DIPONEGORO MEDICAL JOURNAL
(Jurnal Kedokteran Diponegoro)
Online : http://ejournal3.undip.ac.id/index.php/medico
E-ISSN : 2540-8844
Volume 9, Nomor 4, Juli 2020

THE EXISTENCE OF FUNGI AND THE EFFECT OF TERMINAL CLEANSING ON OPERATING ROOM AIRBORNE FUNGI

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ABSTRACT

Background: Fungi is one of the causes of infectious diseases, especially in immunocompromised patients. Surgical site infection (SSI) becomes a major challenge as it is the leading cause of healthcare-associated infection (HAIs). HAIs can be caused by endogenous or exogenous fungi. Exogenous fungi are present in the hospital environment, such as airborne fungi. Fungal contamination of the operating area occurs during surgery or after surgery. The effect of temperature, humidity, the focus of fungal source, and room cleanliness can trigger the growth of fungi in the operating room. **Aim:** To analyse the growth of fungal air contamination and its affecting factors in the operating room of a type C hospital. **Methods:** This study used analytic observational with a cross-sectional design. Total samples were 5 operating rooms that were not in repair. Sampling was using the settle down plate 1/1/1 method. The plates of each replication in each room were 13 plates. The fungal culture was at the temperature of 25^0 C and was observed with LPCB. Measurement of temperature and humidity was using the thermo-hygrometer. The focus of the fungal sources was observed in the ceiling of the operating room. **Results:** In a total of 5 operating rooms, the *Fisher exact* test results showed no significant differences between room cleaning and fungal growth in the air (p=0.400). In the primary data, the most fungal growth in operating room number 1 and number 5 was 5 plates. The decline in the number of plate overgrown occurred in the operating room number 1, from 5 plates to 1 plate. The *Fisher exact* test result showed no significant differences between temperature, humidity, and the focus of fungal source with fungal growth in the air (p=1). **Conclusion:** In this study, room cleaning, temperature, humidity, and the focus of the fungal source showed no effect on the fungal growth in the air.

Key Words: Fungal air, room cleaning, humidity, temperature, the focus of fungal source, operating room.

INTRODUCTION

Fungi are one of the infectious diseases, especially in immunocompromised patients. Ironically, hospitals are one of the sources of opportunistic fungal infections.[1] It is estimated that the number of HAIs (Healthcare-associated infections) caused by fungi is around 2 - 11% of the total HAIs that occur in hospitals. Fungi that can cause HAIs are *Candida* spp., *Aspergillus* spp., *Penicillium* spp., *Fusarium* spp., *Zygomycetes* spp.[2,3,4]

HAIs that can be caused by endogenous or exogenous fungi are Surgical Site Infections (SSIs). *Candida albicans* is endogenous because it is a normal flora in the body. However, it can cause infection in certain conditions. Other types of fungi such as *Aspergillus* sp., *Penicillium* sp., *Fusarium* sp., and *Zygomycetes* sp. are exogenous fungi that are often found in hospital environments and they can cause infection in immunocompromised individuals.[1] The spread of exogenous fungi can occur

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through the surrounding air. Microbiological contamination in the surgical site often occurs during or after surgery. Therefore, environmental cleanliness in critical places in the hospital must be conserved to maintain the air quality in the room.[5]

There were reports on the outbreak of fungal infections due to *Aspergillus* sp. which causes aspergillosis in postoperative patients. The outbreak ended after the installation of HEPA filters in the post-surgical room. This shows the importance of air quality in preventing fungal infections.[6,7] The growth of fungal air contamination is inseparable from a variety of factors, including temperature, humidity, ventilation, light intensity, fungal source focus, and disinfection of room. All those can affect the growth of fungal air contamination in the operating room.[8]

Type C hospital is one hospital that has a risk for fungal growth in the operating room due to its undergoing renovation and fungal source focus. Based on this reasoning, the purpose of this research is to describe air quality based on the presence of fungal air contamination in the operating room and the factors that influence it.

METHODS

This research used an observational type with a cross-sectional design. It was conducted in the operating rooms of type C hospital in September-November 2019.

The population of the research was all operating rooms in type C hospital. The samples used were the operating rooms that were not in use. The sampling process used the settle down plate method by placing 13 SDA media per replication in each room. Each replication covered 2 different times, before and after cleaning the operating room. Incubation plates were at 25^0 -30^0 C to determine fungal growth. The identification of airborne fungi was done by LPCB staining. The sampling of temperature and humidity in each room was done once in the morning using a thermo-hygrometer.

The independent variable of this research was the cleaning of the operating room. Moderating variables were temperature, humidity, and fungal source focus. The dependent variable was airborne fungi growth. The primary data obtained were analyzed using SPSS. A Chi-square test was considered significant if it meets a specific value. If the calculation is less than 5, then the Fisher exact test was used. Data analysis was considered significant if $p<0.05$. This research was approved by the Health Research Ethics Commission of Diponegoro University / Dr. Kariadi Hospital Semarang and the Diponegoro National Hospital Semarang.

RESULTS

The results of the research showed that there was fungal growth in each operating room. The types of fungal include *Aspergillus* sp., *Penicillium* sp., *Mucorales* sp., and 1 mold that could not be identified. The spread of fungal growth in each operating room can be seen in Table 1.

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Table 1. Types of Fungal

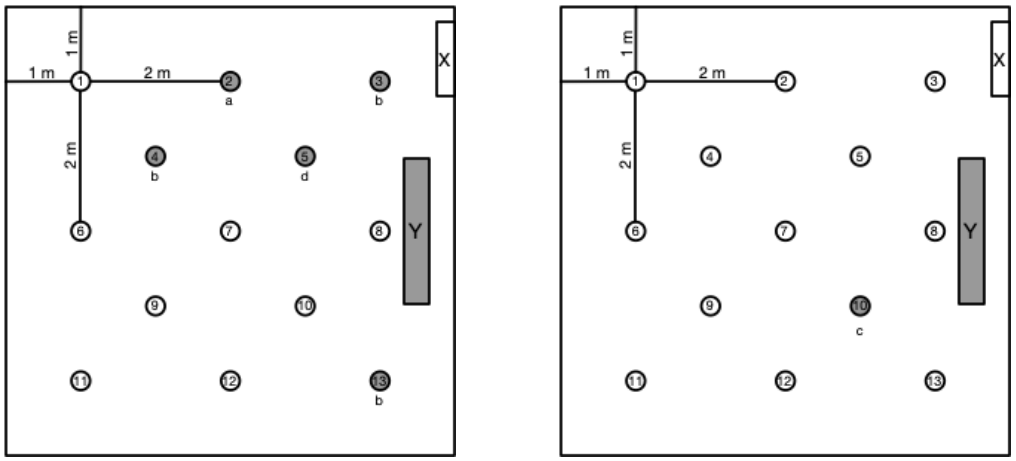
Operating room	Before Cleaning Fungal species	After Cleaning Fungal species
OK 1	- *Aspergillus sp.* (1 plate) - *Penicillium sp.* (3 plates) - Mold can't identify (1 plate)	- *Mucorales sp.* (1 plate)
OK 4.1	- *Aspergillus sp.* (1 plate) - *Penicillium sp.* (1 plate) - *Mucorales sp.* (3 plates)	- *Aspergillus sp.* (3 plates)
OK 5.1	- *Aspergillus sp.* (1 plate) - *Penicillium sp.* (1 plate) - *Mucorales sp.* (1 plate)	- *Penicillium sp.* (1 plate) - *Mucorales sp.* (2 plates)
OK 4.2	- *Penicillium sp.* (1 plate) - *Mucorales sp.* (1 plate)	-
OK 5.2	- *Aspergillus sp.* (1 plate) - *Mucorales sp.* (1 plate)	- *Aspergillus sp.* (2 plates) - *Mucorales sp.* (1 plate)

NB : * 4.1 → First sampling in the operating room 4
* 4.2 → Second sampling in the operating room 4
* 5.1 → First sampling in the operating room 5
* 5.2 → Second sampling in the operating room 5

The spread of fungal growth based on the plate and the focus of fungal sources on the air conditioning area can be seen in Figure 1.

Operating Room 1

Before cleaning **After cleaning**



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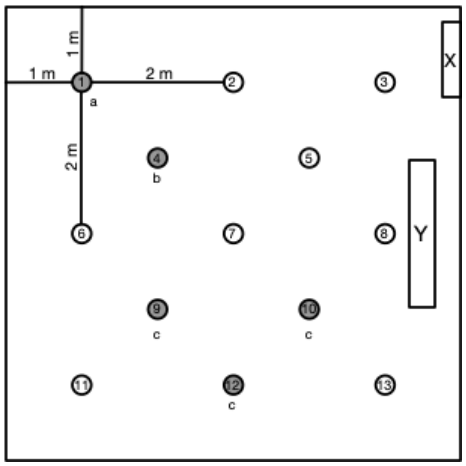
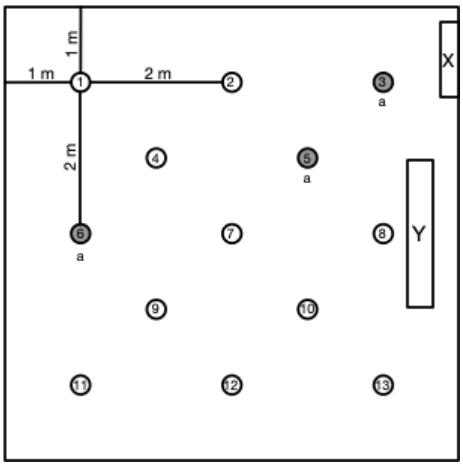
Operating Room 4.1

Before cleaning

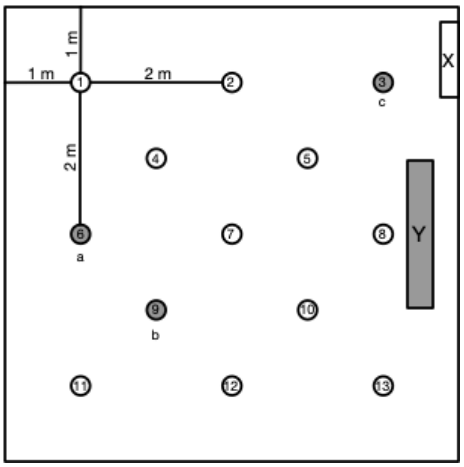


After cleaning

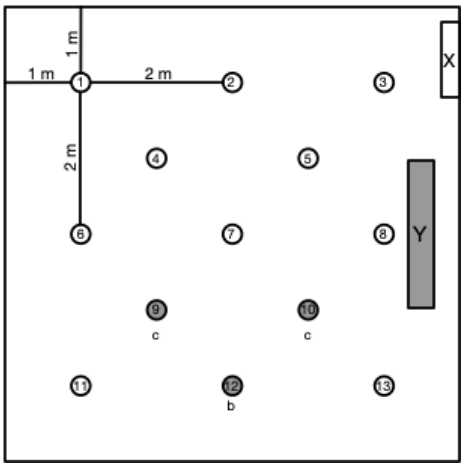


Operating Room 5.1

Before cleaning

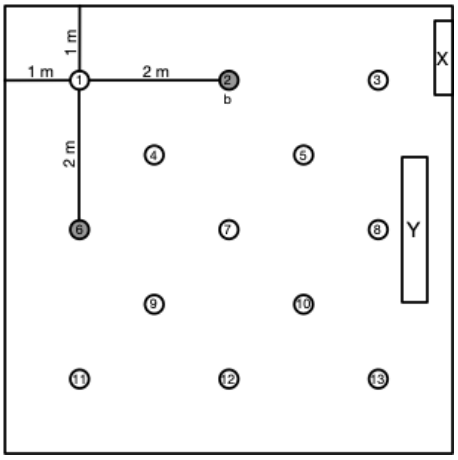


After cleaning

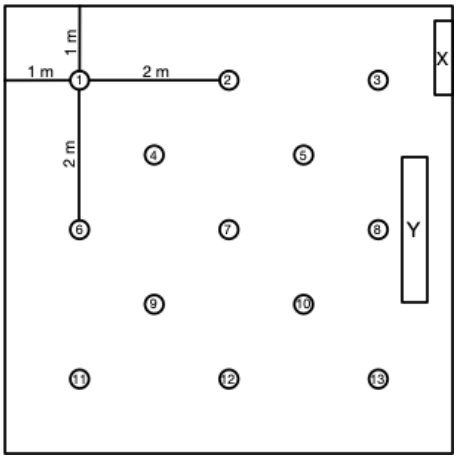


Operating Room 4.2

Before cleaning



After cleaning



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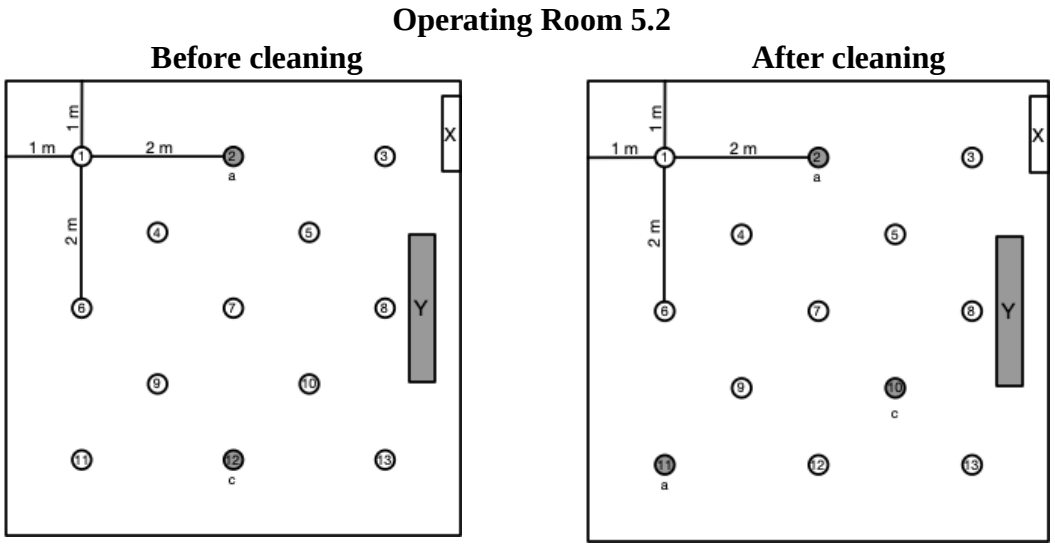

Figure 1. Fungal Growth on Plates based on Fungal Source Focus

Notes: a. *Aspergillus* sp.
b. *Penicillium* sp.
c. *Mucorales* sp.
d. Mold
Y (hatching). Air inlet which is a fungal source focus
X. Exhaust

The sampling-based on cleaning time was done 2 times, before and after cleaning the operating room. The calculations using the Fisher exact test showed no significant value (p>0.05). The aspect of the operating room being measured was temperature. The calculations using the Fisher exact test showed no significant value (p>0.05). Aside from temperature, another aspect of the operating room being measured was the humidity. The calculations using the Fisher exact test showed no significant value (p>0.05). The fungal source focus is seen on the ceiling of the operating room. The Fisher exact test analysis showed no significant results between the fungal source focus with the fungal growth (p>0,05). The results of fungal growth based on the data can be seen in table 2.

Tabel 2. Distribution of Data

Data	Fungal Growth		*P*
	No	Yes	
Time			
After cleaning	1	3	p=0,400
Before cleaning	0	6	
Temperature			
≤ 25^0 C	0	5	p=1
>25^0 C	1	4	
Humidity			
≤ 60%	1	0	p=1
>60%	0	9	
Fungal Source Focus			
No	1	6	p=1
Yes	0	3	

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The fungal source focus seen on the ceiling of the operating room was done by swab and fungal staining. The fungal identified as *Aspergillus sp*. in OK 1 and OK 5. The spread of fungal growth based on fungal source focus can be seen in table 3.

Tabel 3. Fungal Distribution on Fungal Source Focus

Operating room	Before Cleaning		After Cleaning	
	Fungal species	Fungal source focus	Fungal species	Fungal source focus
OK 1	*Aspergillus sp.*	AC area	-	-
OK 4.1	-	-	-	-
OK 5.1	*Aspergillus sp.*	AC area	-	-
OK 4.2	-	-	-	-
OK 5.2	*Aspergillus sp.*	AC area	-	-

DISCUSSION

The Fisher exact test results between operating room cleaning, temperature, humidity, and the presence of fungal source focus with the fungal air contamination growth in the operating room did not show a significant relationship with the p-value for room cleaning at (p=0,400), temperature at (p=1), humidity at (p=1), and fungal source focus at (p=1).

The microbiological quality of the air in the operating room becomes an important parameter to control and prevent the incidence of SSIs. The reason is that air as a dust particulate carrier allows microbial contamination such as fungal infections.[9] The types of fungal obtained from the results of the research were *Aspergillus* sp., *Penicillium* sp., *Mucorales* sp., and 1 unidentified mold. In this research, the

average fungal air contamination growth occurred in each operating room. These results were similar to studies conducted in Mazandaran Province where the types of fungal that often grow in the operating room air are *Aspergillus* sp. and *Penicillium* sp.[10] Also, research in Afghanistan shows that the fungal that causes IFI (invasive fungal infection) in surgical wounds are *Mucorales sp.* (35%), *Aspergillus sp.* (29%), and *Fusarium* (21%).[11] Fungal growth is influenced by several factors such as temperature, humidity, room cleanliness, and the presence of fungal source focus.[12]

The room cleaning referred to in this research is terminal cleaning. Terminal cleaning was done once a week. Samplings were carried out 2 times in each operating room based on cleaning time. In this research, there was a mean reduction in the number of plates covered with fungal between before cleaning, which were 17 plates, and after cleaning, which were 10 plates. The cleaning included cleaning the entire operating room area with disinfectant, followed by vacuum and HEPA filter. Furthermore, the process was followed by sterilization with UV. The room cleaning standard was based on ISO 14644-1 that consisted of all parts of the room including the ceiling, followed by a vacuum and HEPA filter.[13] HEPA filters reduced the growth of microorganisms by 97% and the effect of UV rays on the growth of fungal reaches 99.9%.[14,15]

The physical quality of air such as temperature and humidity are factors that

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determine the presence of microorganisms in the air which can cause an increase in HAIs. In the research, the highest temperature was 28.4^0 C and the lowest was 23.8^0 C. According to Permenkes RI No.7 year 2019, the operating room temperature standard should be at 22-27^0 C.[16] The difference is not significant in this research because, according to research, the most common fungal growth is at a temperature of 32^0 C or in the summer/spring.[17] Besides, the highest humidity value at this research was 66% and the lowest was 52%. According to Permenkes RI No.7 Year 2019, operating room humidity standard is 40-60%.[16] Research showed that the minimum humidity value for fungal growth was 80%.[18] Similar results were also obtained from research conducted in Seoul that the highest concentration of fungal occurred in spring with 79% humidity.[19]

According to the CDC, fungi can grow in places that have high humidity, such as pipes, windows, ceilings, or in wet locations. In this research, the fungal source focus was obtained on the operating room ceiling. Blackish brown discolorations were found in the ceiling of OK 1 and OK 5. Swab and LPCB staining were carried out to identify the type of fungi which was *Aspergillus* sp. According to the CDC, standard cleaning and humidity control is the main key in minimizing the growth of fungal in the room.

CONCLUSION

There was no relationship between the temperature, humidity, room cleaning, and the fungal source focus on the growth of fungal colonies in the air at Diponegoro National Hospital operating rooms.

The research will be more optimal if the calculation of the amount of fungal air contamination is further associated with the incidence of SSIs in patients undergoing surgery. Also, it will be better if samples in operating rooms were compared with those in empty rooms.

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