ORIGINAL ARTICLE

Factors Associated With Airborne Microorganisms Concentration in Inpatient Department of General Public Hospital in Indonesia

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ABSTRACT

Introduction: Healthcare-associated infections (HAIs) becomes a major public health concern. This study aimed to investigate factors associated with airborne microorganisms' concentration in the inpatient department of a general public hospital in Indonesia. **Methods:** This study was conducted using a cross-sectional in 34 inpatients ward. Samples were taken repeatedly from the beginning of the entrance hall (07:00 AM) to the end of the room (2:00 PM) and continued until night (9:00 PM). Sampling instruments were mounted at a height of approximately 1.2–1.5 m, in a fixed location which was presumed to represent the entire room. Different statistical corrections were made using correction factors obtained by a single-stage operating manual for each growing medium from the Conversion Tables. **Results:** The mean of total airborne microorganism was 347.03 CFU / m3 (SD= 89.06). The mean temperature was 25,450C (SD= 1.6), while the average of inpatient room humidity was mean 54.04% (SD 5.54). The mean of room lighting mean was 137.80 Lux (SD= 30.72.). The mean of densities in the inpatient room was mean 8.15 (SD=3.05). **Conclusion:** The total number of airborne microorganisms shows was a positive relationship between humidity and negative correlation with lighting. Modification of humidity and lighting is urgently needed to prevent the growth of microorganisms.

Keywords: Airborne microorganism, Bacteria, Fungi, Hospital

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INTRODUCTION

Healthcare-associated infections (HAIs) also known as nosocomial infection become a major public health concern. HAIs defined as the infections linked with admission to an acute-care hospital and other various settings where patients obtain health care (1). In 2015, it is projected that there were 687,000 HAIs in acute care hospitals in the United States, and that 72,000 individuals diagnosed with HAIs died while hospitalized (2). In Indonesia, the prevalence of HAIs was 9.8%, ranged from 6.1% to 16% in 10 teaching hospitals. Many studies have been conducted over the past thirty years in an effort to determine the cause and mode of transmission of HAI through epidemiological research, but no definitive results have been reached (3,4). Around 12–17 microorganisms cause 80%–87% of Hai, such as S. aureus, Enterococcus species, E. coli, Staphylococci, Candida species, K. pneumoniae and Klebsiella, Bacteroides species, and other pathogens (5–7). People, including patients, are not the only source of airborne germs in a hospital; other factors both within and outside the facility can serve as incubators for the spread of disease. Pathogenicity is spread either from person-to-person contact or by hospital-generated aerosols (8). Using a hospital's HVAC system without regularly replacing the air filters might increase the prevalence of airborne bacteria and other germs known as nosocomial infections (9), contamination of the internal structures due to the age of the hospital and the introduction of organic elements, such as food, flower, and fruit, from the exterior environment brought in by visitors (10).

There have been reports of elevated amounts of airborne microorganisms in sterile medical environments like operating rooms, hospital rooms, intensive care units, surgical units, hematological wards, and maternity wards (11–13). In the general hospital of West Java, Indonesia, very few studies have looked into the relationship between hospital characteristics and the amount of airborne microorganisms in the inpatients' world. Therefore, this study aimed to investigate factors associated with airborne microorganisms' concentration in the inpatient department of general public hospitals in Indonesia.

MATERIALS AND METHODS

This study was conducted using a cross-sectional to measure microorganism levels, relative humidity, temperature, light and occupancy density in 34 inpatients ward. Because of this, the hospital does not utilize any wood or other materials that could foster the growth of bacteria. From the front door (at 7:00 AM) to the back wall (at 2:00 PM) and all the way through the room (at midnight), several samples were collected (9:00 PM). The sampling equipment was placed at a set height of 1.2–1.5 m, thought to be representative of the entire space. Approval of protection human subjects was obtained from the Institutional Review Board of the affiliated university.

For all collections, In order to avoid the accidental isolation of pathogenic bacteria, a single-stage Anderson cascade sampler was utilized, with a flow rate of 28.3 L/min and a sampling time of less than 5 min (14). Three or four samples were taken per microorganism type each time period (07:00-15:00, 15:00-21:00, and 21:00-07:00) to assess the typical concentration of airborne bacteria at those times. After collecting samples of one type of microorganism, it was necessary to wait in order to fine-tune the collection plates before collecting samples of the other two types of microorganisms. Following collection, the bacterial and GNB agar plates were incubated at 37 1 ° C for a day in the lab, whereas the fungal agar plates were kept at 25 1 ° C for the same amount of time (15).

Different statistical corrections were made using correction factors obtained by a single-stage operating manual for each growing medium from the Conversion Tables (8). Each sample had a maximum of 30 colony-forming units (CFU) across all media types. Information below the detectable threshold was deemed to be absent. Colony-forming units (CFUs) per cubic meter of air were used to quantify the bacterial and fungal populations (m3). Our microbial sampling approach was developed to be as accurate as possible in capturing the variety and quantity of microorganisms found in a medical setting. In order to keep track of the air temperature and humidity simultaneously throughout each sampling period, direct-reading temperature and humidity control instruments (IAQ, Model; 8762, TSI, Shoreview, MN, USA) were set up adjacent to the cascade sampler.

Descriptive statistics were carried out using the SPSS program. Correlation analysis was used Pearson correlation test. All correlation coefficients had absolute values below 0.5, suggesting that the aforementioned variables might be combined into a single model. Simple linear regression analysis was used to analyze the relationships between microbial concentrations and air temperature, humidity, light, and density in the wards.

RESULTS

Table I shows a total number of microorganisms, humidity, temperature, lighting, and density in 34 Inpatients Ward at General Public Hospital in West Java, Indonesia. The mean of total airborne microorganism was 347.03 CFU / m3 (SD= 89.06). The mean temperature was 25,450C (SD= 1.6), while the average of inpatient room humidity was mean 54.04% (SD 5.54). The mean of room lighting mean was 137.80 Lux (SD= 30.72.). The mean of densities in the inpatient room was mean 8.15 (SD=3.05).

There was a positive relationship between humidity with total number of airborne microorganisms shows a moderate relationship ($r = 0.369$, $p = 0.032$) with the coefficient of determination 0.136 means that humidity affects the total air germs by 13.6% and the remaining 86.4% of total air germs is influenced by other variables (Table II). More lighting showed a reduction in a total number of airborne microorganisms ($r = 0.426$, $p = 0.012$) with the coefficient value with a determination of 0.182 means that lighting affects the total air germ by 18.14% and the remaining 81.86% of the total airborne microorganisms is influenced by other variables. There was no relationship between temperature and density with a total number of airborne microorganisms.

DISCUSSION

This study found the association between humidity and the total number of airborne microorganisms. This is in line with research conducted by (16), regarding the physical environment and the number of indoor air germs at Makassar Hajj Makassar General Hospital, which states that there is a significant relationship between humidity and total germs in the room. According to (17) supporting environmental

Tabel I : The total number of microorganisms, Relative humidity, Temperature, Lighting and Density in 34 Inpatients Ward at General Public Hospital in West Java, Indonesia

Variabel	Minimum	Maksimum	Mean	SD
Total airbone microorganism	207	518	347.03	90.06
Temperature	23	29	25.45	1.6
Humidity	43	62	54.04	5.54
Lighting	85	193	137.80	30.72
Density	4	13	8.15	3.05

Tabel II : Relationship between the Total number of microorganism, Relative humidity, Temperature, Light and Density

Variabel	r	R^2	p- value
Temperature	0.207	0.043	0.241
Humidity	0.369	0.136	0.032
Light	-0.426	0.182	0.012
Density	- 0.191	0.036	0.264

conditions can stimulate bacterial growth and reproduction of environmental factors that influence the growth and reproduction of bacteria one of which is moisture. In general, bacteria require high enough humidity for bacterial growth. Moisture is one of the factors that influence the survival of microorganisms. The reduction of water content from protoplasms causes metabolic activities to stop, for example in the process of freezing and drying. Relatively low air humidity of less than 20% can cause dryness of the mucous membrane of the membrane so that it interferes with bacterial metabolism to stop. According to (18) microbes have optimum moisture values. In general, for the growth of yeasts and bacteria, high humidity is needed above 85%, while for fungi and actinomycetes require low humidity below 80%. Bacteria are creatures that like being wet, can even live in water. Only in closed water can not thrive, this is due to lack of air.

There is a relationship between lighting with a total number of airborne microorganisms. This is following the research conducted by (19) regarding factors related to the presence of Streptococcus bacteria in the air in Semarang city. In the studied hospital, there are still lacking in direct sunlight and there are still some rooms with an unopen window, which usually triggers the growth of bacteria in the treatment room. According to (20) ultraviolet light has a potential power of 99.9% to kill bacteria. but not all ultraviolet rays have the same potential to kill the same bacteria. Some ultraviolet rays produce ozone which is designed to kill bacteria. Lights with certain UV rays can damage the retina of the eye, especially if someone sees directly. By irradiating at close range bacteria can die instantly while in irradiation at a distance rather far only the breeding alone is disturbed. Bacteria that have spores are more resistant to sunlight.

This study did not find a correlation between temperature and density with total airborne microorganisms. This is following research conducted by (16) on the physical environment and the number of room air germs in the Makassar Haji General Hospital in South Sulawesi which states there is no significant relationship between temperature and the total air germs in the Makasar General Hospital in South Sulawesi, Indonesia. In general, bacteria are more resistant at low temperatures compared to high temperatures so that the decrease in total air germs in the ward can be influenced by indoor temperatures. The optimum temperature for bacterial growth is 25-370C (21). So, with temperatures above 240C in the inpatient's room of a studied hospital is a good temperature for bacterial growth. The temperature in the room is influenced by outside air temperature, air movement, and humidity of the room. For optimal growth of bacteria requires an adequate environment. According to (21) bacteria can be sorted based on the optimum temperature of growth. Therefore, it is very important to maintain the temperature adequately to prevent the growth of microorganisms.

CONCLUSION

In conclusion, the total number of airborne microorganisms' shows was a positive relationship between humidity and negative correlation with lighting. This study did not find a correlation between airborne microorganisms with temperature and density. Therefore, modification of humidity and lighting is urgently needed to prevent the growth of microorganisms. Our analysis, however, did not c onfirm that inpatients toom in the study hospital were infected at the time of the test, but established specific factors that could significantly influence these agents ' airborne concentrations, thus providing a starting point for mitigation recommendations.

ACKNOWLEDGEMENT

The author would like to thank Sekolah Tinggi Ilmu Kesehatan Jenderal Achmad Yani Cimahi for the encouragement and enthusiasm given during the research.

REFERENCES

1. Haque M, Sartelli M, McKimm J, Abu Bakar M. Health care-associated infections - an overview. Infect Drug Resist. 2018;11:2321–33. doi: 10.2147/IDR.S177247
2. CDC. Healthcare-associated Infections. 2019.
3. Gaynes RP, Edwards JR, Jarvis WR, Culver DH, Tolson JS, Martone WJ. Nosocomial infections among neonates in high-risk nurseries in the United States. National Nosocomial Infections Surveillance System. Pediatrics. 1996 Sep;98(3 Pt 1):357–61.
4. Jarvis WR. The epidemiology of colonization. Infect Control Hosp Epidemiol. 1996 Jan;17(1):47–52. doi: 10.1086/647189.
5. Mermel LA, Allon M, Bouza E, Craven DE, Flynn P, O'Grady NP, et al. Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 Update by the Infectious Diseases Society of America. Clin Infect Dis an Off Publ Infect Dis Soc Am. 2009 Jul;49(1):1–45. doi: 10.1086/599376.
6. Sievert DM, Ricks P, Edwards JR, Schneider A, Patel J, Srinivasan A, et al. Antimicrobial-resistant pathogens associated with healthcare-associated infections: summary of data reported to the National Healthcare Safety Network at the Centers for Disease Control and Prevention, 2009-2010. Infect Control Hosp Epidemiol. 2013 Jan;34(1):1–14. doi: 10.1086/668770.
7. Boucher HW, Talbot GH, Bradley JS, Edwards JE, Gilbert D, Rice LB, et al. Bad bugs, no drugs: no ESKAPE! An update from the Infectious Diseases Society of America. Clin Infect Dis an Off Publ Infect Dis Soc Am. 2009 Jan;48(1):1–12. doi: 10.1086/595011.
8. Haddad SH, Arabi YM, Memish ZA, Al-Shimemeri AA. Nosocomial infective endocarditis in critically ill patients: a report of three cases and review of the literature. Int J Infect Dis IJID Off Publ Int Soc Infect Dis. 2004 Jul;8(4):210–6. doi: 10.1016/j.ijid.2003.10.007.
9. Park D-U, Yeom J-K, Lee WJ, Lee K-M. Assessment of the levels of airborne bacteria, Gram-negative bacteria, and fungi in hospital lobbies. Int J Environ Res Public Health. 2013 Jan;10(2):541–55. doi: 10.3390/ijerph10020541.
10. Schabrun S, Chipchase L. Healthcare equipment as a source of nosocomial infection: a systematic review. J Hosp Infect. 2006 Jul;63(3):239–45. doi: 10.1016/j.jhin.2005.10.013
11. Ortiz G, Yagьe G, Segovia M, Catalбn V. A study of air microbe levels in different areas of a hospital. Curr Microbiol. 2009 Jul;59(1):53–8. doi: 10.1007/s00284-009-9398-7
12. Augustowska M, Dutkiewicz J. Variability of airborne microflora in a hospital ward within a period of one year. Ann Agric Environ Med. 2006;13(1):99–106.
13. Li C-S, Hou P-A. Bioaerosol characteristics in hospital clean rooms. Sci Total Environ. 2003 Apr;305(1–3):169–76. doi: 10.1016/S0048-9697(02)00500-4.
14. Anderson K, Morris G, Kennedy H, Croall J, Michie J, Richardson M, et al. Aspergillosis in immunocompromised paediatric patients: Associations with building hygiene, design, and indoor air. Thorax. 1996 Apr;51:256–61. doi: 10.1136/thx.51.3.256.

15. Macher J, Reponen T, Douwes J, Prezant B. Bioaerosols. In 2013.
16. Tamher S. Microbiology for Nursing Students. Yogyakarta: Trans Info Media; 2008.
17. Waluyo L. General Microbiology. Malang: Universitas Muhammadiyah Malang; 2005.
18. Yassin MF, Almouqatea S. Assessment of airborne bacteria and fungi in an indoor and outdoor environment. 2010;7(3):535–44.
19. Pelczar MJ. Elements of Microbiology. Jakarta: Universitas Indonesia (UI-Press), 2016; 2016.
20. Berthelot P, Grattard F, Amerger C, Frery MC, Lucht F, Pozzetto B, et al. Investigation of a nosocomial outbreak due to Serratia marcescens in a maternity hospital. Infect Control Hosp Epidemiol. 1999 Apr;20(4):233–6. doi: 10.1086/501617.
21. Rowan NJ, Anderson JG. Effects of above-optimum growth temperature and cell morphology on thermotolerance of Listeria monocytogenes cells suspended in bovine milk. Appl Environ Microbiol. 1998 Jun;64(6):2065–71. doi: 10.1128/AEM.64.6.2065-2071.1998.