



Microbial Risk Assessment Of Indoor Airborne Microbe In The Community Health Center In Semarang City

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Abstract

Introduction: The Community Health Center is a gathering place for healthy people and sick people, so that it has the potential to become a place for disease transmission. Transmission of the disease can be influenced by the presence of germs in the air. The results of a preliminary study measuring germ numbers showed concentrations of 2575 CFU / m³, 945 CFU / m³ and 492 CFU / m³ exceeding the threshold according to the American Conference of Governmental Industrial Hygienists (ACGHI). The magnitude of potential health risks, especially puskesmas, can threaten the health of officers, patients and the community. The purpose of this study was to determine the magnitude of the risk of exposure to airborne

germs on the health of health center staff.

Method: This research is an analytical study using Microbial Risk Assessment (MRA) method. The sample in this study is the general BP room and KIA-KB room in 13 health centers with a sample of 96 respondents at risk. Concentration of airborne germ numbers was measured using a MAS eco 100 (Microbial Air Sampler) tool. Sampling was carried out with an air volume of 200 liters / minute for 5 minutes according to MAS standards in March - May 2020. Samples were examined at the Semarang City Health Laboratory.

Results: The results showed 44 sample points (42.72%) exceeded the standard threshold required by ACGHI which is 500 CFU / m³. Concentration of airborne germ numbers exceeds the threshold at the Bugangan Public Health Center, Ngemplak Simongan, Karangmalang, Miroto, Purwoyoso and the Gunungpati community health center. Concentration of the number of germs that enter the body of the respondents ranged from 4.69 CFU / kg / day to 23.82 CFU / kg / day. From the MRA calculation the risk characteristics (HQ) values obtained in 13 HQ health centers > 1 with a 9x10⁻¹ probability of infection or 9 cases of infection per 10 people.

Conclusion: The results obtained by the level of risk of airborne germ count HQ > 1, it shows that the risk agent is said to be unsafe and risk to the health of officers

Keywords: Air Germ Figures, Community Health Centers, Microbial Risk Assessment

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INTRODUCTION

Health service facilities are places that are used to carry out health service efforts in a promotional, preventive, curative and rehabilitative manner carried out by the government, regional government and the community. The Community Health Center is one of the health service facilities that serves as a center for health development, a center for fostering the role of the community in the health sector, as well as a first-level health service center that carries out overall activities in a particular area. A good Community Health Center must meet the requirements of adequate infrastructure and also the type of service in accordance with those contained in Permenkes No. 75 of 2014 concerning Community Health Centers. Environmental health requirements include health requirements for water, air, land, facilities and buildings (Regulation of the Minister of Health of the Republic of Indonesia, 2014).

The Community Health Center is a gathering place for healthy people and sick people, so that it has the potential to become a place for disease transmission. Transmission of the disease can be influenced by the presence of germs in the air. The magnitude of potential health risks in health facilities, especially community health centers, can threaten public health, it is necessary to improve the facilities and buildings of Community Health Centers in creating a healthy environment, and can provide protection for health workers, and patients. The Community Health Center as a public service facility is required to maintain and improve a healthy environment in accordance with standards and requirements.

In research on indoor factors, 52% of the building is not well ventilated, 17% is contaminated from inside the building, 11% is contaminated from outside the building, 5% is contaminated by bacteria, 3% is contaminated by the building material itself and 12% of the problems are unknown. (Henry, 2016). Nosocomial infections are obtained from the facilitation of health services and one cause of death. The prevalence of HAIs is estimated at 1.4 million deaths every day worldwide. Based on data from the World Health Organization (WHO) deaths due to HAIs 1.5 to 3 million people each year (Syahputri, 2015).

Indoor air quality is a problem that needs attention because it affects human health. Air quality that does not meet the requirements is proportional to the number of germs in the room. In accordance with Regulation of the Minister of Health of the Republic of Indonesia No. 7 of 2019 concerning Environmental Health of Hospitals (Regulation of the Minister of Health of the Republic of Indonesia, 2019), in the index of germ numbers according to the function of the room or unit in a colony forming unit (CFU / m³) in an empty operating room of 35 CFU / m³ and the operating room there activity of 180 CFU / m³.

Semarang City as the capital of Central Java Province has 37 parent Community Health Centers consisting of 10 inpatient Community Health Centers and 27 outpatient Community



Health Centers. The results of a preliminary study conducted in September 2019 at one of the inpatient Community Health Centers showed that the number of germs in the waiting room was 945 CFU / m³, the general BP was 2575 CFU / m³, and in the inpatient room was 492 CFU / m³, the concentration This exceeds the threshold set according to the American Conference of Governmental Industrial Hygienists (ACGHI) (Environmental Protection Agency, 2003). Based on the above problems, researchers are interested in analyzing the risk of exposure to germ rates on the health of Public Health Center staff using the Microbial Risk Assessment (MRA) method.

METHOD

The research design used in this study is Observational. In determining the amount of microorganism concentration (germ count) in the air through the inhalation route, it is carried out using a Microbial Risk Assessment (MRA) design. The time of the study was conducted in March - May 2020. The sampling place was the general examination room and health and maternal and child health clinic at each Community Health Center. The choice of location is because these are often visited by patients and patients who enter not only from one disease. Sampling of germ numbers using the MAS-100 Eco Air Sampler tool. Sampling was carried out with an air volume of 200 liters / minute for 5 minutes according to MAS standards.

The sample size of respondents in this study 96 samples of officers at 13 Community Health Centers. Sampling of germ numbers was conducted at 103 sample points based on the area of the room. If the area of the room is m² 9 m², the sample points taken are 3 sample points. Whereas if the room area > 9-100 m² the number of samples is 4 sample points with a horizontal cut point.

The MRA draft consists of 4 steps including hazard identification, risk assessment, risk management, and risk communication.

RESEARCH RESULT

1. Risk Agent Concentration

The results of measurements of airborne germ numbers at each sampling location are shown in table 1. Some locations obtained results exceeding the standards required by ACGHI which is 500 CFU / m³. Sampling was carried out at 103 sample points at 13 Community Health Centers, from the results of germ measurement the 44 sample points (42.72%) exceeded the threshold and 59 sample points (57.28%) met the threshold. The highest concentration of germ is 5,190 CFU / m³ at Karangmalang Community Health Center



Table 1. Distribution of Measurement Results for Air Germs

Sampling Location (Community Health centers)	Germs Measurement Results			
	≤500 CFU/m ³	%	>500 CFU/m ³	%
Karangdoro	8	100	0	0
Bugangan	2	28,57	5	71,43
Kagok	5	62,5	3	37,5
Lebdosari	7	87,5	1	12,5
Ngemplak Simongan	2	25	6	75
Karangmalang	0	0	8	100
Kedungmundu	6	75	2	25
Miroto	4	50	4	50
Purwoyoso	6	75	2	25
Gunungpati	2	25	6	75
Ngesrep	8	100	0	0
Pandanaran	4	50	4	50
Karangayu	3	37,5	5	62,5
TOTAL	59	57,28	44	42,72

2. Microbial Risk Assessment (MRA)

Biological agent risk assessment is often referred to as microbial risk assessment (MRA) will provide an overview of the likelihood or probability of a disease due to exposure to microorganisms and the influence of pathogenic microorganisms on human health. This risk assessment consists of four steps namely hazard identification, hazard characteristics, exposure studies and risk characteristics.

a. Hazard Identification

The air microbiological parameter that is often used is the number of airborne germs. The number of airborne germs is total, including all germs in the air. Microorganisms will come out of the host (human or animal), through coughing, sneezing, dry body fluids or due to spores (fungi). The spread of microorganisms in the air can stick to two media, namely solid particulate matter (dust) and water, which can occur indoors or outdoors.



Germes that are spread in the air will cause infection. Microbiological contamination can cause serious health problems, known as hypersensitivity pneumonitis. Air quality in the room greatly affects the comfort of the occupants of the room. In addition to ARI, the presence of microbiological contamination (bacteria, fungi and viruses) in the air can cause sick building syndrome (Environmental Protection Agency, 1991). Physical symptoms associated with biological contamination are coughing, chest tightness, fever, muscle aches and allergies in the upper respiratory tract. It is estimated that the number of bacteria in a single sneeze ranges from 10,000 to 100,000 with particles in the size range $<1\mu\text{m}$ to $\geq 50\mu\text{m}$ (Syahputri, 2015). In table 1 it can be seen that 42.72% of the concentration of germ exceeds the threshold while 57.28% of the concentration of germ meets the threshold set by the American Conference of Governmental Industrial Hygienists (ACGIH) (Rao & Chang, 1996) of 500 CFU / m³

b. Exposure Assessment

Exposure analysis is intended to recognize risk agent exposure pathways so that the number of microorganisms inhaled by individuals in the population can be calculated. Exposure and risk assessment can be evaluated based on the equation model developed by the USEPA (US Environmental Protection Agency) with the following equation (Yang, Lin., Wang, Xue Song, Han & Liu, 2019)

$$\text{ADD inh} \left(\frac{\text{CFU}}{\text{kg. hari}} \right) = \frac{\text{C} \times \text{IR} \times \text{EF} \times \text{EDinhalasi}}{\text{BW} \times \text{AT}}$$

Table 2. Calculation of Risk of Exposure and Chances for Infection

Community Health centers	ADDinh (CFU/kg/hari)			P _{inf}			HQ		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Karangdoro	0,24	12,89	6,11	0,19	0,99	0,96	0,06	3,06	1,44
Bugangan	0,02	72,85	12,30	0,02	1,00	0,99	0,00 5	17,2 6	2,92
Kagok	0,00	36,59	7,70	0,00	1,00	0,97	0,00	8,68	1,83
Lebdosari	0,43	37,17	6,68	0,31	1,00	0,96	0,10	8,81	1,58
Ngemplak	0,01	115,1	19,24	0,01	1,00	1,00	0,00	27,3	4,56
Simongan		9					2	1	
Karangmalang	1,77	101,4	23,82	0,72	1,00	1,00	24,0		5,64
		6					0,42	6	
Kedungmundu	0,00	34,87	9,38	0,00	1,00	0,98	0,00	8,26	2,22



Miroto	0,00	25,87	8,79	0,00	1,00	0,98	0,00	6,13	2,08
Purwoyoso	0,28	70,48	10,26	0,22	1,00	0,99	0,07	16,7	2,43
Gunungpati	0,54	46,55	19,43	0,36	1,00	1,00	0,12	11,0	4,61
Ngesrep	0,03	19,09	4,69	0,03	1,00	0,93	0,00	7	4,53
Pandanaran	0,15	34,68	10,15	0,12	1,00	0,99	0,04	8,22	2,41
Karangayu	0,31	14,51	5,07	0,24	0,99	0,94	0,07	3,44	1,20

Table 2 illustrates the risk of exposure and the probability of infection due to exposure to airborne bacteria. The average daily concentration that enters the body (ADD_{inh}) must consider various factors such as the level of inhalation (rin), the time of exposure (t_{exp}), and the concentration of air in the air (Carducci, Donzelli, Cioni, Federigi, Lombardi, & Verani, 2018). Concentration of the number of germs that enter the body at each Community Health Center (ADD_{inh}) ranges from 4.69 CFU / kg / day to 23.82 CFU / kg / day. The highest concentration of bacteria entering the body is found in Karangmalang Community Health Center while the lowest concentration is in the Ngesrep Community Health Center.

c. Response Dose Analysis

In the MRA the most important part is the appropriate dose response model for estimating infections caused by exposure to risk agents. Exposure to infectious agents can be calculated with the Beta-Poisson equation below

$$P_{inf} = 1 - \left(1 + \frac{\text{dose}}{\eta}\right)^{-r}$$

The probability of infection is interpreted as the likelihood that many people are infected in the population. Seen in table 2 the results of the calculation of the probability of infection at the Community Health Center are 9×10^{-1} cases of infection or as many as 9 out of 10 people have a chance of being infected by airborne germs. The opportunity value of this model can vary due to the virulence factor of microorganisms, the ability of colonization and the human immune status.



d. Risk characteristics

The determination of risk characteristics is the final stage in determining risk assessment. The amount of risk (HQ) due to exposure to microorganisms is categorized as non-carcinogenic with the following equation

$$HQ = \frac{ADD}{RfD}$$

Table 2 shows HQ values > 1 at 13 Community Health Centers. The highest average HQ is at Karangmalang Community Health Center. Risk level (HQ) exposure to airborne germ figures at Community Health Centers is said to be unsafe for the health of the sample population. By using the recommended RfD value based on ACGIH of ≤ 500 CFU / m³ per day, the risk level of exposure to airborne germ count (HQ) is obtained HQ value > 1 at all locations, it shows that the concentration of air germ number risk agents is at risk to the health of the sample population .

DISCUSSION

The results of air germ measurement are influenced by environmental factors. Environmental factors measured include temperature, relative humidity, and area of the room. In table 1, 42.72% concentration of bacteria exceeds the threshold determined by the American Conference of Governmental Industrial Hygienists (ACGIH). Temperature and relative humidity are two important factors that determine the viability of microorganisms in aerosols. The relationship of temperature with the number of airborne germs shows a positive correlation, is the higher the air temperature in the room the higher the number of airborne germs in the room (Septiana, 2018) . Bacterial species can grow in a wide temperature range. Favorable environmental conditions will make bacteria grow well. Environmental factors measured in this study include temperature, relative humidity, and area of the room (Rajasekar & Balasubramanian, 2011). Based on the results of measurements of air temperature at the time of sampling, the recorded air temperature ranged between 22.6 ° C - 32.0 ° C. The optimum temperature for the growth of airborne germs is 37 ° C, the optimum temperature will cause microorganisms to be comfortable to live. According to the Regulation of the Minister of Health of the Republic of Indonesia No 7 of 2019 concerning Environmental Health of the Hospital air quality standards 22-23 ° C (Regulation of the Minister of Health of the Republic of Indonesia, 2019), then the air temperature measured when sampling has passed the standard for the treatment room.

In addition to temperature, humidity will affect the presence of microorganisms in the air. From the results of humidity measurements carried out ranged from 46% to 84% with an average



humidity of 60.64%. High humidity will increase the growth of microorganisms (Wouters & Delmotte, 2005). Relative humidity above 60% can cause the proliferation of pathogenic organisms and allergen organisms (Wouters & Delmotte, 2005).

Microbiological air pollution in the space occurs because the biological amount which includes the number of fungi and bacteria exceeds the maximum allowable limit, thus potentially causing various health problems and diseases. High microorganism content in the air can cause asthma and rhinitis, pneumonia and sick building syndrome (Hoseinzadeh, Samarghandie, Ghiasian, Alikhani, & Roshanaie, 2013).

Exposure assessment is intended to determine the pathways of risk agent exposure so that the number of microorganisms inhaled by individuals in the population can be calculated. The greater the concentration of germ the higher the number of microorganisms that enter through the inhalation pathway. In table 2, the concentration of germs that enter the body (ADDinh) is differentiated based on the location of the Community Health Center, ADDinh values range from 4.69 CFU / kg / day to 23.82 CFU / kg / day. The lowest ADDinh value was found in the Ngesrep Community Health Center and the highest ADDinh was in the Karangmalang Community Health Center. Concentration of germ count in Karangmalang Community Health Center is higher than concentration of germ in other Public Health Centers. This can be influenced by high temperature and humidity that affect the proliferation of organisms. In addition to temperature and humidity factors, the breed of organisms can also be caused by biological environmental factors, namely the number of patients, deliveries and officers who are in the room. Besides the entry and exit of patients in the examination room can cause microbes from outside the room to enter (Unimus, 2009).

In determining the probability of infection due to exposure to the number of germs carried out using the Beta-Poisson model is presented in Table 2. The probability of infection means the number of possible people infected in a population. Calculation results obtained 9×10^{-1} infection chance or as many as 9 people have a chance of being infected from 10 cases assuming the amount of contamination is 4.69 CFU / kg / day - 23.82 CFU / kg / day. Exposure to bacterial numbers of 4.69 CFU / kg / day up to 23.82 CFU / kg / day by inhalation to health workers at the Community Health Center, was declared unsafe for frequency of 235 days / year exposure. The recommended probability of infection is 1×10^{-6} , this means that 1 case is infected per 1,000,000 people. The danger of exposure through inhalation is more risky 10 (Environmental Protection Agency, 1991) than skin contact (dermal) for children and adults (Li, Zhang, Qiu, Zhang, & Wang, 2013).

Air pollution due to microbiology is categorized as a non carcinogenic effect. The level of risk (HQ) in this study is $HQ > 1$, it shows that risk agents are said to be unsafe and risk to the health of officers. Epidemiological findings state that the immune system response can protect



against allergic microbiological pollutants (Hulin, Simoni, Viegi, & Annesi, 2012). So far there is no reference dose (RfD) for microbes. This is because it is not easy to conduct a risk assessment of microorganisms (Li, Zhang, Qiu, Zhang, & Wang, 2013). Based on epidemiological studies from several studies proposing a recommended RFD value of ≤ 500 CFU / m³ per day (Sigsgaard, Bach, & Malmros, 1990).

Risk management is a must if $HQ > 1$. Risk management basically manipulates the dose value so that it is the same as the RfD value. So that the intake value is the same as the RfD value, it can be done by decreasing the concentration (C). Risk management can be done in 2 ways. The first is reducing the concentration of germ until the safe limit of concentration. The second is to reduce exposure time both daily exposure and the frequency of annual exposures.

The magnitude of the risk of exposure to germ numbers is an important concern. Ways that can be done to reduce the number of germs through a process (chemical or physical) that is used to kill all life of microorganisms (Director General of PP and PL Ministry of Health, 2012). The efforts made by the Semarang City Public Health Center in suppressing the number of airborne germs include cleaning and disinfecting. Cleaning activities carried out 2 times a day, namely before service and after service. Because rooms that have not been cleaned have a 2.7 times risk of contamination compared to rooms that have been cleaned (Lee, Berkheiser Jiang, Heckett, Brenda, Hachem, Chemaly, Raad, 2007). In addition to reducing the concentration of airborne germs, it can be done by using a HEPA (High Efficiency Particulate Air) filter to filter out airborne particles and bacteria so that the presence of germ numbers can be minimized.

CONCLUSION

Based on the results of the research that has been done, it can be concluded that the concentration of air pollution in the room at the Community Health Center 42.72% exceeds the threshold set by the American Conference of Governmental Industrial Hygienist (ACGIH).

Concentration of the number of germs that enter the body ranges from 4.69 CFU / kg / day to 23.882 CFU / kg / day, with a probability of infection 9 people infected from 10 cases. While the HQ results obtained are $HQ > 1$ it shows that the agent is noisy towards the health of officers.



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