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Determining Factors of Lung Tuberculosis among Indonesian Children in Community Health Centers: A Cross-sectional Study

Machrumnizar Machrumnizar[1*], Yuliana Yuliana[2], Adang Bachtiar[3*]

[1]Doctoral Program, Faculty of Public Health, University of Indonesia, Indonesia
[2]Departement of Parasitology, Faculty of Medicine, Universitas Trisakti
[3]Department of Health Analysis and Policy, Faculty of Public Health, University of Indonesia, Indonesia

Corresponding author: adang@post.harvard.edu*

Abstract

Background: Tuberculosis is a serious global health issue and is particularly prevalent among children. Early and correct diagnosis is very important for effective management, but tuberculosis diagnosis in children is often difficult because the clinical symptoms are non-specific and difficult to collect specimens. This study aims to determine risk factors based on sociodemographic, socioeconomic, nutrition and clinical status associated with tuberculosis. **Methods:** This study is a cross-sectional study. Children aged 0 to 14 years who came to the community health center with one or more clinical symptoms related to TB from January to December 2023 were studied. Research participants underwent two diagnostic methods, clinical and bacteriological. **Results:** Positif Clinical diagnosis was found to be 72.4%. Meanwhile, bacteriologically confirmed participants were 10.3%, the remainder were unable to produce sputum. Most respondents were men (62.8%), with 66% of respondents aged ≥5 years, and those sociodemographic factors have a significant relationship with tuberculosis in children ($p<0.05$). This study found that 64.7% of respondents had a BMI <18.5 and significantly related to tuberculosis in children ($p<0.05$). Furthermore, tuberculosis incidence and malnutrition also have a significant relationship ($p<0.05$). Contact with active tuberculosis cases shows a significant difference in the proportion of tuberculosis and non-tuberculosis cases ($p=0.009$), while 57.1% of children were exposed to cigarette smoke ($p<0.05$). Government health insurance (BPJS) was used by 70.5% of respondents who were tested positive for tuberculosis, and it is statistically significant ($p<0.05$). Other socio-economic factors were also significant ($p <0.05$) for tuberculosis cases in children whose parents had low education at 85.9%; have 96.8% of jobs with a household income equal to or more than the provincial minimum wage (UMP) of 60.3%. **Conclusion:** In the future, these factors can be utilized to construct prediction models for clinical diagnosis in children suspected of tuberculosis, especially machine learning-based models, in addition to tuberculosis-related clinical symptoms.

Keyword: pediatrics, contact with active tuberculosis cases, tuberculosis, risk factor, comorbidity

Introduction

Among the leading source for morbidity and death in children aged 0 – 14 years is tuberculosis (TB), which is around 12% of the total 10.6 million TB sufferers in the world in 2023 and contributes to 3 – 25% of the total TB caseload [1]. Children might represent up to 20% of the global burden of TB in endemic spots, hence the real situation can vary from forecasts given adequate reporting systems and appropriate diagnosis [2]. Still, there is a fairly modest rate of TB identified cases and notification, particularly in developing nations with limited resources, such as Indonesia, the estimated TB incidence of children aged 0 – 14 in 2022 is 110,881 children or around 15.3% of all TB cases in Indonesia [3]. According to a survey by The United Nations International Children's Emergency Fund (UNICEF), 35 percent of instances of TB among children between the ages of 0 and 14 go unreported, meaning these 110,881 children are only 65% of the total child TB cases in 2022 [4]. Mentioned data indicate the level of community transmission is relatively high.

Bacteriological testing is the standard diagnosis in adult TB but has low sensitivity and specificity when used in children [5]. Since the prevalence of TB in children serves as an immediate clue and surrogate for TB spreads in the community, there is a dearth of novel, easily used, and inexpensive diagnostic methods for TB, especially in remote areas with limited laboratory and x-ray facilities, adds to existing problems [4]. Diagnosis of tuberculosis in children aged 0 – 14 years without specific symptoms is a big challenge for doctors, academics, and program managers because it can hinder diagnosis and lead to worse treatment outcomes [6]. Current diagnostic methods have limited sensitivity, especially in children aged 0 – 14 years [7]. The scoring system, which is an alternative for diagnosing TB in children, is not yet fully implemented according to guidelines [3,8].

Despite clinical and biological variables, there are several socioeconomic and environmental variables that increase the likelihood of TB in children between the ages of 0 and 14. These risk factors are very useful for predicting the development of TB disease. Therefore, knowing the risk factors for TB in children is crucial for making the diagnosis and initiating treatment as soon as possible for the best outcomes. Community health centers in Indonesia are the main place where TB patients seek treatment, so they are the starting point for TB case care which includes early diagnosis, treatment, and reporting. The purpose of this study is to assess the sociodemographic, socioeconomic, and clinical risk factors for TB in children ages 0 to 14 who exhibit one or more TB-related clinical symptoms.

Material and Methods

Data collection

This research was conducted at a community health center in the administrative area of South Jakarta, Indonesia. The respondents are children, aged 0 to 14 years, who came with a cough to receive treatment at the community health centers, between January and December 2023.

Research design

We used a cross-sectional design and studied children with normal nutritional status or malnutrition, including all genders, aged 0 to 14 years, who came with a cough to receive treatment at the community health centers, between January and December 2023. Respondents were determined using consecutive sampling and the sample size was determined using the total sampling method, all respondents who met the inclusion criteria would be included in the study.TB diagnosis is categorized based on clinical diagnosis (accompanied by x-rays and/or tuberculin tests) and bacteriology. The clinical diagnosis was determined by the occurrence or absence of symptoms of a persistent cough lasting more than 2 weeks, weight depletion or no weight gain in the previous two months, fever ≥2 weeks, and malaise ≥2 weeks. Socio-demographic factors (age, gender, age group, weight, height, nutritional status) were recorded during the history taking.

Contact with active TB cases, history of BCG immunization and exposure to cigarette smoke/air pollution were categorized dichotomously. Socio-economic factors (education, employment and parental income, and health insurance) were also categorized dichotomously. This study also recorded the presence or absence of comorbid factors (HIV and DM). A child's nutritional status is determined by the body mass index, or BMI, is calculated using the ratio between body weight in kilograms and height in meters squared. Furthermore, the BMI value of children aged 0-60 months must be compared with the WHO 2005 standard BMI value (WHO, 2006); and BMI values for children and adolescents (5–19 years old) in comparison to the WHO/NCHS 2007 reference (WHO, 2007).

Data analysis

All data that had been collected and entered standard Microsoft Excel was then analyzed using SPSS for Windows (SPSS Inc version 25.0, Chicago, IL). Variables were initially examined univariately, and then a Chi-square statistic was used to evaluate categorical variables in order to determine risk factors in children with tuberculosis. The McNemar statistic was used to estimate the proportion of risk variables between TB and non-TB patients. A statistically significant probability if smaller than 0.05. The odds ratio (OR) and 95% confidence interval (CI) were computed to ascertain the strength of the link.

Results

In this study, 113 out of 156 respondents were diagnosed with pulmonary TB from January to December 2023. Of the TB cases who received treatment, 72.4% of respondents were clinically diagnosed with pulmonary TB. Meanwhile, bacteriologically confirmed TB cases were found in 10.3% of respondents and 89.7% of respondents were unable to produce phlegm. Most of responders (62.8%) were boys, with 34% being less than five years old and 66% being older than five (**Table 1**).

The nutritional status was assessed using the BMI, 64.7% of respondents had a BMI <18.5 and it was significantly associated with the incidence of childhood TB ($p<0.05$). A previous record of interaction with active tuberculosis patients was reported by 54.5% of the respondents. The proportion of TB and non-TB occurrences in the child group differs significantly when exposed to cases of active TB (p-value=0.002). Most respondents received BCG immunization, namely 73.1%. Respondents more often had a history of exposure to cigarette smoke, namely 57.1%, but all respondents did not have a history of HIV and diabetes (**Table 1**).

Most respondents came to the health center with cough symptoms, namely 79.5% and the remaining 20.5% did not experience cough complaints. The change in body weight was not much different, only 49.4% of respondents experienced weight loss. 55.8% of respondents had fever and 44.2% did not have fever, malaise was present in 59.6% of respondents and 40.4% did not have malaise (**Table 1**). All respondents did not use private insurance, but most respondents used BPJS insurance facilities, 70.5%, while 29.5% did not have insurance. Most of the patient's household income corresponds to or exceeds the provincial minimum wage (UMP) of 60.3%. Almost all the respondents' parents had jobs, 96.8% of whom were grouped as non-PNS 85.9% and PNS 10.9%, but only 14.1% had higher education (**Table 2**).

Most respondents were diagnosed with TB based on clinical diagnosis, because it was difficult to obtain children's sputum specimens for bacteriological examination. A bacteriological diagnosis could only be made in 10.3% of respondents and the majority (81.25%) were >10 years old. According to sociodemographic data (**Table 1**) indicates that there are statistically significant variations in proportions of boys and girls ($p<0.001$), body weight ($p<0.001$), height ($p<0.001$). This study showed a notable association between the incidence of TB and nutritional status ($p=0.035$), exposure to cigarette smoke or air pollution ($p=0.006$), but not significantly with BCG immunization ($p=0.328$).

Regarding socioeconomic factors (**Table 2**), TB in childhood occurs more often in families with lower parental education ($p=0.005$), parents who have jobs ($p<0.001$), parental income greater than or equal to the UMP ($p<0.001$) and have health insurance ($p<0.001$). The association among clinical features and the incidence of pediatric TB patients with bacteriological diagnosis is displayed in **Table 3**. Symptoms of cough ($p<0.001$), subfebrile fever ($p<0.001$), malaise ($p<0.001$), and weight loss or no weight gain ($p<0.001$) showed significant differences in proportion between TB and non-TB events.

Table 1. Characteristics related to sociodemographic factors, TB contact, BCG immunization, nutritional status, and Exposure to smoking/air pollution between TB and non-TB respondents.

Characteristics	Frequency		TB	Non-TB	p-Value	Odd Ratio (OR)	95% CI
	N, mean	%, SD					
Bacteriological diagnosis							
1.Yes 2.No	16 140	10.3 89.7	16 97	0 43	**0.009***	**-**	**-**
Age (year)							
1.<5 years **2.**≥5 years	53 103	34 66	38 75	15 28	**0.000¶**	0.964 1.019	0.594 – 1.564 0.790 – 1.315
Gender							
1.Boy 2.Girl	98 58	62.8 37.2	72 41	26 17	**0.000¶**	1.054 0.918	0.797 – 1.393 0.589 – 1.429
Weight (kg)	19.6218	8.94918			**0.000***	-	18.21 – 21.04
Height (cm)	104.3910	26.23235			**0.000***	-	100.24 – 108.54
Body Mass Index (BMI)							
1.<18.5 **2.**>18.4	101 55	64.7 35.3	91 22	10 33	**0.000***	3.463 0.254	1.997 – 6.005 0.168 – 0.382
Contacts with active TB patients							
1.Yes 2.None	85 71	54.5 45.5	62 51	23 20	**0.002¶**	1.026 0.970	0.741 – 1.420 0.664 – 1.418
BCG immunization							
1.Yes 2.No	114 42	73.1 26.9	85 28	29 14	0.328*	1.115 0.761	0.883 – 1.408 0.445 – 1.302
nutritional status							
1.Malnutrition 2.Normal	100 56	64.1 35.9	90 23	10 33	**0.000***	3.425 0.265	1.974 – 5.941 0.178 – 0.396

Smoke exposure/air polution							
1.Yes	89	57.1	65	24	**0.006¶**	1.031	0.756 – 1.405
2.None	67	42.9	48	19		0.961	0.645 – 1.432

**Chi-square test, p-value <0.05; ¶McNemar test, p-value <0.05*

Table 2. Characteristics related to socioeconomic factors, clinical symptoms, and smoke exposure between TB and non-TB respondents.

Characteristics	Frequency		TB	Non-TB	p-Value*	Odd Ratio (OR)	95% CI
	N, mean	%, SD					
Parents education							
1.Low **2.**High	134 22	85.9 14.1	97 16	37 6	**0.005¶**	0.998 1.015	0.66 – 1.150 0.425 – 2.422
Parents occupation							
• Not working • Working	5 151	3.2 96.8	4 109	1 42	**0.000¶**	1.522 0.988	0.175 – 13.238 0.932 – 1.047
Household income							
• < UMP • >= UMP	62 94	39.7 60.3	42 71	20 23	**0.000¶**	0.799 1.175	0.536 – 1.192 0.859 – 1.606
Government health insurance							
1. None 2. Yes	46 110	29.5 70.5	30 83	16 27	**0.000¶**	0.713 1.170	0.435 – 1.170 0.906 – 1.510
Chronic coughing ≥2 weeks							
1. Yes 2. None	124 32	79.5 20.5	90 23	34 9	0.937*	1.007 0.972	0.842 – 1.206 0.490 – 1.931
Weight loss or does not increase in the last 2 months							
1.Yes 2.None	77 79	49.4 50.6	60 53	17 26	**0.000¶**	1.343 0.776	0.893 – 2.020 0.568 – 1.059
Subfebris febris ≥2 weeks							
1.Yes 2.None	87 69	55.8 44.2	63 50	24 19	**0.003¶**	0.999 1.001	0.731 – 1.365 0.675 – 1.486

Malaise ≥ 2 weeks							
1. Yes	93	59.6	67	26	**0.024¶**	0.981	0.737 – 1.305
2. None	63	40.4	46	17		1.030	0.669 – 1.585

**Chi-square test, p-value <0.05; ¶McNemar test, p-value <0.05.*

Table 3. Characteristics related to clinical factors among TB and non-TB respondents based on bacteriological diagnosis

Characteristics	Frequency		TB	Non-TB	p-Value*	Odd Ratio (OR)	95% CI
	N, mean	%, SD					
Chronic cough ≥2 weeks							
1. Yes	124	79.5	14	110	**0.000¶**	1.114	0.908 – 1.366
2. None	32	20.5	2	30		0.583	0.154 – 2.216
weight drop or did not rise in the previous 2 months							
1. Yes	77	49.4	7	70	**0.000¶**	0.875	0.490 – 1.562
2. None	79	50.6	9	70		1.125	0.708 – 1.787
Subfebris fever ≥2 weeks							
1. Yes	87	55.8	11	76	**0.000¶**	1.266	0.880 – 1.822
2. None	69	44.2	5	64		0.684	0.323 – 1.446
Malaise ≥ 2 weeks							
1. Yes	93	59.6	10	83	**0.000¶**	1.054	0.704 – 1.578
2. None	63	40.4	6	57		0.921	0.474 – 1.788

¶*McNemar test, p-value <0.05*

Discussion

The purpose of this cross-sectional study was to identify the predictive variables for both TB and non-TB diagnoses among children aged 0 – 14 years in Community Health Center facilities in Indonesia. TB risk factors such as HIV and diabetes were not found in child respondents, so no analysis was carried out.

Participants in this study underwent two diagnostic methods, namely clinical and bacteriological. Negative smear test results reportedly contribute to 13–20% of transmission and are, on average, 20–25% more infectious than those with positive test results [9]. Previous studies reported that most TB cases were diagnosed based on clinical criteria (50 – 58%) [10,11]. Likewise, a previous cohort study found 16% (58/372), 95% CI, 12-19% of cases came from smear negative sources [9], meaning 84% of TB cases were smear positive. However, another study reported that 65.2% of TB patients had negative BTA results and 34.8% had positive BTA results [12]. In children, TB disease is generally determined based on clinical diagnosis, which is the accepted method when bacteriological evidence is not available [13]. As is often reported, most respondents were boys. Various studies have similar findings where TB cases occur more often in boys [12,14,15] and variations in the age range of children who contract TB. Younger children are believed to be more affected than older children [16-19] due to household contacts of active TB patients and immature immunity. However, exposure to active TB can also occur in the community. Boys have a tendency for physical activity and high socialization, so they enjoy playing outside the house. This causes boys to potentially encounter adult active TB and be exposed to cigarette smoke or air pollution [20,21].

Malnutrition and tuberculosis (TB) have a reciprocal association in which malnutrition raises the likelihood of getting active TB by six to ten times and TB contributes patients to malnutrition [22,23]. Patients with active TB tend to be underweight, having a BMI below 18.5 kg/m2, which is considered an index of malnutrition. Thus, TB incidence is strongly correlated with poor nutrition and lowly BMI [23]. The possibility of TB increases due to malnutrition, both micro and macro deficits, compromised immunity. Being infected with TB can intensify metabolism and require more energy, which can lead to ease appetites and nutrition malabsorption, ultimately raising the possibility of underweight [22,24]. Previous study found that, compared to the control group, TB patients had a higher likelihood of having a BMI of less than 18.5 kg/m2 [25]. Numerous countries where tuberculosis prevalence is elevated, most children are exposed to cigarette smoke or secondhand smoke. A comprehensive analysis encompassing eighteen observational studies revealed that exposure to tobacco-related smoke resulted in children being 3.41 times more likely to contract tuberculosis and a 1.64-times more likely to develop latent tuberculosis infection [26]. Research in Spain reported that exposure to cigarette smoke in children (95% CI: 9.63–18.17) and had an increased prevalence of TB (13.48%) [27]. Higher vulnerability to pulmonary tuberculosis illness has been attributed to several biological factors, including poor mucosal secretion clearance, impaired alveolar macrophage phagocytic capacity, diminished immunological reaction, and/or CD4+ lymphopenia brought on by cigarette nicotine [28,29]. Another study that looked at the relationship between TB disease and exposure to cigarette smoke also reported that the detrimental impact of smoking on tuberculosis transmission was significantly reduced immediately after smoking cessation, hence highlighting the value of smoking cessation programs in the fight against TB [30]. Case-control studies carried out in Brazil and India have shown that firewood or biomass smoke, apart from cigarette smoke, is a separate threat to TB. But there is currently still a dearth of information about the pathway via which biomass smoke results in chronic pulmonary illness [31,32].

Noticing a high connection between TB disease in children and a history of interaction with the source of TB cases is crucial since it is well-known that the risk of developing TB is directly proportionate to the quantity of germs one receives exposure to [33]. Multivariate analysis in previous research showed a significant relationship between household contacts of children with active TB, obtained OR = 15,288 and 95% CI: 5,378–43,457, household contacts with smokers obtained OR = 7,094 and 95% CI: 2,128–23,648, contacts > 18 hours with TB sufferers obtained OR = 4.681 and 95% CI: 1.198–18.294 [34]. Children beneath the age of five, especially under 1 year, who meet a source of TB cases usually have a 50% chance of contracting TB, and ninety-five percent of TB occurs within a year after contact. Home contacts, caregivers, and medical professionals are considered close contacts of active tuberculosis cases [26] because they have a greater chance of contracting *Mycobacterium tuberculosis* and developing primary active tuberculosis [35,36].

The sole licensed and amply used vaccine to prevent TB prompted by *M. tuberculosis* is Bacillus Calmette-Guérin (BCG) [37,38]. The BCG immunization has been shown to be highly effective in preventing meningitis and miliary TB in children, with a 70 to 80 percent success rate [37, 39]. An 18-year cohort study in Tunisia found 36.5% of TB cases in individuals who received BCG vaccination compared to 63.3% of unvaccinated individuals [40]. The World Health Organization (WHO) lists fever, inexplicable weight decrease, lethargy or exhaustion, sweating at night, chest pain, and cough lasting longer than two weeks as manifestation and indicators of TB. Given the risk of overdue diagnosis in those infected and subsequent spread via close contacts, overtime cough is the most noticed manifestation in tuberculosis thus summons inquiry, particularly in resource-constrained states where tuberculosis incidence rises (defined as $\geq$100 in 100,000 inhabitants) [41]. In the study population conducted in the Philippines, providing positive TB test results, 84.9% experienced cough $\geq$ 2 weeks, fever $\geq$ 2 weeks of unexplained cause (6.9%), considerable and unintended weight loss (9.5%), and 6.3% of patients experienced exhaustion, sluggishness, and malaise [42]. Study finding concluded that all participants with cough symptoms of whichever length for TB examining versed rose sensitivity from forty-two percent to fifty-one percent [43].

This research shows that 70.5% of respondents who have national health insurance facilities (BPJS), 75.5% of respondents tested positive for pulmonary TB. Meanwhile, research in the Philippines reported that 16% of individuals who tested positive for TB were enrolled in a health insurance program (51%) [42]. Since TB is known to be a disease of poverty, national health insurance program in Indonesia's both improves the capacity of TB patients to seek treatment and contributes significantly to TB reporting rate. The study's finding revealed the respondents' parents who were positive for TB had non-PNS jobs with a household income equal to or more than the provincial minimum wage but had low education. A systematic review of studies found a correlation between tuberculosis and a poor educational attainment with a pooled odds ratio = 2.34 [44]. In a South African study including adolescents aged 12 to 18, characteristics that were predictive of TB were older age, ethnic background, low household earning, and basic schooling or lesser for both parents [45]. Due to the correlation with the increasing prevalence of TB, socioeconomic determinants are linked to the availability of healthcare services, the capacity to fulfill nutrition demands, also the availability of a decent and standardized living space [46]. Working parents are linked to external environment and tuberculosis infection, which can spread to children. Exposure that children obtain from a household member who has TB is nearly fourfold inclined to contract the disease [47,48].

Conclusion

Despite the modest study, this study underscores the importance of sociodemographic, socioeconomic, active TB contacts, malnutrition conditions, and exposure to cigarette smoke or air pollution in the diagnosis of tuberculosis in children, in addition to TB-related clinical symptoms (cough, fever, malaise, and weight loss).

Study limitations

This research was conducted at a community health center and there were no patient home visits so it did not analyze environmental factors which are one of the determinants of TB. However, other factors managed to show meaningful results.

Ethical considerations

All procedures involving patients in this study were approved by the Ethical Review Committee of the Faculty of Medicine, Trisakti University No.055/KER/FK/I/2024. Informed consent was signed by all patients' legal guardians.

Acknowledgments

Not Applicable.

Conflict of Interest

The authors have disclosed no conflicts of interest.

Availability of data and materials

The corresponding author will make the datasets used and/or analyzed in this work accessible upon an acceptable request.

Authors' contributions

M.M: study concept, writing up, data interpretation, methodology writing, statistical analysis, Finalize the manuscript revisions and provide approval.

A.B: study concept, revise manuscript, and provide final approval.

Y.Y: data collection, revise manuscript, and provide final approval.

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