Room sterilization using ultra violet lamps in reducing the air germs number of tuberculosis patients' house

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Abstract

Mycobacterium Tuberculosis can survive in the air, with its ability depending on environmental factors such as Ultraviolet (UV) light. UV light can be generated from sunlight or UV-C lamps, which are utilized for air germ sterilization. This study aimed to assess the efficacy of room sterilization using a UV lamp in reducing airborne germ counts. This experimental research took place from March to September 2023 and employed a one-group pretest-posttest design. The research was carried out in 21 houses of tuberculosis patients in Kupang City. The intervention involved the use of 16-watt and 20-watt UV lamps in two rooms of each house. The variable measured was the airborne germ count, assessed by examining the Most Probable Number (MPN) coliforms, both before and after sterilization (UV light irradiation), calculated through laboratory examination. The collected germ count data were then statistically analyzed using the paired t-test. Room sterilization using a 16W UV lamp effectively reduced the number of room germs (p 0.046<0.05). Similarly, room sterilization with a 20W lamp significantly reduced the number of room germs in the households of tuberculosis patients (p 0.004<0.005). Ultraviolet lamps can be employed for sterilizing rooms in the homes of tuberculosis patients, particularly in cases where sunlight cannot penetrate the house. These lamps can eliminate airborne germs, thereby reducing their count and the risk of disease transmission within the household.

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Patient consent for publication: the patient signed the form that they were required to fill out as proof that they are aware of and knowledgeable about the data collected by the researcher.

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Introduction

Tuberculosis (TB) is an infectious disease caused by the bacterium Mycobacterium tuberculosis, which enters the body through the respiratory tract.[1] Tuberculosis remains a global public health issue, both worldwide and in Indonesia.[2] Globally, approximately 10 million people were affected by the disease, resulting in 1.4 million deaths in 2019, while morbidity rates reached 9.6 million and mortality rates were estimated at 1.4 million in 2021, with the potential for annual increases. India, Indonesia, China, the Philippines, Pakistan, Nigeria, Bangladesh, and South Africa collectively account for two-thirds of TB cases worldwide, and they are all classified as lower-middle-income countries.[3–5] In Indonesia, TB cases have reached 1,000,000, with a persistently high number of annual deaths.[6] In Kupang City itself, the number of pulmonary TB cases for 2018, 2019, and 2020 were 670 cases, 667 cases, and 522 cases, respectively.[7]

Several factors contribute to TB transmission within communities, involving TB germs, individual factors, and environmental conditions.[8,9] The conditions of houses, including factors like humidity, temperature, lighting, ventilation, housing density, and the number of house floors, are also associated with the incidence of TB transmission, serving as determining factors in the presence of TB germs within people's homes.[10–13] Behavior has also been demonstrated to be linked to the incidence of TB transmission within the community.[14,15]

Wearing a mask or covering your mouth/nose when coughing/sneezing, as well as washing your hands with soap and running water, can be employed as measures to prevent the incidence and transmission of TB.[6] Case detection and consistent, comprehensive treatment must be pursued to break the chain of TB transmission. Implementing clean and healthy living habits, enhancing community nutrition, and administering the BCG vaccine are also necessary to bolster the body's resistance to TB transmission.

Environmental factors significantly influence the presence of TB germs.[9,11] This is also the case in Kupang City, where ventilation conditions are associated with the incidence of Tuberculosis, with an Odds Ratio (OR) value of 16.3. This implies that a house with inadequate ventilation increases the risk of its occupants getting infected with Tuberculosis by 16.3 times compared to the occupants of well-ventilated houses. Similarly, residents of houses with insufficient lighting face a 4.5 times higher risk of contracting tuberculosis than residents of well-lit houses.[13] Therefore, it is necessary to intervene against environmental risk factors to reduce the risk of TB transmission in the community, particularly to family members in the patient's house.[9] This data can be used to assess the effectiveness of UV lamps in sterilizing rooms in the homes of TB patients, reducing the number of airborne germs and lowering the risk of TB transmission. This study aims to determine the effectiveness of room sterilization using Ultraviolet Lamps in reducing the number of airborne germs in the homes of Tuberculosis patients in Kupang City.

Materials and Methods

This research follows a quasi-experimental design with a one-group pretest-posttest design. It was conducted in Kupang City, with the target population comprising all TB patients in the city. The research sampled 21 houses of TB patients, with one sample from each house taken before and after the intervention involving irradiation using 16W and 20W UV lamps.

The variable measured is the number of airborne germs, assessed by examining MPN coliforms before and after sterilization, calculated based on laboratory examinations. According to the Decree of the Minister of Health of the Republic of Indonesia No. 1077/Menkes/Per/V/2011, the acceptable standard value for indoor air germ numbers is <700 CFU/m³.[16] All primary data were collected directly through measurements and experiments in the homes of TB patients. Determining 21 Tuberculosis patients's homes where intervention would be carried out in the form of UV lamp sterilization; Determining two rooms frequently used for activities by tuberculosis sufferers with different areas in each house; Designing an ultraviolet sterilizer using UV lamp power (16 W and 20 W); Measuring air germ numbers before sterilization in selected homes using Microbial Air Samplers; Carry out sterilization with varying lengths of time: 60 minutes for two rooms for each 16W and 20W; Measuring the air germ count after sterilization using Microbial Air Samplers; test the difference in germ numbers before and after sterilization using a UV lamp; and create a final research report. To prevent the negative impact of using UV lamps when installing them in each room, it is important to wear protective glasses, or use a long cable from each UV lamp and plug it outside the room. There must be no people, animals or plants in the room while sterilization is being carried out in the room.

Data from the survey of TB patients' homes were statistically analyzed using a paired t-test to determine the effectiveness of reducing the number of airborne germs after intervention with different types of lights. The research has obtained ethical approval from Poltekkes Kemenkes Kupang, with Number LB.02.03/1/0008/2022, dated March 4, 2022. Throughout the research, the researcher adheres to ethical principles related to informed consent, respect for human rights, beneficence, and nonmaleficence.

Results

This research was conducted in 21 homes of tuberculosis sufferers by measuring the number of airborne germs in bedrooms and other rooms often used for family gatherings. The germ counts were assessed before and after the room sterilization intervention using an ultraviolet (UV) lamp. The lamps used were of 16W and 20W.

Table 1 indicates that the average number of germs before room sterilization using a 16W ultraviolet lamp was 206.19 CFU/m3, while after the intervention, it decreased to 129.81 CFU/m3. The results of the normality test showed that the germ numbers before and after the intervention using a 16W UV lamp did not follow a normal distribution, so the bivariate test employed the non-parametric Wilcoxon test.

Table 2 indicates that the average number of germs before room sterilization using a 20W ultraviolet lamp was 273.90 CFU/m³, while after the intervention, it decreased to 134.76 CFU/m³. The results of the normality test showed that the germ numbers before and after the intervention using a 20W UV lamp did not follow a normal distribution. Therefore, the non-parametric Wilcoxon test was used in the bivariate test to assess the difference in room germ numbers before and after sterilization.

Table 1. Room air germ numbers before and after sterilization using a 16W UV Lamp in houses of tuberculosis patients in Kupang City.

Intervention	Mean	Min-Max	SD	N	Median	Uji Shapiro-wilk (p)
Pre 16Watt	206.19	15-525	159.42	21	130.00	0.049
Post 16Watt	129.81	5-508	161.74	21	68.00	0.000

Table 2. Room air germ numbers before and after sterilization using a 20W UV lamp in houses of tuberculosis patients in Kupang City.

Intervention	Mean	Min-Max	SD	N	Median	Uji Shapiro-wilk (p)
Pre 20Watt	273.90	45-690	144.60	21	293.00	0.609
Post 20Watt	134.76	10-370	114.69	21	93.00	0.007

Table 3 reveals that after the intervention involving room sterilization using 16W lamps, 17 rooms exhibited a decrease in the number of air germs, while in 4 other rooms, there was an increase in the number of air germs. Statistically, this remains significant with a p-value of 0.046 or $p<0.05$, signifying that room sterilization using a 16W UV lamp effectively reduces the number of room germs. Furthermore, Table 3 demonstrates that room sterilization using 20W lamps reduced the number of room germs in the houses of tuberculosis sufferers in 19 houses. Conversely, in 2 houses, there was an increase in the number of germs. According to non-parametric tests, sterilizing the room using a 20W UV lamp is statistically effective in reducing the number of room germs ($p=0.004<0.05$).

Discussion

Tuberculosis remains a significant global health concern, affecting not only the world but also Indonesia and East Nusa Tenggara (NTT) Province. It is one of the infectious diseases that pose a public health challenge. Pulmonary TB results from the clinical manifestations of bacterial infections caused by Mycobacterium tuberculosis. Mycobacterium tuberculosis (Mtb) is a metabolically versatile bacterium with the ability to switch to alternative pathways when exposed to drugs or stresses, enabling its survival and long dormancy periods. This disease is easily transmitted through the air via the splashes of saliva or phlegm from patients who are TB-positive and carry the bacteria TB.[17–19] The environment plays a substantial role in the spread of Tuberculosis, categorizing this disease as environmentally based. It is essential for the public to have a better understanding of the methods of transmission and prevention of Tuberculosis (TB).[20] This understanding could potentially contribute to reducing the number of TB cases and preventing an increase in its prevalence.

This research aims to measure the general count of airborne germs, evaluating whether they adhere to the stipulated standards, specifically if they fall below the standard value (<700 CFU/m^3) or exceed it (>700 CFU/m^3). This study does not encompass the identification of specific germ types present in the air, such as Mycobacterium tuberculosis, pathogenic germs, or non-pathogenic germs. The requirement for the presence of pathogenic biological germs in the air within a household is 0 CFU/m^3.[16,21]

Various types of germs and viruses can experience growth inhibition or even destruction when exposed to sunlight, including Tuberculosis germs and the SARS-CoV-2 virus. Sunlight can contribute to suppressing the growth and survival capabilities of germs outside the human body, thereby reducing the risk of Tuberculosis transmission.[22] The effectiveness of UV radiation, whether from sunlight or lamps, is contingent on the specific molecules it encounters. UV light can only affect exposed surfaces or areas. The UV rays' germicidal potential depends on the room's surface area and the type of bacteria or virus.[23] Recognizing the crucial role of lighting in preventing Tuberculosis transmission within households, this study introduced an intervention involving the provision of lighting or room sterilization utilizing 16W and 20W Ultra Violet (UV) lamps in the residences of Tuberculosis patients. The research revealed that the median germ count in the 16-watt and 20-watt UV lamp interventions was higher prior to room sterilization than after UV lamp usage. This indicates that illuminating rooms with UV lamps can effectively decrease germ numbers.

Tuberculosis is an infectious disease that can rapidly spread due to its transmission through bioaerosols.[24] Bioaerosols consist of biological particles in the form of aerosols originating from living organisms, including microorganisms or components of these organisms such as metabolites, toxins, or microorganism fragments. The primary constituents of bioaerosols include bacteria, viruses, peptidoglycan, endotoxins, fungi, and Volatile Organic Compounds.[25,26]

Airborne germs consist of microorganisms present in the air, including fungi, bacteria, and viruses. Microorganisms suspended in the air can originate from the external environment or be contaminants within enclosed spaces. Bacteria like Mycobacterium tuberculosis have the ability to survive in the air, and their ability to persist in the air is largely influenced by environmental factors such as temperature, humidity, and sunlight. Transmission of these bacteria from the air to humans can occur through various means, including air currents and respiratory droplets.[26,27]

The count of airborne germs serves as an indicator of air pollution caused by bacteria, some of which may have pathogenic properties. Germ count represents the quantity of microorganisms, both pathogenic and non-pathogenic, determined through visual observation or with the aid of a magnifying glass on the culture media used for examination. The count is then calculated based on the standard test for bacteria using agar plates. The measurement of airborne germ numbers typically employs the Most Probable Number (MPN) method. This approach calculates the bacterial concentration based on the assumption that bacteria are evenly distributed within a liquid medium. Consequently, if samples are collected consistently from a source, an average bacterial count can be expected.[26]

Airborne germ numbers exceeding quality standards can have a detrimental impact on individuals in the room, particularly when they are in a weakened state, as these germs can compromise their already vulnerable immune system. One alternative for reducing the concentration of airborne germs is to employ ultraviolet (UV) light emitted from a lamp.[28,29]

Previous research indicates that UV lamps effectively reduce airborne germs in hospitals and other healthcare facilities.[30] Other studies have demonstrated that UV lamps can significantly decrease overall bacterial counts and are more effective than manual disinfection in hospital settings.[31,32] Similarly, research conducted in Kupang City confirms that using UV lamps for illumination can help decrease air germ concentrations. This study reveals that 20W UV lamps are more efficient at reducing germ numbers than 16W UV lamps. Nonetheless, both types of lamps can serve

Table 3. Differences in air germ numbers in room sterilization using 16W and 20W ultra violet lamps based on the Wilcoxon test.

Intervention		N	Z score	p
Pre-post 16Watt	Negative ranks	17	-1.999	0.046
	Positive ranks	4		
Pre-post 20Watt	Negative ranks	19	-2.868	0.004
	Positive ranks	2		

as alternatives for reducing airborne germs when adding ventilation is problematic or when direct sunlight cannot enter the house.

The presence of ventilation and lighting in a house are closely interrelated. Ventilation serves as a means for both light and fresh air to enter. Thus, the broader the ventilation, the more sunlight can penetrate the house, resulting in more germs in the room being exposed to UV rays from the sun, ultimately killing them. When direct sunlight can enter the house, it not only inhibits the growth of germs but can also lead to their immediate destruction, thereby reducing the risk of Tuberculosis transmission within the house.[33] Ventilation also aids in decreasing the concentration of germs in the room by allowing cleaner external air to flow in, displacing potentially germ-laden indoor air.[34] The broader the ventilation, the more air carrying infectious droplets and other sources of pollutants can be expelled from the room.

Previous research has demonstrated a connection between room lighting and the germ count in hospital treatment rooms,[33] as well as an association with Tuberculosis incidence.[35] The source of room lighting can be sunlight or ultraviolet (UV) lamps. It is crucial for this lighting to be consistently available to maintain well-lit rooms that are not conducive to germ proliferation. To enhance the influx of sunlight into a house, it is necessary to increase the number of entrances, such as windows, vents, and glass tiles, or to provide room lighting using UV lamps.[22]

UV light is a form of electromagnetic radiation with a wavelength of 100-400 nm, divided into three wavelength bands: UV-A (315-400 nm), UV-B (280-315 nm), and UV-C (100-280 nm). Naturally, ultraviolet light is present in sunlight. Of the three types of UV light, only UV-C can be utilized for germ sterilization activities. In addition to sunlight, UV-C radiation can be generated by artificial lighting. A UV lamp contains low-pressure mercury vapor enclosed in a specialized UV-emitting glass tube. Approximately 95% of the energy emitted by this lamp falls within the 253.7 nm wavelength, which falls within the UV-C range.[29]

This research still has limitations, specifically the absence of testing the effect of distance (room area) on reducing air germ numbers, even though both distance and room area are known to have an effect on reducing germ numbers. Similar to previous research, the distance of exposure to a UV lamp statistically influenced the difference in the reduction of germ numbers on cutlery, with the closer the distance, the higher the reduction in germ numbers.[36] Therefore, it is hoped that future research can further investigate the impact of distance and room size on air germ numbers.

With this research, it is hoped that to reduce the number of germs in homes, especially the homes of Tuberculosis sufferers, people will be able to increase or improve ventilation to allow sunlight to enter. If this is not possible, they can use artificial lighting, specifically by using ultraviolet light from UV lamps. It should be noted that in general, UV-A, UV-B, and UV-C radiation that reaches the Earth can have various effects, including skin redness when directly exposed to the skin for an extended period. Considering these impacts, several precautions must be taken when using UV lamps.[23] These precautions include not placing the lamp near people, plants, or pets, avoiding entering the room when the UV lamp is on, and not looking directly at the UV lamp unless you are using safety glasses. It is also advisable not to use the lamp for extended periods. For safe usage, it is hoped that the Health Service or Community Health Center will continue monitoring their use and assessing the health impacts that may directly affect the community.

Conclusions

Room sterilization using 16W and 20W UV lamps can effectively reduce the number of room germs. The use of 20W ultraviolet lamps has a more significant impact on reducing the number of germs in the room air. Therefore, it is recommended to reduce the number of germs in the house by illuminating (sterilizing) the room using Ultraviolet lights or by adjusting the ventilation position to increase the sunlight entering the house. Considering the potential negative impacts of UV lamps, it is hoped that the Health Service or Community Health Center will continue monitoring their use and assessing the health impacts that may directly affect the community.

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