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Determinants of latent tuberculosis infection among nurses at public health centers in Indonesia

Meira Erawati^{*} and Megah Andriany

Department of Nursing, Faculty of Medicine, Universitas Diponegoro, Indonesia

Abstract

Background: The incidence of latent tuberculosis among healthcare workers, especially nurses, at public health centers in Indonesia has been increased. Therefore, factors related to the tuberculosis incidence need to be further investigated.

Objective: This study aimed to identify the determinants of latent tuberculosis infection among nurses at public health centers in Indonesia.

Methods: This non-experimental, cross-sectional study included 98 nurses. Data on the determinants of latent tuberculosis infection were collected using validated questionnaires, and the infection status was confirmed by Interferon Gamma Release Assay or IGRA test. Logistic regression was used for statistical analysis, with a significance level of $p < 0.05$.

Results: Health facilities for tuberculosis transmission prevention were available in all public health centers (100%). Protocols for preventing tuberculosis transmission including occupational health and safety training (OR = 13.24, 95% CI [2.29–58.55]; $p = 0.001$), handwashing after contact with patients or specimens (OR = 20.55, 95% CI [4.23–99.93]; $p = 0.000$), and wearing of medical masks (OR = 9.56, 95% CI [1.99–45.69]; $p = 0.005$) were found to be significant determinants of latent tuberculosis infection among nurses.

Conclusion: The availability of protective equipment and implementation of health protocols among nurses at public health centers are the main determinants of latent tuberculosis infection. Hence, they should be maintained by all nurses to prevent the spread of tuberculosis.

Keywords

latent tuberculosis; occupational health; public health; risk factors; nurses; Indonesia

*Corresponding author:

Meira Erawati, Dr, RN

Faculty of Medicine, Universitas Diponegoro
Jl. Prof. Soedarto, SH, Tembalang,
Semarang, Central Java, Indonesia, 50275
Tel +6224 76480919
Fax +6224 76480919
Email: mei_ra7@fk.undip.ac.id

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Background

Globally, tuberculosis (TB) infected approximately ten million people in 2019 and caused the death of 1.2 million people with HIV-negative status. This incidence mostly occurred in Southeast Asia, Africa, and the Western Pacific (World Health Organization, 2020a). In Indonesia, TB incidence reached 845,000 cases in 2018; thus, Indonesia ranked third in countries with the highest incidence of TB worldwide after India and China (World Health Organization, 2020b). A year later, Indonesia had a high burden status for TB incidents and stood in the top three countries for TB, TB/human immunodeficiency viruses, and multidrug-resistant TB (World Health Organization, 2019). One of the Indonesian provinces with a relatively high TB incidence was Central Java (Indonesian Ministry of Health, 2018b), located on Java island with a population density of 1,060/km² (Central Statistics Agency of Central Java, 2019). Given this population density, TB cases further increased in Central Java, reaching 143.57 per 100,000 population in 2018 (Department of Health of Central Java, 2018).

In Indonesia, public health centers are the first-level health service centers that provide care for patients with TB. The Ministry of Health Regulation No. 67 of 2016 states that these public health centers should implement programs for controlling TB, including identifying new patients, providing medication, compiling case reports, and referring to a higher level of health service facilities (Indonesian Ministry of Health, 2016). Nurses and other healthcare workers who make either direct or indirect contact with patients provide these TB services (Nathavitharana et al., 2017).

TB transmission can occur from patients to nurses who provide care through the airborne route. Among all healthcare professionals, nurses have the highest risk of infecting TB (Wang et al., 2018). Patient–nurse transmission can occur in the room where the nurses serve the patients. The risk of infection increases if nurses do not wear standardized personal protective equipment (PPE). Hence, the availability of personal protective facilities for nurses is vital when interacting with patients and sputum specimens (Diel et al., 2020). Unfortunately, PPE is not always available in all health facilities, and its use is prioritized only in high-risk situations (Chughtai & Khan, 2020).

The knowledge of healthcare workers, including nurses, is related to their behaviors, affecting the risk size of TB infection (Alotaibi et al., 2019). Training on TB management can increase the knowledge and self-efficacy of nurses in managing patients with TB (Akande, 2020). Bacillus Calmette–Guérin (BCG) vaccination, as recommended by World Health Organization (WHO), also increases a person's immunity, thereby reducing the risk of TB infection. This vaccination also applies to healthcare workers who provide services to patients with TB. BCG revaccination significantly strengthens the body's response to producing Th1/Th17 as an antimycobacterial cytokine (Rakshit et al., 2019).

Along with making disease prevention facilities available in healthcare service centers, health protocols for preventing TB transmission also needs to be strictly implemented. For example, using soap or hand sanitizer for handwashing effectively reduces the risk of TB transmission. The frequency of handwashing also determines the degree of TB transmission risk (Han, 2018). In addition, wearing medical masks protects someone from TB transmission. The use of a medical mask that consists of three cloth layers effectively prevents TB transmission by up to 56% (Dharmadhikari et al., 2012). The use of N95 respirators shows the same effect as medical masks in preventing airborne infection spread. However, the N95 respirators are more advantageous because they filter minute microorganisms and offer a lower leakage rate than medical masks (Smith et al., 2016). Other Personal Protection Equipment (PPE) forms frequently used by healthcare workers to prevent respiratory infections include face shields and medical gloves. However, PPE is not always available in many healthcare facilities, and its use is limited to high-risk situations. Face shields should be used with other available PPEs because face shields alone cannot withstand aerosol penetration from the side directions. More precisely, face shields are used for protection in addition to medical masks (Roberge, 2016).

Tuberculosis transmission from patients to nurses does not necessarily cause serious symptoms. Nurses generally do not show any clinical symptoms, making bacterial exposure unrecognizable. This condition is known as latent TB (World Health Organization, 2016). If not handled properly, latent TB may eventually develop into an active state. In Semarang, the incidence of latent TB among healthcare workers reached 24% in 2019, mostly affecting nurses. This statistic shows the magnitude of the risks that nurses encounter when caring for patients. Several demographic factors have already been identified as risk factors of latent TB infection among nurses and healthcare workers (Erawati & Andriany, 2020); however, other determinants, such as healthcare facility availability and health protocol implementation among nurses, to prevent latent TB infection remain unexplored. Thus, this study aimed to identify the determinants of latent TB infection among nurses at public health centers in Indonesia.

Methods

Study Design

A non-experimental cross-sectional study was conducted to identify the prevalence ratio of TB among nurses in public health centers in Semarang, Indonesia.

Participants

The Health Office of Semarang oversees 37 public health centers, all of which provide TB services for patients. However, only 34 public health centers were included in this study; the other three did not confirm their availability. Using a total sampling technique, 98 nurses were recruited as respondents. The inclusion criteria were nurses working at public health centers in Semarang, providing direct or indirect TB patient care, aged over 20 years, and having working experiences for at least six months.

Instruments

The researchers used two types of data collection tools: the questionnaire and interferon-gamma release assays (IGRA). The questionnaire was used to collect demographic data, PPE availability to protect disease transmission, TB prevention programs in the workplace, and nurses' health protocols to prevent TB transmission. The question items on the demographic data questionnaire were adopted from a previous study in Indonesia by Erawati and Andriany (2020), while items regarding PPE availability to protect disease transmission, TB prevention programs in the workplace, and nurses' health protocols to prevent TB transmission were adopted from the Regulation of the Minister of Health of the Republic of Indonesia Number 67 of 2016 concerning the control of tuberculosis (Indonesian Ministry of Health, 2016).

The demographic data contained questions about age, sex, academic degree, and work duration, presented in the form of multiple-choice questions. Questions about PPE availability to protect disease transmission consisted of five items, while questions about TB prevention programs in the workplace and nurses' health protocols to prevent TB transmission consisted of six items. The questionnaire could only be answered with "yes" or "no." The researchers only adopted the questionnaires, so a pilot testing was conducted among 32 TB healthcare workers, including 20 physicians and 12 laboratory technicians at health centers. The results indicated that the questionnaires were valid ($r = 0.393\text{--}0.568$ [per question] greater than the r -table [0.349]) and reliable (Cronbach's $\alpha = 0.74$).

Furthermore, the IGRA test aimed to confirm whether the respondents suffered from latent TB infection or not. This test was chosen with the consideration that the test result was not affected by BCG vaccination (Jaime et al., 2019). In addition, it showed higher specificity (97%–99%) than the tuberculin skin test (Eralp et al., 2012; Napoli et al., 2017).

Data Collection

The survey team for data collection consisted of two researchers, one nursing student, and two laboratory technicians. Before collecting data, this team held discussions to achieve uniform perceptions and submitted a research permit to the Head of the Semarang Health Office. After the permission was granted, the researchers confirmed with the public health centers for their participation, as well as with the survey team members and the persons in charge of the public health centers regarding the time of data collection and the number of respondents involved in the study. The laboratory technicians and researchers attended the public health centers at the agreed time. The researchers requested the respondents to complete the questionnaire and check it to

ensure completeness. If unanswered questions were found, the researchers asked the respondents to complete the answer at that time.

After questionnaire completion, the laboratory technician extracted 4 ml of venous blood from each respondent for laboratory examination. The blood was stored in a heparinized tube to prevent clotting. The blood specimens were then sent to Kimia Farma Clinical Laboratory for IGRA analysis following the laboratory protocols.

Positive results of the IGRA test indicated latent TB infection, whereas negative results indicated no latent TB infection. The results of the IGRA test were submitted privately to the head of each public health center to maintain confidentiality. Subsequently, the respondents were directly informed of their IGRA test results in person.

Data Analysis

The completed questionnaires were arranged according to the public health centers' names where the respondents worked. The data were entered into Excel (Windows 10) and analyzed using univariate analysis in the form of a single-frequency distribution table. Multivariate analysis using logistic regression was also done with a significance level of $p < 0.05$. The IBM SPSS statistics 20 was used for analysis.

Ethical Considerations

The research ethics committee of the Department of Nursing, Faculty of Medicine, Universitas Diponegoro, Indonesia, approved this study (No. 42/EC/KEPK/D.Kep.VI/2019, dated 18 June 2019). The respondents' rights based on the Declaration of Helsinki were remained protected throughout the study period. This study obtained permission from the head of the Semarang Health Office prior to collecting data from August to October of 2019. All respondents provided informed consent for study participation.

Results

This study included 98 eligible nurses as respondents, who all came from 34 public health centers in Semarang, Indonesia. Inpatient facilities were found in 10 (29%) public health centers, and 19 (50%) had achieved an intermediate level of accreditation. In addition, as an effort to prevent disease spread, all public health centers (100%) provided PPE, including medical masks, handwashing sinks, hand sanitizers, medical gloves, and medical and nonmedical trash bins.

Table 1 Demographic data and the implementation of TB transmission prevention protocols by nurses

Variable	N	%	Mean \pm SD	p-value
Age			37.17 \pm 9.55	0.771
≤35 years	52	53		
>35 years	46	47		
Sex				0.606
Male	38	39		
Female	60	61		
Educational degree				0.664
Diploma	60	61		
Postgraduate	38	39		
Work duration			12.75 \pm 9.94	0.483
≤10 years	53	54		
>10 years	45	46		
Training in tuberculosis patient management				0.346
Yes	60	61		
No	38	39		
Occupational health and safety training				0.940
Yes	69	70		
No	29	30		
Handwashing before contact with patients or specimens				0.379
Yes	62	63		
No	36	37		
Handwashing after contact with patients or specimens				0.805
Yes	69	70		
No	29	30		
Wearing a medical mask every contact with patients or specimens				0.104
Yes	70	71		
No	28	29		
Wearing medical gloves every contact with patients or specimens				0.771
Yes	46	47		
No	52	53		

SD, standard deviation

Table 1 summarizes the demographic data and the implementation of TB transmission prevention protocols by nurses. The majority of the respondents were younger than 35 years (53%; mean score: 37.17 \pm 9.55 [min–max = 23–56]),

were female (61%), and achieved a diploma degree (61%). More than half of the respondents have worked for more than ten years (12.75 \pm 9.94), attended training in TB patient management (60%), and attended occupational health and

safety training (70%). Furthermore, 63% and 70% of the respondents washed their hands before and after contact with patients or specimens, respectively. During contact with patients or specimens, 71% of the respondents used medical masks, and 47% used medical gloves.

Table 2 presents the IGRA test results of the respondents. Of the 98 respondents, 24 (25%) showed a positive IGRA result.

Table 2 IGRA test results on nurses

IGRA test	N	%
Negative	74	75
Positive	24	25

Table 3 Distribution of respondents based on the determinants and IGRA test

Determinant	IGRA Test		Total (%)	OR (95% CI)	p-value
	Positive	Negative			
Age				2.22 (0.540–9.123)	0.269
≤35 years (ref)	10	42	52		
>35 years	14	32	46		
Sex				2.62 (0.415–16.553)	0.306
Male (ref)	1	37	38		
Female	23	37	60		
Educational degree				0.92(0.224–3.746)	0.903
Diploma (ref)	14	46	60		
Postgraduate	10	28	38		
Training in tuberculosis patient management				1.59(0.436–5.791)	0.483
Yes (ref)	12	48	60		
No	12	26	38		
Occupational health and safety training				13.24(2.994–58.553)	0.001**
Yes (ref)	10	59	69		
No	14	15	29		
Washing hand before contact with patients or specimens				1.52(0.385–5.964)	0.552
Yes (ref)	14	48	62		
No	10	26	36		
Handwashing after contact with patients or specimens				20.55(4.225–99.928)	0.000***
Yes (ref)	10	59	69		
No	14	15	29		
Wearing a medical mask every contact with patients or specimens				9.56(1.999–45.691)	0.005*
Yes (ref)	3	76	70		
No	21	7	28		
Wearing medical gloves every contact with patients or specimens				3.85(0.741–19.978)	0.109
Yes (ref)	17	29	46		
No	7	45	52		

Note: multivariable logistic regression was performed to analyze the data. (*) p -value = 0.005, (**) p -value = 0.001, (***) p -value = 0.000. CI, confidence interval; IGRA, interferon-gamma release assay; OR, odds ratio

Table 3 shows that some implementations of TB transmission prevention protocols that are potential as determinants of latent TB infection among nurses are attending training on occupational health and safety (OR = 13.24, 95% CI [2.994–58.553]; p = 0.001), washing hands after making contacts with the patient/patient's specimen (OR = 20.55, 95% CI [4.225–99.928]; p = 0.000), and wearing a medical mask when making contacts with the patient/patient's specimen (OR = 9.56, 95% CI [1.999–45.691]; p = 0.005).

Discussion

This present study focused on identifying potential determinants of latent TB infection among nurses at public health centers in Indonesia. Results showed that 34 public health centers in Semarang provided health services for patients with TB, and 29% had inpatient facilities. These 34

public health centers had provided various facilities for preventing TB transmission and other infectious diseases. These facilities included masks, handwashing sinks, hand sanitizers, medical gloves, and medical and nonmedical trash bins. These study results are in line with a previous study by (Honda & Iwata, 2016), which reported that the availability of healthcare facilities is necessary to prevent the transmission of an infection from the patients to healthcare workers, or vice versa via airborne or droplet route. The provision of PPE and facilities for healthcare workers in Indonesia has been structurally managed according to the Regulation of the Minister of Health No. 31 of 2018, which concerns the application of medical facilities, infrastructure, and devices. With its implementation on all fronts, the availability of PPE for healthcare workers who provide care for patients with TB can be adequately fulfilled (Indonesian Ministry of Health, 2018a).

The medical mask is one of the PPEs that should be available in all TB healthcare facilities. Patients with TB are

advised to use a medical mask (Dharmadhikari et al., 2012) to ensure the prevention of transmitting the disease to other people, especially when coughing (World Health Organization, 2019). In addition, the N95 respirator is a type of mask recommended for healthcare workers, including nurses who care for patients with confirmed or even suspected TB (Smith et al., 2016). Visitors are also advised to use the N95 respirator when in a closed room with infectious cases.

One of the prominent principles of TB patient care is the availability of handwashing sinks and closed trash bins at public health centers. WHO recommends that patient care procedures should be performed in a clean or hygienic environment that facilitates the practice of prevention and control of healthcare-associated infection, antimicrobial resistance, infection prevention and control, and water, sanitation, and hygiene. To meet this recommendation, health centers should make the materials and equipment for proper hand hygiene available during treatment (World Health Organization, 2019).

TB Transmission Prevention Protocols

The factors affecting the success of TB transmission prevention and control are not only determined by the availability of facilities but also healthcare workers' behaviors to follow the established prevention protocols.

In this study, most of the nurse participants who provided care to patients with TB had received training on TB patient management, consistent with a previous Chinese study in which most respondents had received training on TB patient management before direct contact with patients (Chen et al., 2019). This training is a prerequisite for nurses who provide TB services. The training aims to improve the triage ability of nurses so that they can determine whether a patient needs isolation or not, as well as increase their ability to reduce TB infection spread and protect themselves against this transmission (World Health Organization, 2019). Hopefully, with all this knowledge, nurses can provide quality and safe health services for themselves and their patients.

Handwashing before and after contact with patients with TB or TB specimens has been regularly practiced by up to more than 60% of the nurses. This result reflects one of the mandatory protocols in nursing care implementation (Malliarou et al., 2013). Therefore, every nursing action provided to patients should always begin and end with handwashing.

Moreover, 71% of the respondents used medical masks every time they made contact with patients or their specimens. Although healthcare workers who serve patients with TB are obliged to wear medical masks, many find it inconvenient, consistent with a previous study. According to this previous study, healthcare workers did not use masks properly, especially the N95 respirator masks, because of several factors, such as hairstyle (46.4%), makeup (42.9%), high ambient temperature (60.7%), and communication problems (65.7%) (Kerr & Mbhele, 2019). Healthcare workers use other types of masks, such as the medical mask, a three-layer mask that can filter out droplets. However, the N95 respirator mask can withstand droplets and filter out airborne particles compared with the medical mask (Ippolito et al., 2020). With such advantages, healthcare workers in areas with a high burden of TB are recommended to utilize the N95 respirator. Nowadays, wherein the coronavirus disease 2019 (COVID-19)

pandemic exhibits a high rate of transmission, respirator use among healthcare workers is a huge investment that saves costs by maintaining the safety of the healthcare workers, including nurses (Mukerji et al., 2017).

Meanwhile, 47% of the respondents used medical gloves during patient or specimen contact. The use of medical gloves to prevent infection transmission comes along with handwashing (Andersen, 2019). Therefore, the use of medical gloves is obligatory for all healthcare workers, especially when performing actions that require direct contact between nurses, physicians, or other healthcare workers and patients or patient specimens. Especially, donning medical gloves is required when performing sterilized procedures and having direct contact with blood, body fluids, injured skin, or mucous membranes of patients with TB (World Health Organization, 2012b).

Latent TB Infection Determinants Among Nurses

The IGRA test was positive in 24 (25%) respondents, indicating that the prevalence of latent TB infection among nurses is relatively high. This result is in line with a previous study conducted in Victoria, Brazil, wherein latent TB infection was highly prevalent among healthcare workers in the city (Lacerda et al., 2017). Considering the high prevalence of latent TB infection among healthcare workers, a periodic screening program is essential as the basis for developing infection prevention programs in healthcare workers (Lacerda et al., 2017). The high rate of TB transmission from patients to nurses may occur during home visits (Pan et al., 2016) and in some risky units, such as general medical outpatient waiting and consulting rooms, X-ray department waiting room, respiratory medicine outpatient, and TB clinic waiting room, respiratory medicine outpatient consulting room, and general medical and respiratory medicine outpatient waiting room (Escombe et al., 2019). Bacterial transmission from patients to nurses and other healthcare workers can be minimized through simple architectural modifications to the existing infrastructures to improve natural ventilation in these spaces and density control using mathematical modeling to estimate the reduced risks of TB transmission (Escombe et al., 2019).

According to the current study's multivariate regression analysis, several determinants of latent TB infection were statistically significant. Occupational health and safety training, handwashing after contact with patients or specimens, and medical mask-wearing were the determinants of latent TB infection among nurses. In line with the IGRA test results, these determinants were demonstrated to be significant.

In this study, occupational health and safety training was a determinant of latent TB infection for nurses. Nurses who have not received such training are 13 times more likely to suffer from latent TB infection than those who have attended this training. Therefore, the success of the training should be evaluated individually and developed to prevent and overcome patient management errors (Houghton et al., 2020). Furthermore, how these knowledge and skills are practiced in everyday life is highly influenced by many factors. Some factors that affect healthcare workers' behaviors in complying with the appropriate PPE protocols include the use of relevant guidelines and how these guidelines are communicated. Other factors include support from managers, workplace cultures,

training, physical space, access and trust in PPE, and the desire to provide good care for patients (Beam et al., 2011).

In general, the behaviors of nurses in using PPE when interacting with patients remained favorable. Handwashing was identified as one of the significant determinants of latent TB infection among nurses in public health centers. It can prevent disease transmission from patients to nurses or vice versa (Mathur, 2011) and should be performed 1–2 minutes before and after nursing or medical intervention (World Health Organization, 2012a). Handwashing with soap and water kills microorganisms more effectively than water alone (Burton et al., 2011); however, hand-rubbing with alcohol provides similar protection to handwashing with soap and water (Nasution et al., 2019).

Furthermore, 60% of the respondents wore medical masks, and the habit of using PPE showed to be statistically significant as a determinant of latent TB infection. These results align with a previous study, which reported that the frequent habit of using PPE by healthcare workers is appropriate (Engelbrecht et al., 2016). Healthcare workers must implement good health protocols to prevent TB transmission when caring for their patients. Medical masks and gloves made of latex are effective PPEs against the spread of respiratory diseases and other infections (Chughtai & Khan, 2020).

However, this study has two potential limitations. First, respondents' habits in implementing health protocols were assessed using a questionnaire, suggesting a potential data bias. Second, data were collected only from a single province in Indonesia; therefore, the findings may not be generalized to the entire nursing community.

The implications of this research can be used as a basis for policymaking in improving nurses' safety when caring for patients with TB, especially during the COVID-19 pandemic, where the risk of TB transmission increases among nurses. Further research may explore other determinants of latent TB infection, such as environmental factors and agents. Regarding the host factor, data on the behaviors of nurses can be collected by direct or peer observation.

Conclusion

In general, all public health centers have provided PPE for nurses who care for patients with TB. However, the prevalence of latent TB infection among nurses remains high (25%). Occupational health and safety training, handwashing after patient or patient specimen contact, and wearing a medical mask during patient or patient specimen contact were the determinants of latent TB infection among nurses at public health centers in Semarang, Indonesia.

Declaration of Conflicting Interest

The authors declare that they have no conflict of interest in this study.

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Authors' Contributions

ME and MA conceptualized the article, conducted the data gathering, analyzed the data, and developed the manuscript equally. All authors agreed with the final version of the manuscript to be published, and they were accountable for all aspects of the work.

Authors' Biographies

Meira Erawati, Dr, RN is a Lecturer of Maternal and Child Nursing Division, Department of Nursing, Faculty of Medicine, Universitas Diponegoro, Semarang, Indonesia.

Megah Andriany, Ph.D, RN is a Lecturer of Community and Family Nursing Division, Department of Nursing, Faculty of Medicine, Universitas Diponegoro, Semarang, Indonesia.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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