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Prevention of Tuberculosis Transmission Through *Mycobacterium Tuberculosis* Detection in the Air

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Abstract

Tuberculosis (TB) is a dangerous and highly contagious disease. Global cases have increased since, and Indonesia is one of the countries with the highest number of TB cases. This study aimed to prevent TB transmission by analyzing air contamination. Air samples were taken from three primary health cares (PHCs) in Surabaya City, East Java Province, Indonesia, and cultured in Mycobacterium Growth Indicator Tube (MGIT) media. Of the 108 air samples collected, 36 came from the waiting room, 36 from the examination room, and 36 from the laboratory room. As a result, the waiting room (50%), examination room (16.7%), and laboratory room (2.7%) were declared positive. In short, the air in the three PHCs contained *mycobacterium tuberculosis*. There is a need for room management to prevent TB transmission.

Keywords: air, *mycobacterium tuberculosis*, primary health care

Introduction

Tuberculosis (TB) is a dangerous and highly contagious disease, posing a significant threat regarding mortality and morbidity, in which nearly one-quarter of the global population is infected by the bacteria.[1,2] *Mycobacterium tuberculosis* (MTB) emerges as the causative agent of TB, leading to fatalities and representing a major infectious agent in humans.[3,4] TB remains a major health concern worldwide, persisting as a substantial public health menace with significant medical, social, and financial consequences, particularly in developing and tropical countries.[5] Rajasekaran *et al.* assert that TB is a severe global burden often referred to as a disease of poverty.[6]

World Health Organization (WHO) reveals that the number of people suffering from TB in 2021 reached 10.6 million cases, demonstrating an increase of around 600,000 cases from 10 million cases in 2020. Of 10.6 million cases, 6.4 million (60.3%) have been reported, and the patients undergo treatment; conversely, 4.2 million (39.7%) remain undiagnosed and unreported.[7] The Southeast Asian region, primarily composed of tropical countries, contributes to 40% of global TB-related deaths. It has been assessed that 10% of patients with extrapulmonary TB exhibit musculoskeletal involvement, and 50% of these musculoskeletal TB cases manifest as spinal TB.[8] Overall, TB-related deaths remain alarmingly high, with at least 1.6 million individuals succumbing to TB, representing an increase from the previous year's estimate of around 1.3 million deaths.[7]

Additionally, approximately 187,000 individuals die from TB in conjunction with human immunodeficiency virus (HIV).[7,9] Around 90% of TB cases affect young adults, with a higher prevalence among males than females.[10,11] More than half of TB patients are of productive age, according to WHO, and the age ranges between 25 and 44 years.[12,13] This poses a serious concern, especially for developing countries like Indonesia, as the majority of TB patients are in their productive years.

Indonesia occupies the second position with the highest number of TB cases worldwide after India in which this position is followed by China, the Philippines, Pakistan, Nigeria, Bangladesh, and the Democratic Republic of Congo.[14]

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Indonesia is ranked third with the highest number of TB cases in 2020, totaling 824,000 cases; in 2021, this number increased to 969,000 cases, representing an estimated 17% rise in cases.[13] The TB incidence rate in Indonesia stands at 354 per 100,000 population, indicating that out of every 100.000 individuals in Indonesia, 354 are afflicted with TB.[13]

East Java is one of the provinces with the highest number of TB cases in Indonesia, with Surabaya City contributing the most, totaling 4,628 cases.[15] This study selected three primary health care (PHCs) in densely populated areas where the Surabaya City Government recorded 184 TB cases.[15] As population density increases, the dissemination of TB bacteria becomes more prevalent.[16] Measurements were conducted at the PHCs because the government focused on TB patient care and monitoring at these nearby facilities.

A mode of transmission for pulmonary TB is through the dissemination of "droplet nuclei" from infected patients. However, in the post-pandemic era, there has been a lack of research regarding the presence of MTB in the air. Therefore, this study was carried out to prevent TB transmission by analyzing MTB contamination for management policies in waiting rooms, examination rooms, and laboratory rooms at three PHCs in Surabaya City, Indonesia.

Method

This descriptive observational study collected air samples from the waiting, examination, and laboratory rooms for general and TB patients in three PHCs in Surabaya City, Indonesia (Figure 1). These PHCs were located in the Eastern, Northern, and Western parts of the city. All the rooms utilized in this study met the standard size requirements for PHC, including a waiting room of 16 m^2, an examination room of 12 m^2, and a laboratory room of 9 m^2.

Figure 1. (A) Waiting Room; (B) Examination Room; (C) Laboratory Room in Three Primary Health Care

Air sampling was conducted using the As82 PURIVA H1 device, with a suction rate of 200 m^2 per hour. Sampling was taken for one hour using HME Twinstar Drager virus and bacteria filters. The number of samples was determined based on the Federer formula. The study took 36 repetitions, resulting in each group comprising 36 samples, totaling 108 samples. The repetitions were made during active hours at selected PHCs.

After an hour, the device was turned off, and the filters were collected. The sampling underwent decontamination using 4% NaOH and was then cultured on Mycobacterium Growth Indicator Tube (MGIT) media. The cultures were incubated in MGIT machines until growth occurred or were declared negative after 40 days. Positive culture results were subsequently subjected to identification to differentiate between MTB and mycobacteria other than tuberculosis (MOTT) using SD TB Ag MPT64 Rapid test (Figure 2A, 2B, 2C).

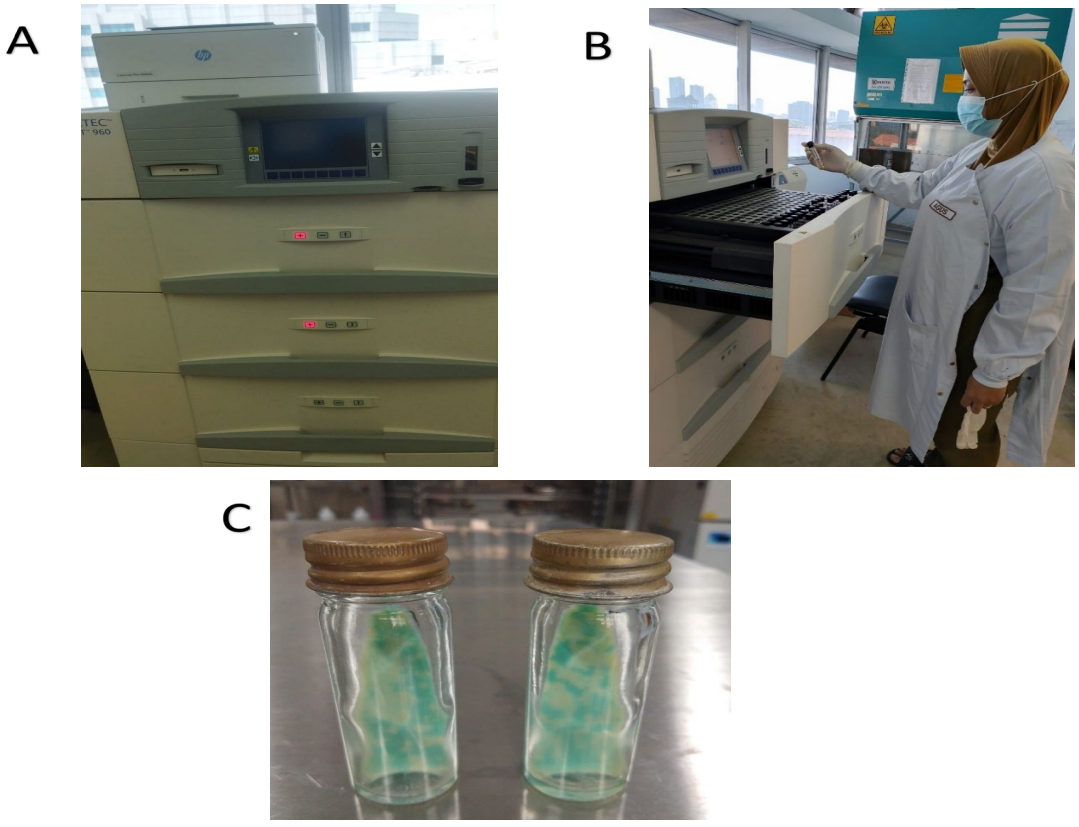

Figure 2. (A) MGIT instrument for automated MTB culture; (B) Analyst Observing the Culture Results in Tubes; (C) A positive TB Colony Result

Results

The waiting and examination rooms at the PHC were not separated between TB and non-TB patients, thus posing a significant risk of TB transmission. The waiting room was where patients queued to wait to be called into the examination room, while the examination room was for health personnel conducting patient interviews and examinations.

Table 1. Results of *Mycobacteria Tuberculosis* Examination in the Air of Primary Health Care

Area	The Number of Samples	Positive
Waiting Room	36	18 (6 TB, 12 MOTT)
Examination Room	36	6 (TB)
Laboratory Room	36	1 (TB)

Notes: TB = tuberculosis, MOTT = *mycobacterium* other than *tuberculosis,*

The result showed that, of 36 samples, 18 samples examined from the waiting rooms (50%) tested positive, and six samples from the examination rooms (16.7%) also tested positive. In contrast, only one sample from the laboratory rooms (2.9%) was tested positive.

Discussion

Pulmonary TB emerges as a disease transmitted through droplet nuclei from TB patients with acid-fast bacilli (AFB) positive status.[17] When an infected patient coughed, respiratory droplets containing MTB bacteria were released into the surrounding air.[17] If an individual is in the vicinity of these droplets, or if the wind carries them and an individual inhales them, then 10% of this group will develop active TB. At the same time, 90% will become latent carriers. However, those with a strong immune system can eradicate the MTB bacteria.[1]

Individuals with weakened immune systems or those influenced by specific risk factors are more susceptible to TB. Several risk factors that can heighten vulnerability to TB include HIV infection, diabetes, the use of immunosuppressive drugs, malnutrition, prolonged exposure to tobacco smoke, crowded and poorly ventilated environments, contact with TB patients, and advanced age[18] Given the high mortality rate associated with TB, and its transmission can be prevented.[17]

Preventing TB dissemination includes identifying and treating TB cases, utilizing masks, ensuring adequate ventilation, practicing good hygiene, administering preventive therapy, and promoting public education and awareness.[18]

TB is not transmitted through activities such as shaking hands, sharing foods or drinks, touching bed linens or toilet seats, sharing toothbrushes, or kissing one another.[17] When an individual inhales TB bacteria, the bacteria start settling in the lungs and commence multiplying. Afterward, the bacteria enter the bloodstream, and the bacteria start spreading to other body elements (e.g., kidneys, brain, and spine). TB attacking the throat or lungs will likely be transmitted to the surrounding environment. In contrast, TB affecting other body parts (e.g., spine or kidneys) will not be contagious.[19] Those suffering from pulmonary TB have enormous potential to transmit the disease to people spending time together with the sufferers in their daily lives.[18] TB transmission can occur in various settings, including households, workplaces, and health facilities such as hospitals, PHCs, and clinics.[20]

A previous study stated that specific requirements were typically needed for outpatient pulmonary TB care facilities.[21] First, the waiting room should provide comfortable seating for patients and their families, with ample space to accommodate the number of patients attending. Adequate ventilation is essential to maintain the fresh air and prevent disease transmission. Second, the examination room should have a sterilizable or easily cleanable examination table and essential tools such as stethoscopes, thermometers, and blood pressure monitors. It should also be equipped with a sink or handwashing station for sanitation purposes. Third, the consultation room should be furnished with a desk and chairs for doctor-patient communications. It should be stocked with paper and pens for recording patient medical information.[21]

Additionally, using a computer or electronic record-keeping system to maintain patient records is advisable. Fourth, the laboratory area should be equipped with necessary laboratory instruments like microscopes for examining patient sputum samples, as well as the required chemicals and reagents for conducting analyses. Fifth, the medication storage room should serve as a secure and locked medication storage area.[21] It should include a working table or medication preparation area and a refrigerator for storing vaccines or medications requiring specific temperature control. Sixth, sanitary facilities should include clean and sterilized toilets and sinks. There should be safe disposal containers for contaminated medical materials and proper sanitation systems to ensure cleanliness and hygiene within the facility.[21]

The standard requirements for pulmonary TB clinics to prevent TB transmission to others include carrying valid identification, such as an ID card or driver's license, wearing a mask while in the pulmonary TB clinic area, cleaning hands with hand sanitizer or washing them with soap and water before entering the clinic, maintaining a safe distance from other patients in the waiting area, informing healthcare personnel if experiencing symptoms such as cough, cold, or other potentially contagious signs, completing and signing the informed consent form for pulmonary TB examination, undergoing sputum examination to determine the presence of MTB bacteria, and following instructions and procedures provided by the healthcare personnel during examination and treatment.[4]

In this study, one of the selected PHCs was located in a densely populated area and had inadequate facilities for its large patient population. All TB patient waiting rooms in three PHCs were shared with other patients, increasing the potential for faster transmission. The waiting room, being the most crowded, had the highest concertation of bacteria. Conversely, the examination room was more conducive to minimizing TB transmission since patients were managed individually, reducing contact. The laboratory with the lowest density had only one out of 36 samples tested positive for TB bacteria.

There was no separation for TB and non-TB patients at three PHCs in this study. This situation poses a considerable risk, as if a TB patient sneezes or coughs, there is limited awareness that MTB bacteria may spread into the surrounding environment, thereby increasing the risk of TB transmission. WHO has set Millennium Development Goals to make TB no longer a social or public health problem by 2030.[13] However, the findings suggested that without improvements in spatial policies within PHCs, these PHCs could potentially become sources of TB transmission for those seeking care. This could result in a failure to meet the Millennium Development Goals and to eliminate TB as a public health concern.

A total of 12 samples were found positive for MOTT out of 25 positive samples. According to the Global Laboratory Initiative, the NSW Health, and the American Society for Microbiology, the diagnosis of TB involves various tests, including MTB culture, AFB staining, Tuberculin Skin Tests (TST), and rapid molecular tests.[22–24] The current MTB detection program developed by the Indonesian Ministry of Health in 2020 involves the use of a rapid molecular test device.[25] These devices can detect MTB within two hours and determine whether the MTB strain is sensitive or resistant to rifampicin. However, a limitation of rapid molecular test is that it can only detect MTB and cannot identify MOTT. Further extensive study is necessary to confirm these findings, it is essential to consider that patients with MOTT may not receive appropriate treatment, potentially becoming transmission sources to other patients or individuals in their vicinity.

In future studies, reactivating AFB staining in conjunction with a rapid molecular test device could be examined. This approach would allow for a more comprehensive assessment. If the rapid molecular test results are negative but AFB staining is positive, it would strongly suggest that the cause of the patient's illness is MOTT rather than MTB.

Conclusion

The presence of MTB in the air of waiting rooms, examination rooms, and laboratory rooms at three PHCs in Surabaya City, Indonesia, necessitates effective management of these spaces to prevent the transmission of TB. First, it is imperative to establish a governmental policy that mandates separating waiting areas for patients with respiratory infections from those without. Such a measure is essential to achieving the WHO target for TB elimination. Second, given the rise in cases of MOTT infections, there is an urgent need for more comprehensive TB microscopic examinations to ensure timely treatment of MOTT patients. Third, a policy requiring all patients visiting a PHC to wear masks must be instituted.

Abbreviations

TB: tuberculosis; MTB: *mycobacterium tuberculosis*; WHO: World Health Organization; HIV: human immunodeficiency virus; PHC: primary health care; MGIT: Mycobacterium Growth Indicator Tube; MOTT: *mycobacteria* other than *tuberculosis*; acid-fast bacilli: AFB.

Ethics Approval and Consent to Participate

This study was approved by the Research Ethics Committee of dr. Soebandi Public General Hospital (No. 420/2453/610/2023).

Competing Interest

The authors declare no significant competing financial, professional, or personal interests might have affected the performance or presentation of the work described in this manuscript.

Availability of Data and Materials

The primary author can provide all data and materials from this study.

Authors' Contribution

NNJ, EBK, and INT contributed to the design and implementation of the research. NNJ was involved in the data analysis, while EBK provided supervision. NNJ, EBK, and INT were involved in manuscript preparation, content refinement, and administration. All the authors discussed the results and contributed to the final manuscript.

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