlation between bacterial and fungal counts in air samples and on used masks was analyzed by Pearson's correlation coefficient. Contamination on the used masks was analyzed using Pearson's correlation coefficient. The significant level was set at $p<0.050$.

Results

A total of 230 used masks were collected from 214 personnel to assess the bacterial and fungal contamination. Personnel results found the mean ± SD of bacterial contamination on the outside area of the used masks was 186 ± 199 cfu/cm2, which was significantly higher than the inside area of 47 ± 58 cfu/cm2 at $p<0.001$. The used masks from hospital personnel working in male and female wards had relatively higher bacterial contamination than the others wards (Table 1). Most isolated bacteria were *Staphylococcus* spp. (45%) and *Pseudomonas* spp. (16% and 16%), respectively. Details are presented in (Table 1). For personnel contamination ≥ 500 cfu/cm2 on the areas of the used masks was significantly higher than the inside area (34 ± 18 and 15 ± 9 cfu/cm2) at $p<0.001$. The used masks from hospital personnel working in male and female wards had relatively higher fungal contamination than the others wards (Table 2). Fungal found on inside and outside areas of the used masks were *Aspergillus* spp. (37% and 60%, respectively), and *Penicillium* spp. (11% and 25%, respectively) (Table 2).

Table 1

Bacterial contamination on used surgical masks collected by studied wards: inside and outside areas of the used masks (n = 230).

Studied wards	Mean ± SD of bacterial contamination (cfu/cm2/piece)	
	Inside mask	Outside mask
Male medical ward (n=40)	56 ± 91	221 ± 256
Female medical ward (n=40)	38 ± 20	249 ± 253
Emergency room (n=40)	33 ± 16	157 ± 153
Operation room (n=30)	40 ± 53	110 ± 171
Intensive care unit (n=25)	51 ± 31	139 ± 130
Out-patient department (n=35)	48 ± 71	65 ± 58
Total (n=230)	**47 ± 56***	**186 ± 199***

* Statistically significant difference by paired t-test, $p<0.001$

Remarks: Most isolated bacteria from inside areas were *Staphylococcus* spp (54%) and *Pseudomonas* spp. (34%), and most isolated bacteria from outside areas were *Staphylococcus* spp (45%) and *Pseudomonas* spp. (27%).

Table 2

Fungal contamination on used surgical masks collected by studied wards: inside and outside areas of the masks (n = 230).

Studied wards	Mean ± SD of fungal contamination (cfu/cm2/piece)	
	Inside mask	Outside mask
Male medical ward (n=40)	16 ± 21	21 ± 28
Female medical ward (n=40)	13 ± 5	38 ± 15
Emergency room (n=40)	18 ± 7	104 ± 52
Operation room (n=30)	13 ± 6	32 ± 15
Intensive care unit (n=25)	16 ± 7	39 ± 17
Out-patient department (n=35)	13 ± 6	44 ± 20
Total (n=230)	**15 ± 9***	**34 ± 18***

* Statistically significant difference by paired t-test, $p<0.001$

Remarks: Most isolated fungi from inside areas were *Aspergillus* spp (37%) and *Penicillium* spp. (25%), and most isolated fungi from outside areas were *Aspergillus* spp (60%) and *Penicillium* spp. (37%).

Analysis of 215 indoor air samples collected from the studied wards revealed that the OPD had the highest bacterial and fungal mean counts (376 ± 254 cfu/m3 and 263 ± 219 cfu/m3, respectively). While the intensive care unit had the lowest bacterial mean count (86 ± 8 cfu/m3) and the operation room had the lowest fungal mean count (74 ± 24 cfu/m3). Most isolated bacteria and fungi from indoor air samples were similar to those bacteria and fungi found from those collected from the mask areas. Moreover, isolated bacteria and fungi were preliminarily identified, it was found that the predominant bacteria and fungi were *Staphylococcus* spp. (57%) and *Penicillium* spp. (39%) and *Aspergillus* spp. (31%), respectively. Details are shown in table 3.

Table 3

Means and standard deviation of bacterial and fungal counts of air samples collected from studied wards.

Studied wards	Mean ± SD of bacterial count (cfu/m3)	Mean ± SD of fungal count (cfu/m3)
Male medical ward (n=40)	426 ± 291	134 ± 122
Female medical ward (n=35)	351 ± 172	162 ± 88
Emergency room (n=40)	376 ± 254	263 ± 219
Operation room (n=30)	86 ± 8	74 ± 7
Intensive care unit (n=25)	34 ± 5	23 ± 4
Out-patient department (n=24)	375 ± 253	263 ± 218
One-door (n=6)	786 ± 88	261 ± 141

Remark: Most isolated bacteria were *Staphylococcus* spp. (57%) and most isolated fungi were *Penicillium* spp. (39%) and *Aspergillus* spp. (31%).

The correlation between bacterial and fungal counts in air samples collected from working wards and the microbial contamination loads on the used masks (inside or outside area) was analyzed. It was found that bacterial and fungal counts in air samples showed significantly positive correlation with the microbial contamination found on outside area only of the used masks ($r=0.36$, $p=0.018$ and $r=0.21$, $p=0.005$, respectively). The details are shown in table 4.

Table 4

Pearson's correlation coefficient between bacterial and fungal counts in air samples and load of microbial contamination on used masks (inside and outside areas).

Load of microbial contamination on used masks	Bacterial counts in air samples (cfu/m3)	Fungal counts in air samples (cfu/m3)
Bacterial contamination on used masks		
inside area	r=0.016, p=0.834	r=0.006, p=0.933
outside area	r=0.361, p=0.018*	r=0.206, p=0.005*
Fungal contamination on used masks		
inside area	r=0.044, p=0.520	r=0.074, p=0.281
outside area	r=0.092, p=0.180	r=0.027, p=0.695

* Statistically significant correlation at $\alpha = 0.05$

Discussion

This study was a short-term assessment of bacterial and fungal contamination on the used surgical masks among hospital personnel and microbial air quality in their working wards. The disposable masks were originally developed to filter droplets containing microorganisms from the wearer, but they are also used probably to protect the human respiratory system from fine air-borne particles that are known to be hazardous to the respiratory system.[23,24,25] The high bacterial contamination on outside area of disposable masks in different exposure areas, which could be a source of cross-infection of microorganisms from the nose and mouth of the wearer from spreading to others. It is not efficient to filter particles of some infectious agents.[26] Moreover, the used masks were contaminated by the wearer. The present study found that both bacterial and fungal contamination on outside areas of the used masks were significantly higher than inside areas (186 ± 199 vs. 47 ± 58 cfu/cm2, $p<0.001$ and 34 ± 18 vs. 15 ± 9 cfu/cm2/piece, $p<0.001$, respectively). This evidence supported that the studied surgical masks could filter the air-borne particles from the wearer's nose and mouth. The most isolated bacteria and fungi from the used masks were *Staphylococcus* spp. and *Aspergillus* spp., respectively. It was some used mask behaviors that increased the microbial contamination on the masks.[27] When isolated colonies were randomly selected to identify bacterial species and fungal genera/species by Gram's stain and lactocylphenol cotton blue staining, respectively, it was found the predominant isolates contaminated on the outside of the used masks were *Staphylococcus* spp. (45%) and *Pseudomonas* spp. (27%), and *Aspergillus* spp. (60%), and *Penicillium* spp. (37%).

The microbial quality of air was assessed by comparing the bacterial and fungal counts to the OPD had the highest average of bacterial and fungal counts (376 ± 254 cfu/m3 and 263 ± 219 cfu/m3), while ICU and OR had the lowest counts. Most isolated bacteria and fungi from indoor air samples were similar to those bacteria and fungi found from those collected from the mask areas. Moreover, isolated bacteria and fungi were preliminarily identified, it was found that the predominant bacteria and fungi were *Staphylococcus* spp. (57%) and *Penicillium* spp. (39%) and *Aspergillus* spp. (31%), respectively. Details are shown in table 3.

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Conclusion

This present study revealed that the high bacterial contamination on the outside area of the used surgical masks worn by hospital personnel working in male and female wards. It showed a significant correlation with microbial air quality of working wards. To reduce the load of bacterial contamination on the used masks, the hospital environment, especially microbial air quality in the operation room should be controlled.

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