A Case Study of Utilizing Bio Sterilizer in a Hospital to Reduce Bacteria Density

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Abstract. Bacteria live and grow anywhere, especially in hospitals as a place of patient care. An infected person, when coughing and touching objects, will deliver the transmission to the surrounding environment. Air is a potential means for viruses and bacteria to act as intermediaries for the transmission of various diseases. Currently, many air purifiers have been manufactured and are expected to be able to suppress the growth of viruses and bacteria to minimize the potential for transmission. The study's goal was to see how effective a biosterilizer was at reducing bacterial loads in hospital treatment rooms after it was activated. The study inspected the indoor air quality of the internal medicine room and the emergency unit in Linggajati Hospital, Kuningan Regency. The examined parameters were PM10 particles, viral load, and bacterial load as determined through air sampling and the swab method at 27 points, both before and after placing the bio sterilizer. Samples were examined in the laboratory, and the concentration of airborne particles was tested by a multifunction air quality detector. Interviews were also conducted with hospital staff and patients regarding the benefits of this sterilizer. The analysis was carried out by assessing the difference in air quality before and after the placement of the biosterilizer. The results of the study showed that 24-h operation of a biosterilizer may reduce bacterial density by about 50% but is ineffective for reducing airborne particles (PM 10). According to officers and patients, the placement of the biosterilizer has a positive psychological impact and improves the condition of the room, reducing complaints of pain. Hospitals and other health-care facilities may want to consider using a biosterilizer to improve indoor air quality and provide better services.

Keywords: bacterial load · biosterilizer · indoor particles

1 Introduction

In early 2021, the COVID-19 cases in Indonesia tended to increase every day. In October, the COVID cases started to decrease. There were 4.233.014 cases recorded with 142.889

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deaths in 34 provinces, and DKI Jakarta, West Java, and Central Java accounted for the highest number of cases [1]. This case will continue to increase with low prevention.

Infected people can transmit the virus, which can spread from them to other people [2]. The droplets would spread out and then stick to the wall or other things. The transmission occurs when the droplets enter the body through the mouth, nose, and eye, either directly or through intermediate things. Information from the COVID-19 pandemic indicates that the virus is spreading more efficiently than influenza [2]. Vaccination is expected to prevent the spread of COVID-19.

Health workers are at a very high risk of contracting COVID-19. As of December 2020, 369 health workers [202 doctors, 15 dentists, and 142 nurses] had died from being infected with COVID-19 [3]. The potential for infection will be even greater if the number of cases also increases. As front-line caregivers, health workers must prioritize their own health and safety. In addition to nutritious food and supplements, they also need a healthy work environment [4].

A health service with good lighting and ventilation is expected to minimize the chain of transmission between the health workers and patients [4, 5]. A limited space results in increased patient density and accelerated transmission, especially if the patients and health workers do not comply with health protocols [6].

Disinfection Sterilization An air purifier is a tool that functions to clean and kill indoor air viruses. It also functions as an ionizer to remove some bad particles from the air. The result of laboratory testing found that the tool can suppress the growth of bacteria and fungi [7, 8]. However, the benefit of reducing the number of indoor germs is not yet known [9].

The effectiveness of a bio sterilizer in cleaning indoor air will be influenced by the area, the distance from the air purifier, and the condition of the room, such as; humidity, lighting, air circulation, the initial density of the viruses and bacteria, and the concentration of particles.

This article informs readers about the effectiveness of bio sterilizers in improving indoor air quality. Biosterilizers are expected to be a solution for assisting patient care by providing cleaner indoor air. The National Institute of Health Research and Development (HREC-NIHRD) has conducted research that aims to prove the effectiveness of the tool, which is supported by ethical clearance approved by the Health Research Ethics Committee, Number LB.02.01/2/KE.400/2021.

2 Material and Methods

This study was conducted in a quasi-experimental method in Linggajati Hospital, Kuningan Regency, for seven months, starting in May and ending in November 2021, and data collection was done in October 2021. The main variables in this study are bacterial load, virus load, airborne particles, and patient and health worker perceptions.

The concept of this research was based on the benefits of bio-sterilizers in the treatment room. Before the air purifier activates, the concentration of particles, germs, and bacteria is supposed to be higher. The effectiveness of a biosterilizer is strongly influenced by the active time and distance of microorganisms from the device. An overview of the conceptual framework is as follows: To find out the presence of the virus, we

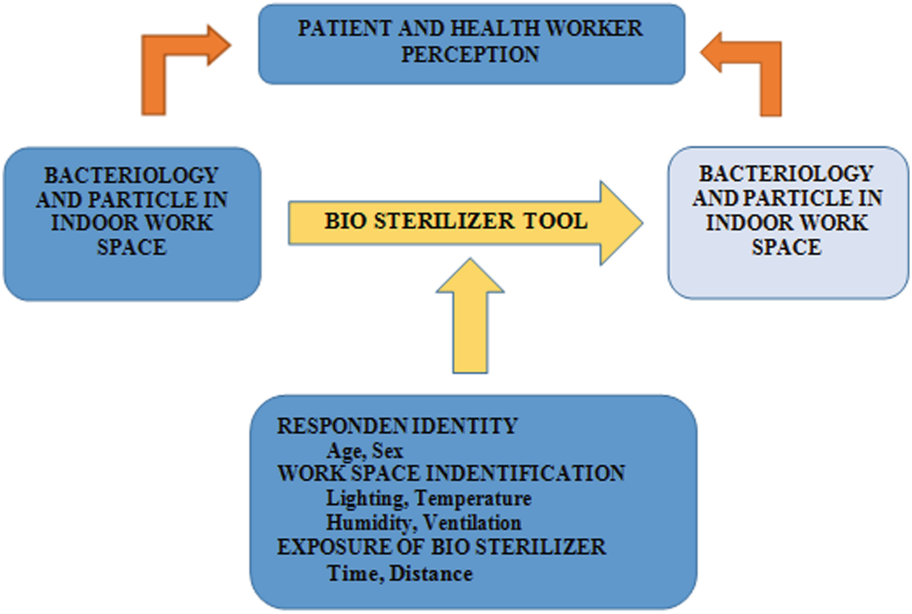

Fig. 1. Conceptual framework

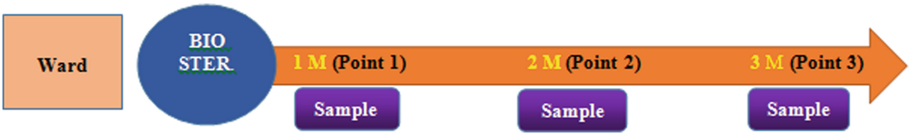

Fig. 2. Sampling location

swabbed the media in the treatment room (handles, walls, and existing equipment) and then examined it in the laboratory of the Faculty of Medicine, Swadaya Gunung Jati University, Cirebon, using the ribonucleic acid (RNA) method followed by a polymerase chain reaction (PCR) test (WHO, 2020) [2, 9, 10] (Fig. 1).

The presence of bacteria was determined using a Microbiological Air Sampler (MAS) by capturing air passed through a Petri dish containing Plate Count Agar (PCA). Samples from Petri dishes were incubated for 18–24 h at 350–370 °C. The growth of bacterial colonies was examined using a colony counter [11]. Sampling was done at 1 m, 2 m, and 3 m from the biosterilizer, Fig. 2.

In accordance with the treatment at the hospital, 9 units of bio-sterilizer were placed in 3 treatment rooms [12]. First, in the internal medicine room. This room is for patients with COVID-19 symptoms who are subjected to rapid antigen tests. There are 6 beds and 3 devices tested in this room. Second, in internal medicine room 2. This room is for suspected COVID-19 patients who are waiting for PCR test results. There are 14 beds and 3 devices tested in this room. The last three devices were placed in the emergency unit.

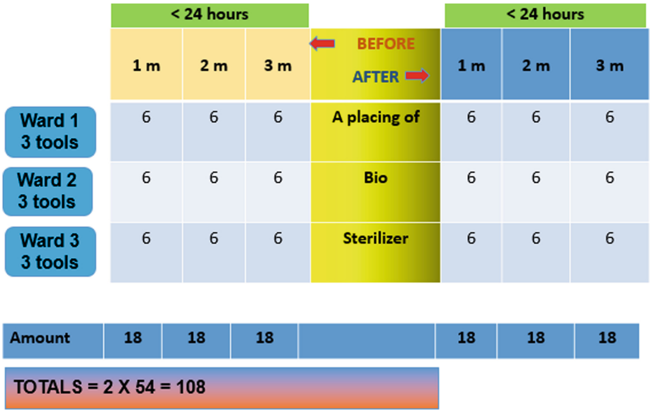

Fig. 3. Total air samples

Sampling was carried out in duplicate at each point by laboratory staff in Linggajati Hospital, Kuningan. Here are the details as shown in Fig. 3.

The air purifier used in our experiment has a 20 cm × 20 cm width and 40 cm height. It was supplemented with a grounding cable and left powered on for more than 24 h. Its internal components consist of both an air-sucking fan and an exhaust system. Inspection of particulate matter-10 (PM10) air particles, lighting, temperature, and indoor humidity is carried out using a digital multifunction air quality detector. The measurement location is in the center of each room.

We conducted an interview using a structured questionnaire to explore the perceptions of patients and health workers regarding indoor air quality in the presence of biosterilizers [11, 12]. The respondents were all the staff and patients in the room during the study. The respondent consists of patients, three duty-scheduled nurses, and cleaning staff. Interviewers and respondents during the interview process follow health protocol procedures to prevent transmission of COVID-19.

The interviews were conducted before and after placing the biosterilizer. The total sample consisted of 47 respondents. Overall, the respondents in the treatment room are as follows: a)Level 1 treatment room, with as many as 14 respondents (6 patients + 2 cleaners + 6 nurses), b) level 2 treatment room, with as many as 22 respondents (14 patients + 2 cleaners + 6 nurses) and c) Level 3 treatment room with 11 participants (3 patients + 2 cleaners + 6 nurses). Patients with severe symptoms, patients on ventilators, and new patients are excluded from the survey.All interviewers were trained to equalize their perception of the data and the procedures for conducting interviews. Before the interview, the interviewer explained the aim of the research, the benefits and risks of participating in it, and asked for their consent.

During the study, we kept following health protocols such as wearing masks, keeping our distance, frequently washing our hands with soap, or using hand sanitizers. Furthermore, the researcher participating in this study must be healthy, free of COVID-19 infection, and vaccinated. If contact happened with a COVID-19 patient, the researchers should have a PCR test, and the handling is integrated with Linggajati Hospital. The hospital will also handle further testing if the PCR test results are positive for COVID-19.

3 Results

The results show that the lighting in each room comes from windows and lamps with intensities ranging from 124 to 167 lx. The room temperature ranges from 25 °C to 29 °C, and the humidity ranges from 66% to 80%. There is no air conditioner or air filter installed in the room. The internal medicine room has a closed design with only a door for access. Ventilation comes from an open window near the bed. The design of the emergency unit is connected to other rooms with higher ceilings to keep air flowing.

General cleaning of the room is carried out by the janitor starting at 7 a.m. It is done by sweeping and mopping the floor, while the cleanliness of walls and windows was not monitored during data collection. The air purifier has a strong build as it is coated with a metal plate, but it may not be attractive enough for room decoration.

Before the biosterilizer was activated, the SARS-CoV-2 virus was found on the wall located in internal medicine room 2 and on the surface of the trash can in an emergency unit. After 24 h of activation, no virus was found at the same location. However, a new virus was found at a different location.

The lower the bacterial load discovered, the closer the distance from the biosterilizer. By comparing the results before and after activation of the biosterilizer, the bacterial load decreased by 63% at 1-m distances, 40.2% at 2-m distances, and 39.8% at 3-m distances (Table 1).

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Table 1. Total Bacteria Number by Distance from Before and After Bio Sterilizer Active

Distance	Bacteria Number (CFU/m^3)						%Diff. Average	Total Sample
	Before			After				
	Min	Max	Average	Min	Max	Average		
1 M	44	1242	407	55	257	149	63,4	36
2 M	68	653	246	64	225	147	40,2	36
3 M	73	849	244	70	219	147	39,8	36

Table 2. Relation of bacterial load before and after activation of bio sterilizer by distance

Distance	*t*	*df*	*mean*	*SE*	*CI*		*p_value*
					Lower	*Upper*	
1 m	3,33	34	257,26	77,19	100,40 -	414,12	0,002
2 m	2,19	34	98,84	45,05	7,30 -	190,39	0,035
3 m	2,07	34	97,20	46,97	1,75 -	192,66	0,046

Table 3. Result of Examination PM10 Before and After Activation of Bio Sterilizer (p_value < 0,005)

Examination	Number of Minimum	Number of Maximum	Average	Total Sample
Before	41	45	42	18
After	47	52	50	16

Table 4. Perception of Respondents Before and After Activation of Bio Sterilizer (p_value < 0,005)

Complaint	Before		After	
	Count	%	Count	%
Yes	31	67,0	8	8,5
No	16	33,0	39	91,5
Total	47	100	47	100

Statistically, there was a significant difference in the mean of total bacteria before and after activation of the device (p-value < 0.05). The mean total bacterial difference decreased dramatically with increasing distance from the bio sterilizer, decreasing from 0.002 at 1 m to 0,035 at 2 m to 0.046 at 3 m (Table 2).

The result of the analysis shows that particle testing before and after activation of the tool presents a normal distribution. to find out the difference between before and after activation by using the t-test. Here are the results:

The concentration of PM 10 before placement of the device ranges from 41–45 g/m^3, with a mean of 42 g/m^3. After placing the device, it is slightly increased, ranging from 47 to 52 g/m^3 with a mean of 50 g/m^3 and counting a difference of 16% (Table 3). The lowest concentration was found in the emergency unit and the highest in the internal medicine room.

The results of the analysis showed that the variance of the data before and after the placement of the device was homogeneous, and there was a significant difference between the average PM 10 before and after the placement of the bio-sterilizer. The particulate concentration is higher once the device is switched on.

Prior to the activation of the bio sterilizer, two-thirds (67.0%) of respondents reported unpleasant indoor air. 59.6% of respondents stated that they feel a hot temperature, 14.9% feel humid, 17.0% feel less airflow, and 14.9% smell bad, while 33.0% state they have no complaints. Table 4. After activating the bio-sterilizer, the percentage of respondents experiencing indoor air complaints decreased by 74.2%.

4 Discussion

Air-borne diseases have a high potential to spread and to cause a pandemic. COVID-19 is an example of a disease that was still a problem in every country in the world until the end of 2021. At the beginning of 2019, COVID-19 started in Wuhan, China, and then spread to other parts of the world, including Indonesia [13]. In Indonesia, COVID-19 spread to all provinces in 510 districts, causing 1.827.303 cases and 55.940 deaths. From January to June 2021, COVID-19 cases kept increasing rapidly, resulting in a burden on hospitals [14].

Linggajati Hospital was not a reference hospital for COVID-19, but it became a referral hospital at a time when COVID-19 cases were high. Due to the limitations of hospital facilities, PCR examinations in the hospital were conducted in collaboration with another laboratory. Linggajati Hospital renovated its lung ward to be an isolation room to improve its service quality. The medical care ward can become a point of disease transmission, including COVID-19, because infectious bacteria can easily spread, especially in a room with poor hygiene [5, 7, 15]. Linggajati Hospital was still required to improve its infrastructure quality to reach health standards as described in Permenkes No. 7 issued in 2019 [16].

When the COVID-19 case reached its peak in June 2021, many hospitals, including Linggajati Hospital, received numerous referrals until the medical care ward was fully occupied. The case subsided in October 2021, with almost no COVID-19 patients being hospitalized. The decreasing cases were the result of a successful vaccination program and health protocol implementation, especially for the use of masks [17]·

The data collection in this study was conducted when there was no COVID-19 patient hospitalized in the ward. The SARS-CoV-2 virus was expected to be non-existent, but the examination result showed the existence of 2 viruses before and 1 virus after the activation of the biosterilizer. This finding indicates the potential for Covid-19 transmission by hospital visitors exposed to the SARS-CoV-2 virus but showing no symptoms and/or not reporting their condition, as suggested by the fact that no Covid-19 patient was admitted to the hospital seven days before the data collection activity. The SARS-CoV-2 virus multiplies and dies rapidly: it can survive two days on iron surfaces, four days on glasses, and five days on plastic [18]. Due to the small number of viruses that can be examined, we are unable to confirm whether the virus's existence was related to the activated bio-sterilizer.

The finding on the virus is closely related to ward hygiene [19]. Our data sampling was indeed performed after the schedule of indoor ward cleaning, but the cleaning staff did not perform a thorough cleaning as they were observed to miss disinfecting the walls, window glasses, and items placed inside the ward.

As for bacteria quantification, we examined samples from each colony. We found significant differences in the average number of bacteria before and after the sterilizer was activated. The average bacteria concentration was 244–407 before the sterilizer activation and 149–147 after the activation. Based on Permenkes No. 7 issued in 2019 about environmental health in the hospital, the recommended thresholds of microbial content are 180 CFU/m^3 for the in-use operating room, 35 CFU/m^3 for the unoccupied operating room, and 10 CFU/m^3 for an ultraclean operating room. The concentration of airborne bacteria found in this study is much higher than the recommended numbers [16, 19].

A high concentration of bacteria in the air increases the risk of infection as many harmful bacteria can live there, such as Staphylococcus aureus, Staphylococcus p., Neisseria m., Corynebacterium diphtheriae, hepatitis B virus, and cytomegalovirus [20]. The concentration of bacteria indoors can be suppressed by improving room conditions through better hygiene, lighting, and ventilation, and by maintaining optimum room temperature and humidity [4]. Utilizing hospital cleaning staff for thorough cleaning, activating the air conditioner, and regularly monitoring temperature and humidity are some actionable routines to suppress indoor bacteria concentration.The installation of an air purifier is another thing to consider [20]. We found the total bacteria count was reduced upon biosterilizer activation, and the most significant reduction in concentration was located near the air purifier. The reduction was found to be effective within a 3-m radius of the air purifier.

Unfortunately, the air purifier "Bio Sterilizer" is ineffective at reducing PM10 particulate matter concentrations, as the PM10 concentration was found to be higher after activating the purifier (Table 3). This finding shows the opposite result from what was expected based on the device's functional specification. The captured concentration only represents a one-time measurement, which is not comparable to the standard particulate concentration obtained from 8 or 24-h observations. Regardless, our examination result on the particulate concentration should be able to provide an overview of the air quality inside the medical care ward.

The increasing PM concentration found in our examination may have been caused by a missing or dysfunctional air filter when the air was being sucked into the device. Some enhancements that may be required before using the air purifier cover improvements in the visual design and air filtering function.

Based on our examination, both hospital staff and patients supported the usage of air purifiers inside the medical care ward. The existence of an indoor air purifier gave the perception of better indoor air quality, especially when the device was activated, and it could also help alleviate the symptoms in patients.

5 Conclusion

The air purifier "Bio Sterilizer" helps reduce the number of bacteria inside the medical care ward, although it is inefficient in reducing the concentration of particulate matter. Both medical staff and patients expect to have better indoor air quality in the medical care wards, and the usage of air purifiers will help to achieve this aspiration. The hygiene of the flooring and items in the medical care unit should be maintained under strict control. Indoor air quality inside the medical care unit should be inspected regularly as well.

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