

Determinants of Latent Tuberculosis Infection (LTBI) among Health Workers in Community Health Centers, Makassar City: A Case-Control Study

Elia Nofian^{1,*}, Masni², Ida Leida Maria³, Nur Nasry Noor³ and Muhammad Arsyad⁴

¹Master of Public Health Student, Faculty of Public Health, Hasanuddin University, Makassar, Indonesia

²Department of Biostatistics, Faculty of Public Health, Hasanuddin University, Makassar, Indonesia

³Department of Epidemiology, Faculty of Public Health, Hasanuddin University, Makassar, Indonesia

⁴Department of Health Promotion and Behavioral Sciences, Faculty of Public Health, Hasanuddin University, Makassar, Indonesia

Abstract: The prevalence of latent tuberculosis infection (LTBI) in Asia reaches 36% based on Tuberculin Skin Test (TST) results, and healthcare workers represent a high-risk group for occupational TB exposure. In South Sulawesi Province, 2,488 LTBI cases were reported in 2024, with Makassar City contributing the highest number. This study aimed to identify determinants of LTBI among healthcare workers in community health centers in Makassar City using a retrospective case-control design. Cases were healthcare workers with positive TST results recorded in the SITB database, while controls were healthcare workers from the same centers with negative TST results selected through simple random sampling with a 1:1 ratio. Bivariate analysis was conducted using Odds Ratios (OR), and variables with $p < 0.25$ were included in a multivariate logistic regression model to determine independent factors. A total of 316 cases and 316 controls were analyzed. Inconsistent mask use (AOR = 5.20; 95% CI: 3.60–7.51), history of contact with TB patients (AOR = 2.63; 95% CI: 1.82–3.80), and absence of BCG immunization (AOR = 2.30; 95% CI: 1.50–3.53) were independently associated with LTBI. Although smoking was significant in bivariate analysis, it was not retained in the final multivariate model. These findings highlight the importance of strengthening infection prevention and control practices and routine LTBI screening among healthcare workers in primary healthcare settings.

Keywords: Latent tuberculosis infection, healthcare workers, mask use, contact history, BCG immunization, case-control study.

INTRODUCTION

Tuberculosis is a re-emerging infectious disease, namely an infectious disease whose cases have decreased and then increase again, especially in developing countries, and is a public health problem [1]. The Mycobacterium Tuberculosis bacteria causes tuberculosis, which is transmitted through a tuberculosis patient who coughs, sneezes, or talks through the air when face to face with a healthy person [2]. Tuberculosis is preventable and usually curable. TB is the second leading cause of death after COVID-19, with 10 million people falling ill each year, making it a global health problem [3]. Tuberculosis cases in the world in 2022 and 2023 experienced a significant increase due to delayed diagnosis and treatment due to the COVID-19 pandemic. Globally, 8.2 million new cases were diagnosed with TB in 2023, up from 7.5 million in 2022 and 7.1 million in 2019, and well above the levels of 5.8 million in 2020 and 6.4 million in 2021 [4].

Not everyone exposed to TB bacteria becomes ill. Approximately 70% are uninfected, 30% are infected, 95% have latent infection, and 5% have active TB [5]. In situations where the immune system is still functioning, the Mycobacterium tuberculosis bacteria within

the granuloma lumps do not multiply, maintaining a state called "dormant." However, the person does not show any symptoms or signs of the disease, chest X-rays are also normal, and there is no evidence of the bacteria, as the number of bacteria is very small. People in this condition are known as latently infected with TB (LTBI), often referred to as latent tuberculosis infection [6]. The global prevalence of latent tuberculosis infection in 2014 was 23.0%, with the Southeast Asia, Western Pacific, and Africa regions having the highest prevalence of those experiencing latent tuberculosis infection [7]. The findings of the analysis of the prevalence of latent tuberculosis infection in Asia showed that it was 21% and 36% based on the results of IGRA (Interferon-Gamma Release Assays) and TST (Tuberculin Skin Test) [8]. Globally, there were approximately 1.8 billion cases of latent tuberculosis infection in 2019, with a prevalence of 24%, down from 1.6 billion in 1990 with a prevalence of 31%. China was the country with the most cases in 2019 [9].

Several studies on the prevalence of latent tuberculosis infection worldwide found a prevalence of LTBI of 29.9% among healthcare workers at the University of Nigeria Teaching Hospital [10]. The prevalence of LTBI was 15.8% in South Korean referral hospitals with IGRA examination [11]. At Nampula Central Hospital, Mozambique, 34.4% of healthcare workers had latent tuberculosis infection [12]. A systematic review of the literature reported that the

*Address correspondence to this author at the Master of Public Health Student, Faculty of Public Health, Hasanuddin University, Makassar, Indonesia; E-mail: office.elianofian@gmail.com

average prevalence of LTBI among healthcare workers in China was 51.5%, ranging from 27.9-88.8% [13]. Research in Indonesia has verified the prevalence of latent tuberculosis infection among healthcare workers. The study, conducted at the Lubuk Alung Special Pulmonary Hospital, found a prevalence of 38.1% [14]. Research findings in Semarang City found the prevalence of latent tuberculosis infection among health workers at Community health centers was 23% [15]. Another study in Manado City found a prevalence of 75% in hospitals [16]. Research conducted on health workers at the West Sumatra Pulmonary Hospital identified a prevalence of latent tuberculosis among health workers of 32% [17]. A study conducted at a regional hospital in Depok found that 49% of health workers had latent tuberculosis infections [18].

Several risk factors that can influence the incidence of latent tuberculosis infection in health workers in health facilities include longer work period, work location, health worker profession, history of direct contact with TB patients, individual characteristics (male gender, age, education level) and medical history (presence of scars or history of BCG vaccination, household contact with TB sufferers, smoking habits, chronic diseases, immunosuppressive conditions, and diabetes) [19]. TB case data for South Sulawesi Province in 2022 was 24,409 cases, then in 2023 it became 26,578 cases and continued to increase in 2024 as many as 30,348 cases with the highest number of cases in Makassar City (9,944 cases) followed by Gowa (2,180 cases) and Bone (2,078 cases). The results of the provision of Tuberculosis Prevention Therapy (TPT) for patients with latent tuberculosis infection, namely positive Tuberculin Skin Test (TST) results, are still very low. In 2022, there were 658 cases, then in 2023 there were 1,230 cases, and for 2024 there were 2,488 cases [20].

Early detection of latent tuberculosis infection among healthcare workers remains very low. In South Sulawesi Province, 159 healthcare workers received TPT in 2022, 236 in 2023, and 389 in 2024. Despite the low incidence, there is a persistent incidence of latent tuberculosis infection among healthcare workers [20]. Tuberculosis cases in Makassar City have increased over the past four years, reaching 5,803 cases in 2021, 8,080 in 2022, 9,050 in 2023, and 9,944 in 2024. Specifically, latent tuberculosis infection (LTBI) cases were found in 2022, with four cases involving healthcare workers, 306 in 2023, and 197 in 2024, with six healthcare workers. In 2025, data from mandatory Tuberculin Skin Test (TST) screening on healthcare workers revealed 345 LTBI cases out of 2,371 healthcare workers examined at Community Health Centers [21]. To date, research identifying risk factors for latent tuberculosis infection in health workers at Community Health Centers (Puskesmas) is still rare,

especially in developing countries like Indonesia. Therefore, researchers are interested in conducting a study with a population of health workers at Community Health Centers in Makassar City using the Tuberculin Skin Test method with a case-control design to conclude causation. It is hoped that the results can serve as a reference for future actions to prevent latent tuberculosis infection in health workers and reduce the risk of reactivation of active tuberculosis.

METHOD

The study is an analytical observational study with a retrospective case control design which aims to determine the relationship between risk levels and disease events based on cases that have occurred so that analysis is carried out on the case group (patient group) and the control group (non-patient group) [22]. This study aims to analyze the risk of age, gender, contact history, BCG immunization history, length of service, LTBI training history, nutritional status, mask use history, active/passive smoking, comorbid diabetes mellitus, and the most dominant risk factors for the incidence of latent tuberculosis infection in health workers at community health centers in Makassar City. The population of this research case is all health human resources (HR) of community health centers who conducted tuberculin tests in 2025 as recorded in the SITB of the Health Service in Makassar City. Sampling in this study is as follows:

Case

The case sample of this study was conducted with total sampling, namely covering the entire population of latent tuberculosis infection sufferers in health workers recorded in SITB spread across health centers throughout Makassar City, totaling 345 cases.

Control

The control sample for this study consisted of health workers from all community health centers in Makassar City who did not suffer from latent tuberculosis infection and had negative tuberculin test results. This control sample was taken using a simple random sampling technique from the same community health centers as the case study using the Random Number Generator (RNG) application and will be selected by the absence sequence number from the community health center's monthly absence report. The selection ratio used was 1:1.

1. Case sample inclusion criteria

- Patients with latent tuberculosis infection are health workers who work at the Makassar City community health center.

- Results of the tuberculin skin test with an induration diameter of ≥ 10 mm
 - Registered in SITB in 2025
2. Control sample inclusion criteria
- Not a sufferer of latent tuberculosis infection among health workers at the same health center as the case sample
 - Have taken a Tuberculin Skin Test with a negative result
3. Exclusion criteria
- Not willing to be interviewed
 - Health workers on study leave or transfer of duties

During the data collection process, researchers were assisted by enumerators, who were TB program managers at community health centers, who assisted with interviews and observations. Prior to the interviews at the community health center, enumerators received on-the-job training to align their perceptions and ensure the data collection process aligned with the research objectives. To minimize interviewer bias, enumerators received standardized training prior to data collection. A structured questionnaire was used, and enumerators were not informed about the study hypotheses. Data verification was conducted by the principal investigator to ensure consistency and accuracy.

Statistical analysis was performed using Jamovi. Bivariate analysis was performed using the Odds Ratio (OR) test to analyze the risk of variables such as age, gender, contact history, BCG immunization history, length of service, LTBI training, BMI, history of mask use, active/passive smoking, and comorbidities on the incidence of latent tuberculosis infection in health workers. Multivariate analysis was performed using the Logistic Regression test to identify independent variables that have the most significant influence on the incidence of LTBI in health workers. This study has received a recommendation for Research Ethics approval from the Faculty of Public Health, Hasanuddin University with Number: 1528/UN4.14.1/TP.01.02/2025 on August 13, 2025.

RESULT

The study was conducted at Community Health Centers throughout Makassar City from August 22 to September 30, 2025. The subjects in this study were all cases and controls selected with a case-control ratio of 1:1. The initial data of cases in this study were 345, but

there were 29 cases that met the exclusion criteria (moved, retired, and stopped) with details of 3 people refused, 13 people stopped their duties, 1 person retired, 9 doctors completed their internships, and 3 people moved their duties, so that those who were willing to be interviewed were 316 cases and 316 controls with the number of respondents at Community Health Centers throughout Makassar City as many as 632.

Table 1 shows that the characteristics of respondents in the case group were D4/S1/Professional education with the most respondents (50.3%) and the control group were D4/S1/Professional education with 181 respondents (57.3%). The characteristics of respondents' ethnicity in the case group were mostly Bugis with 134 respondents (42.4%) and the control group were mostly Bugis with 147 respondents (46.5%). The profession of respondents in the case group was mostly nursing with 79 respondents (25.00%) and the control group was mostly nursing with 119 respondents (38.00%). The characteristics of the health center section in the case group were mostly in the adult and elderly age cluster 3 with 82 respondents (25.9%) and in the control group were mostly in the adult and elderly age cluster 3 with 106 respondents (33.50%). The characteristics of respondents in the case group who took TPT medication were 50 respondents who did not take TPT medication (15.8%) and 266 respondents who took TPT medication (84.2%).

In bivariate analysis, several variables that are at risk for LTBI incidents in health workers at Makassar City Community Health Centers are: gender (OR:1.9), contact history (2.21), history of BCG immunization (2.36), history of mask use (OR=5.01) and active/passive smoking (2.39) (Table 2).

Based on the results of multivariate logistic regression analysis, inconsistent mask use history was the strongest independent factor associated with LTBI in healthcare workers (AOR = 5.20; 95% CI: 3.60–7.51; $p < 0.001$). Healthcare workers who did not consistently use masks were more than five times more likely to experience LTBI compared to those who used masks consistently. Additionally, a history of contact with TB patients (AOR = 2.63; 95% CI: 1.82–3.80; $p < 0.001$) and no history of BCG immunization (AOR = 2.30; 95% CI: 1.50–3.53; $p < 0.001$) were also independently associated with LTBI.

Although smoking status showed a significant association in the bivariate analysis, this variable was not retained in the final multivariate model after adjusting for other variables. This suggests that the effect of smoking on the occurrence of LTBI is likely to

Table 1: Operational Definitions of Study Variables

Variable	Operational definition	Measurement method / Data source	Scale	Category
LTBI (Outcome)	Status of latent TB infection based on Tuberculin Skin Test (TST) results in health workers	SITB/Dinkes data (TST results)	Nominal	Cases: TST positive (induration ≥ 10 mm). Controls: TST negative (as recorded)
Age	Respondent's age at the time of TST screening/research data collection	Questionnaire/HR summary (year)	Ratio $\rightarrow$ categorized	<40 years vs ≥ 40 years
Sex	Biological gender of respondents	Questionnaire/HR summary	Nominal	Male / Female
History of TB contact	Ever had close contact with an active TB patient (at work/home) during a certain period	Interview questionnaire	Nominal	Yes / No
BCG immunization history	History of BCG immunization (or proof of BCG scar if used)	Questionnaire $\pm$ scar observation (if performed)	Nominal	Yes / No
Length of employment	Length of service as a health worker at a community health center (or related facility)	Questionnaire/HR summary (year)	Ratio $\rightarrow$ categorized.	≤ 5 years vs > 5 years
History of LTBI training	Ever participated in formal training/education related to LTBI/TB IPC	Questionnaire	Nominal	Ever / Never
Nutritional status (BMI/IMT)	Nutritional status based on Body Mass Index = Weight (kg) / Height (m^2)	Weight/Height measurement or examination data (specify source)	Ratio $\rightarrow$ classified.	Normal (<25) vs Abnormal (overweight/obese ≥ 25)
History of mask use	Compliance with wearing masks when treating patients (including when in contact with patients who are coughing/suspected of having TB)	Interview/observation questionnaire	Ordinal $\rightarrow$ categorized.	Consistent (always) vs Inconsistent (rarely/never).
Smoking status (active/passive)	Exposure to cigarette smoke: active smoking or exposure to cigarette smoke at home/work	Questionnaire	Nominal	Exposed (active/passive) vs. Not exposed
History of Diabetes Mellitus	History of DM based on diagnosis by health personnel/regular medication (self-report)	Questionnaire (and/or medical evidence if available)	Nominal	DM present / DM absent

Table 2: Characteristics of Respondents

Characteristics	LTBI			
	Case		Control	
	n	%	N	%
Education				
High School	34	10.80	12	3.80
D3	107	33.90	101	32.00
D4/Bachelor's Degree/Professional Degree	159	50.30	181	57.30
Master's	16	5.10	22	7.00
Total	316	100.00	316	100.00
Ethnic group				
Bugis	134	42.40	147	46.50
Makassar	104	32.90	100	31.60
Toraja	35	11.10	27	8.50
Mandar	5	1.60	2	0.60
Enrekang	11	3.50	7	2.20
Luwu	3	0.90	7	2.20
Other	24	7.60	26	8.20
Total	316	100.00	316	100.00
Profession				
General Practitioner	20	6.30	13	4.10
Dentist	6	1.90	7	2.20

(Table 2). Continued

Characteristics	LTBI			
	Case		Control	
	n	%	N	%
Nurse	79	25.00	120	38.00
Midwife	67	21.20	62	19.60
Laboratory Assistant	26	8.20	23	7.30
Epidemiologist	7	2.20	9	2.80
Health Promotion	12	3.80	9	2.80
Nutritionist	4	1.30	5	1.60
Medical Records	19	6.00	13	4.10
Pharmacist	12	3.80	16	5.10
Other	64	20.30	39	12.30
Total	316	100.00	316	100.00
PART				
Cluster 1: Management	56	17.70	34	10.80
Cluster 2: Mothers and Children	70	22.20	63	19.90
Cluster 3: Adults and the Elderly	82	25.90	106	33.50
Cluster 4: Infectious Disease Management	36	11.40	43	13.60
Cluster 5: Cross-Cluster	72	22.80	70	22.20
Total	316	100.00	316	100.00
Take TPT medication				
No	50	15.80	0	0
Yes	266	84.20	0	0
Total	316	100	0	0

be confounded by other variables in the model. The probability of LTBI occurrence was calculated using the following logistic regression equation:

$$\text{logit}(P) = -1.568 + 0.968X_1 + 0.831X_2 + 1.649X_3$$

$$P = \frac{1}{1 + \exp^{(-(-1.568 + 0.968 + 0.831 + 1.649))}}$$

$$P = \frac{1}{1 + \exp^{(-1.880)}}$$

$$P = \frac{1}{1 + 0.153} = 0.867$$

The results of the calculation of these values indicate that a history of high-risk contact, a history of high-risk immunization, and a history of high-risk mask use have an 86.7% chance of LTBI occurrence in health workers at Makassar City community health centers.

DISCUSSION

This study identified several factors that play a role in the incidence of latent tuberculosis infection (LTBI) among health workers at the Makassar City Community Health Center. The main findings show that behavioral factors and direct exposure in the workplace play a stronger role than demographic characteristics alone. This indicates that the risk of LTBI among health

workers is more influenced by the intensity and quality of interaction with TB patients and adherence to infection prevention practices. Age did not show a significant relationship with the incidence of LTBI. These findings are in line with a study in Semarang, which also found no significant differences between age groups of health workers [15], as well as a study at the Central Anatolian Hospital, Italy [23]. Theoretically, increasing age may reflect accumulated exposure to *Mycobacterium tuberculosis* [24]. However, in the context of primary care such as community health centers, job rotation, workload distribution, and the implementation of infection prevention procedures can minimize the influence of age on the risk of infection. The differences in the results reported in the study at Lecce Hospital [25] and other study [26] are likely related to variations in hospital settings, exposure levels, and different infection control policies.

Gender was found to be associated with the incidence of LTBI, with men having a higher risk. These findings are consistent with a study in Morocco [27] and other studies showing similar patterns [28]. A study in Peru also reported an increased risk of LTBI in men compared to women. This difference can be explained by a combination of biological and behavioral factors. Immunologically, there are differences in the immune response between men and women to bacterial infections [29]. In addition, behavioral factors such as

Table 3: Risk Factors for Latent Tuberculosis Infection in Health Workers at Community Health Centres in Makassar City

Variables	LTBI				Total		OR	95% Confidence Intervals		Note
	Case		Control					Lower	Upper	
	n	%	n	%	N	%				
Age										
≥ 40 years	134	42.4	144	45.6	278	44.0	0.879	0.642	1.2	Not Significant
< 40 years	182	57.6	172	54.4	354	56.0				
Gender										
Male	51	16.1	29	9.2	80	12.7	1.9	1.17	3.09	Significant
Female	265	83.9	287	90.8	552	87.3				
Contact History										
Yes	148	46.8	90	28.5	238	37.7	2.21	1.59	3.08	Significant
No	168	53.2	226	71.5	394	62.3				
BCG Immunization History										
No	94	29.7	48	15.2	142	22.5	2.36	1.6	3.49	Significant
Yes	222	70.3	268	84.8	490	77.5				
Years of service										
> 5 years	187	59.2	198	62.7	385	60.9	0.864	0.627	1.19	Not Significant
≤ 5 years	129	40.8	118	37.3	247	39.1				
LTBI Training										
No	231	73.1	229	72.5	460	72.8	1.03	0.727	1.47	Not Significant
Yes	85	26.9	87	27.5	172	27.2				
Nutritional Status/BMI										
BMI ≥ 25	139	44.0	127	40.2	266	42.1	1.17	0.852	1.6	Not Significant
BMI < 25	177	56.0	189	59.8	366	57.9				
Mask										
Inconsistent Use	250	79.1	136	43.0	386	61.1	5.01	3.53	7.12	Significant
Consistent Use	66	20.9	180	57.0	246	38.9				
Smoking Status										
Active/Passive	44	13.9	20	6.3	64	10.1	2.39	1.38	4.16	Significant
Non-smoker	272	86.1	296	93.7	568	89.9				
DM history										
Yes	11	3.5	17	5.4	28	4.4	0.634	0.292	1.38	Not Significant
No	305	96.5	299	94.6	604	95.6				

Table 4: Multivariate Logistic Regression Analysis of Factors Associated with LTBI among Healthcare Workers in Makassar City

Predictor	Estimate	SE	Z	P	Odds ratio	95% Confidence Interval	
						Lower	Upper
Intercept	-1.568	0.180	-8.71	<.001	0.209	0.147	0.297
Contact History	0.968	0.187	5.17	<.001	2.632	1.824	3.800
BCG Immunization History	0.831	0.219	3.79	<.001	2.296	1.495	3.527
History of Mask Use	1.649	0.187	8.80	<.001	5.201	3,603	7.509

smoking habits and differences in the type of service tasks can also affect the level of exposure. History of contact with TB patients is an important determinant in the occurrence of LTBI. Epidemiologically, TB transmission is greatly influenced by the intensity and

duration of contact with infectious cases [30]. Research in Sana'a City, Yemen, showed an increased risk of LTBI in health workers with a history of contact [31], and other studies also reported a high proportion of LTBI in close contact groups [32]. These results

emphasize the importance of implementing strict infection control, especially in service units with a high frequency of interaction with TB patients.

BCG immunization history shows a relationship with the incidence of LTBI. Although the protection of BCG against latent infection is still debated, this vaccine is known to stimulate an immune response to mycobacterial antigens [33]. A study in Thailand reported an increased risk of LTBI among healthcare workers without BCG scars [34] and research in Jember also showed the protective effect of BCG immunization [35]. Variations in findings between studies may be influenced by differences in vaccination coverage, age at immunization, and level of exposure in the workplace. Length of employment did not show a significant association with LTBI. Although theoretically longer duration of employment may increase cumulative exposure [36], studies in Jember [35] and Riyadh [37] also reported similar results. This suggests that length of employment is not always directly proportional to infection risk if infection prevention and control procedures are consistently implemented.

Participation in LTBI training was examined as an occupational characteristic rather than a direct biological risk factor. No significant association was observed between participation in LTBI training and the incidence of LTBI among healthcare workers. Although WHO recommends education and training as a core component of TB prevention programs [38, 39]. Training attendance alone may not directly translate into reduced infection risk. The effectiveness of training likely depends on consistent implementation of infection prevention and control measures in daily practice. Differences in findings across studies, including reports from Sri Lanka [40]. Nutritional status is a condition that reflects an individual's physical appearance, resulting from an imbalance in the metabolism of nutrients excreted by that person. Nutritional status is assessed using the Body Mass Index [41]. These differences indicate that the effectiveness of training is highly dependent on implementation, supervision, and system support in health care facilities. Nutritional status based on body mass index did not show a significant association with LTBI. The relationship between obesity and immune response to TB remains complex [42]. A study in Afghanistan also showed no increased risk of LTBI in groups with normal or low BMI [43]. This suggests that in the healthcare worker population, occupational exposure factors may be more dominant than nutritional status. The use of masks emerged as the factor most consistently associated with LTBI incidence. These results are in line with studies in Colombo [40] and Semarang [45] which showed that compliance with mask use significantly reduced the risk of infection.

Masks act as a barrier against droplets and airborne particles carrying *Mycobacterium tuberculosis* [44]. Therefore, compliance with the use of personal protective equipment is a key component in TB prevention strategies in primary health care facilities. Smoking status showed a relationship in bivariate analysis and was consistent with findings in Morocco [27].

Exposure to cigarette smoke is known to increase susceptibility to TB infection and affect the immune response [46]. However, after adjustment in the multivariate analysis, the effect of smoking was no longer significant. This suggests that the relationship may be influenced by other interrelated factors, such as gender or exposure patterns in the workplace. Diabetes mellitus did not show a significant association in this study. Although some studies have reported an increased risk of LTBI in individuals with DM [31, 48], this association may be influenced by glycemic control and disease severity. This study did not assess these clinical parameters, so the findings should be interpreted with caution. This study has several limitations. Behavioral variables were obtained through self-reports, which could potentially lead to recall bias and misclassification. Environmental factors such as ventilation and room density were not evaluated, even though they play a role in TB transmission. In addition, the study was only conducted at health centers in Makassar City, so generalization to other health facilities should be done with caution. In addition, the use of TB program managers as enumerators may have introduced interviewer bias, although standardized training and supervision were implemented to minimize this risk.

CONCLUSION

This study shows that factors independently associated with the incidence of latent tuberculosis infection (LTBI) among health workers at the Makassar City Community Health Center are a history of contact with TB patients, no history of BCG immunization, and inconsistent use of masks. Among these factors, inconsistent use of masks is the strongest determinant in the multivariate model. These findings emphasize the importance of strengthening infection prevention and control (IPC) efforts in primary health care facilities. The Makassar City Health Office needs to, improve regular screening and early detection of LTBI among health workers, strengthen policies and supervision of personal protective equipment use, and ensure the availability of adequate masks in health care facilities. In addition, training related to TB prevention and control needs to be accompanied by monitoring and evaluation mechanisms to ensure effective implementation in the field. Community health centers

are expected to increase compliance with mask use during service delivery and strengthen a culture of occupational safety to protect health workers from the risk of TB exposure in the workplace.

ACKNOWLEDGEMENTS

The researchers would like to express their gratitude to the South Sulawesi Provincial Health Office, Makassar City Health Office, and Makassar City Community Health Centers for their support and assistance in data collection during the research.

REFERENCES

- [1] Nasry Noor N. *Epidemiology of Infectious Diseases*. First Edition. Makassar: UPT Unhas Press 2021.
- [2] Widoyono. *Tropical Diseases: Epidemiology, Transmission, Prevention & Eradication*. Jakarta: Erlangga Publishers 2008.
- [3] Ministry of Health of the Republic of Indonesia. Report on the Tuberculosis Control Program for the Year 2023 [Internet]. Jakarta; 2024. Available from: https://www.tbindonesia.or.id/wp-content/uploads/2024/12/Laporan-Program-Penanggulangan-TBC-2023_Final.pdf
- [4] WHO. *Global Tuberculosis Report 2024* [Internet]. 1st ed. Geneva: World Health Organization; 2024. 1 p. Available from: <https://iris.who.int/server/api/core/bitstreams/7292c91e-ffb0-4cef-ac39-0200f06961ea/content>
- [5] PDPI. *Tuberculosis: Guidelines for Diagnosis and Management in Indonesia* [Internet]. Revised Edition 2. Jakarta: Indonesian Lung Doctors Association; 2021. Available from: https://www.tbindonesia.or.id/wp-content/uploads/2021/06/UMUM_PNPK_revisi.pdf
- [6] Hengky HK, Maria IL, Safar M, Khuzaimah A, Amir MY, Santoso A. Childhood Tuberculosis: Epidemiology, Etiology, Pathophysiology, Pathogenesis, Risk Factors, Prevention and Diagnosis: A Narrative Review. *International Journal of Statistics in Medical Research* [Internet] 2025. <https://doi.org/10.6000/1929-6029.2025.14.38>
- [7] Houben RMGJ, Dodd PJ. The Global Burden of Latent Tuberculosis Infection: A Re-estimation Using Mathematical Modelling. Metcalfe JZ, editor. *PLoS Med* 2016; 13(10): e1002152. <https://doi.org/10.1371/journal.pmed.1002152>
- [8] Shrestha AB, Siam IS, Tasnim J, Dahal A, Roy P, Neupane S, *et al.* Prevalence of latent tuberculosis infection in Asian nations: A systematic review and meta-analysis. *Immunity Inflammation & Disease* 2024; 12(2): e1200. <https://doi.org/10.1002/iid3.1200>
- [9] Ding C, Hu M, Guo W, Hu W, Li X, Wang S, *et al.* Prevalence trends of latent tuberculosis infection at the global, regional, and country levels from 1990–2019. *International Journal of Infectious Diseases* 2022; 122: 46-62. <https://doi.org/10.1016/j.ijid.2022.05.029>
- [10] Ogu C, Ebenezar C, Nwaogwugwu O, Ogu R, Nduka I. Tuberculin Skin Test Reactivity among Health Care Workers in the Abia State University Teaching Hospital, Aba South-east Nigeria. *TOIDJ* 2024; 16(1): e18742793270091. <https://doi.org/10.2174/0118742793270091240126112157>
- [11] Park JS. The Prevalence and Risk Factors of Latent Tuberculosis Infection among Health Care Workers Working in a Tertiary Hospital in South Korea. *Tuberc Respir Dis* 2018; 81(4): 274. <https://doi.org/10.4046/trd.2018.0020>
- [12] Belo C, Naidoo S. Prevalence and risk factors for latent tuberculosis infection among healthcare workers in Nampula Central Hospital, Mozambique. *BMC Infect Dis* 2017; 17(1): 408. <https://doi.org/10.1186/s12879-017-2516-4>
- [13] Guo HY, Zhong QH, Zhou J, Zhao ZM, Zhang XL, Chen ZH, *et al.* Risk of prevalence of latent tuberculosis infection in healthcare workers—an idiographic meta-analysis from a Chinese perspective. *J Thorac Dis* 2021; 13(4): 2378-92. <https://doi.org/10.21037/jtd-20-1612>
- [14] Fenty A. Factors Associated with Latent Tuberculosis Infection Among Healthcare Workers at Lubuk Alung Specialized Lung Hospital. Master's thesis, Andalas University 2016.
- [15] Erawati M, Andriany M. The Prevalence and Demographic Risk Factors for Latent Tuberculosis Infection (LTBI) Among Healthcare Workers in Semarang, Indonesia. *JMDH* 2020; 13: 197-206. <https://doi.org/10.2147/JMDH.S241972>
- [16] Angelia A, Doda DVD, Manampiring AE. Prevalence of Latent Tuberculosis and Evaluation of Hospital Policies Based on Healthcare Workers' Perceptions of Tuberculosis Prevention. *JBM* 2020; 12(3): 192. <https://doi.org/10.35790/jbm.12.3.2020.31632>
- [17] Maulana I. Factors Associated with Latent Tuberculosis Infection Among Healthcare Workers at the West Sumatra Lung Hospital. Padang: Thesis, Andalas University 2023.
- [18] Alfiiyyah A. Analysis of Quality Control of Pulmonary Tuberculosis (TB) Infection Among Staff at Hospital X in Depok in 2024 [Internet]. Depok: Thesis, FKM-UI; 2024. Available from: <https://lib.fkm.ui.ac.id/detail?id=137386&lokasi=lokal>
- [19] Apriani L, McAllister S, Sharples K, Alisjahbana B, Ruslami R, Hill PC, *et al.* Latent tuberculosis infection in healthcare workers in low- and middle-income countries: an updated systematic review. *Eur Respir J* 2019; 53(4): 1801789. <https://doi.org/10.1183/13993003.01789-2018>
- [20] South Sulawesi Provincial Health Office. South Sulawesi Provincial TB Management 2025;
- [21] Makassar City Health Department. TB Manager of Makassar Province 2025.
- [22] Nasry Noor N, Arsin AA. *Basic Epidemiology*. First Edition. Makassar: Unhas Press 2022.
- [23] Ture Z. Latent Tuberculosis Infection in Healthcare Workers: A Cross-Sectional Study from a Tertiary Hospital in Central Anatolia. *J Clin Pract Res* 2024; 484-90. <https://doi.org/10.14744/cpr.2024.23434>
- [24] Nababan B, Triasih R, Chan G, Dwiwardiani B, Hidayat A, Dewi SC, *et al.* The Yield of Active Tuberculosis Disease and Latent Tuberculosis Infection in Tuberculosis Household Contacts Investigated Using Chest X-ray in Yogyakarta Province, Indonesia. *Tropical Med* 2024; 9(2): 34. <https://doi.org/10.3390/tropicalmed9020034>
- [25] d'Ettorre G, Karaj S, Piscitelli P, Maiorano O, Attanasi C, Tornese R, *et al.* Right to Occupational Safety: Prevalence of Latent Tuberculosis Infection in Healthcare Workers. A 1-Year Retrospective Survey Carried out at Hospital of Lecce (Italy). *Epidemiologia* 2023; 4(4): 454-63. <https://doi.org/10.3390/epidemiologia4040038>
- [26] Klayut W, Srisungngam S, Suphankong S, Sirichote P, Phetsuksiri B, Bunchoo S, *et al.* Prevalence, Risk Factors, and Result Features in the Detection of Latent Tuberculosis Infection in Thai Healthcare Workers Using QuantiFERON-TB Gold Plus. *Cureus* [Internet] 2024; [cited 2025 May 8]. <https://doi.org/10.7759/cureus.60960>
- [27] Boucaid A, Zegmout A, Bhairis M, Amraoui M, Laaraje A, Kabiri EH, *et al.* Epidemiology of Latent Tuberculosis in Moroccan Healthcare Workers: Prevalence Patterns and Predisposing Factors. *Cureus* [Internet] 2024; [cited 2025 May 13]. <https://doi.org/10.7759/cureus.75740>
- [28] Meregildo-Rodriguez ED, Yuptón-Chávez V, Asmat-Rubio MG, Vásquez-Tirado GA. Latent tuberculosis infection (LTBI) in health-care workers: a cross-sectional study at a northern Peruvian hospital. *Front Med* 2023; 10: 1295299. <https://doi.org/10.3389/fmed.2023.1295299>
- [29] Dias SP, Brouwer MC, Van De Beek D. Sex and Gender Differences in Bacterial Infections. Richardson AR, editor. *Infect Immun* 2022; 90(10): e00283-22. <https://doi.org/10.1128/iai.00283-22>

- [30] Sopacuaperu SKV, Wowor TJF. Factors Associated with the Incidence of Pulmonary Tuberculosis in Xyz. *Journal of Science and Technology* 2024.
- [31] Al-Khamesy KSA, Al-Shehari MM, Al-Moyed KAKA, Atf-allah JYY, Al-Shamahy HA, Al-Hadad AM. Prevalence and Risk Factors of Latent Tuberculosis Among Healthcare Workers in Sana'a City, Yemen Using Whole Blood Interferon- γ Release Assay. *Univ J Pharm Res* [Internet] 2022; [cited 2025 May 13]. <https://doi.org/10.22270/ujpr.v7i5.833>
- [32] Birroudhoh F. Early Detection of Latent Tuberculosis Infection (LTBI) in Household Contacts of Tuberculosis Patients Using the Mantoux Test at the Rengel Community Health Center. *ARL* 2024; 8(10): 2867-70. <https://doi.org/10.46799/ar.v8i11.2218>
- [33] Morrison H, McShane H. BCG: Past, Present and Future Direction. In: Christodoulides M, editor. *Vaccines for Neglected Pathogens: Strategies, Achievements and Challenges* [Internet]. Cham: Springer International Publishing 2023 [cited 2025 Nov 19]. pp. 171-95. https://doi.org/10.1007/978-3-031-24355-4_8
- [34] Chanpho P, Chaiear N, Kamsa-ard S. Factors Associated with Latent Tuberculosis Infection among the Hospital Employees in a Tertiary Hospital of Northeastern Thailand. *IJERPH* 2020; 17(18): 6876. <https://doi.org/10.3390/ijerph17186876>
- [35] Wardani HR, Mertaniasih NM, Soedarsono S. Risk Factors Of Latent Tuberculosis Infection In Healthcare Workers At Hospitals In Jember City Indonesia. *AJID* 2021; 15(1): 34-40. <https://doi.org/10.21010/ajid.v15i1.4>
- [36] Rosamarlina, Jahiroh, Lisdawati V, Hendrawati N, Sundari T, Rusli A, *et al.* Duration of Work Improves Risk of Latent TB Infection in Health-Care Workers. In: *Proceedings of the 4th International Symposium on Health Research (ISHR 2019)* [Internet]. Bali, Indonesia: Atlantis Press 2020 [cited 2025 May 15]. <https://doi.org/10.2991/ahsr.k.200215.053>
- [37] Almohaya A, Aldrees A, Akkielah L, Hashim AT, Almajid F, Binmoammar T, *et al.* Latent tuberculosis infection among health-care workers using Quantiferon-TB Gold-Plus in a country with a low burden for tuberculosis: prevalence and risk factors. *Ann Saudi Med* 2020; 40(3): 191-9. <https://doi.org/10.5144/0256-4947.2020.191>
- [38] Ministry of Health of the Republic of Indonesia. Guidelines for Training and Competency Improvement in the Health Sector [Internet]. Jakarta: Directorate of Health Workforce Quality Improvement; 2023. Available from: https://ditmutunakes.kemkes.go.id/assets/images/panduan/695368_pedoman-pelatihan-dan-peningkatan-kompetensi-bidang-kesehatan_20240226151838.pdf
- [39] WHO. WHO guidelines on tuberculosis infection prevention and control: 2019 update. Geneva: World Health Organization; 2019. 1 p. https://www.ncbi.nlm.nih.gov/books/NBK539297/pdf/Bookshelf_NBK539297.pdf
- [40] Yasaratna NR, Weerasinghe MC. Risk Factors for Latent Tuberculosis among Health-care Workers in Sri Lanka. *WHO South-East Asia Journal of Public Health* 2024; 13(1): 9-15. https://doi.org/10.4103/WHO-SEAJPH.WHO-SEAJPH_42_24
- [41] Yusnitasari As, M. Thaha II, Syafar M. Comorbidity Of Diabetes Mellitus On Clinical Manifestations And Quality Of Life In Patients With Pulmonary Tuberculosis. *Mkmi* 2016; 11(2): 86-91. <https://doi.org/10.30597/mkmi.v11i2.529>
- [42] Deddy Herman, Rizanda Machmud, Nur Indrawaty Lipoeto. Unraveling the Link between Obesity and Tuberculosis: A Systematic Review of the Underlying Mechanisms. *Biosmed* 2024; 9(2): 6453-66. <https://doi.org/10.37275/bsm.v9i2.1205>
- [43] Qader GQ, Seddiq MK, Rashidi KM, Manzoor L, Hamim A, Akhgar MH, *et al.* Prevalence of latent tuberculosis infection among health workers in Afghanistan: A cross-sectional study. *Kumar R, editor. PLoS ONE* 2021; 16(6): e0252307. <https://doi.org/10.1371/journal.pone.0252307>
- [44] Solberg RB, Fretheim A, Elgersma IH, Fagernes M, Iversen BG, Hemkens LG, *et al.* Personal protective effect of wearing surgical face masks in public spaces on self-reported respiratory symptoms in adults: pragmatic randomized superiority trial. *BMJ* 2024; 386: e078918. <https://doi.org/10.1136/bmj-2023-078918>
- [45] Erawati M, Andriany M. Determinants of latent tuberculosis infection among nurses at public health centers in Indonesia. *Belitung Nurs J* 2022; 8(1): 28-34. <https://doi.org/10.33546/bnj.1846>
- [46] Sujana SP, Hamda FH, Latif YI, Asyary A. The association between secondhand smoke exposure and risk of developing active tuberculosis in individuals with latent tuberculosis infection: a systematic literature review 2025.
- [47] Suci D, Arsin AA, Noor NN, Saleh LM, Nasir S. Risk Factor Analysis of Latent Tuberculosis Infection in Mamuju Tengah Regency 2024; 14(2): 622-632.
- Zhou G, Guo X, Cai S, Zhang Y, Zhou Y, Long R, *et al.* Diabetes mellitus and latent tuberculosis infection: an updated meta-analysis and systematic review. *BMC Infect Dis* 2023; 23(1): 770 <https://doi.org/10.1186/s12879-023-08775-y>

Received on 10-01-2025

Accepted on 15-02-2026

Published on 11-03-2026

<https://doi.org/10.6000/1929-6029.2026.15.09>© 2026 Nofian *et al.*

This is an open-access article licensed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the work is properly cited.