ASSOCIATION BETWEEN HOUSEHOLD FOOD INSECURITY AND ACTIVE PULMONARY TUBERCULOSIS AMONG UNDER-FIVE CHILDREN IN LOW-RESOURCE SETTING: A MATCHED CASE-CONTROL STUDY IN WEST SUMATERA, INDONESIA

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ARTICLE HISTORY
Received: 7 April 2025 **Revised:** 21 April 2025 **Published:** 6 May 2025

ABSTRACT
Malnutrition weakens children's immune systems, increasing vulnerability to infections. Household food insecurity (HFI), combined with malnutrition and environmental factors, may elevate the risk of tuberculosis (TB) in children under five, though evidence in this age group remains limited. This study aimed to examine the association between HFI and the odds of active pulmonary TB (PTB). A case-control study was conducted in Padang City from July to December 2024, involving 63 PTB cases (aged 1–5 years) and 252 community-matched controls. Cases were identified through healthcare centers and hospitals using the Xpert MTB/Rif assay and/or clinical criteria. Controls were recruited from the same communities via the Posyandu child-maternal health program and showed no signs of PTB. HFI was assessed using the 18-item Household Food Security Survey Module, categorizing households into food secure, low food security, and very low food security. Potential confounders, including child characteristics, Posyandu attendance, and household smoking, were collected through caregiver interviews and adjusted using multivariable logistic regression. Among participants, 38.1% of PTB cases and 15.1% of controls experienced very low food security. In contrast, 33.3% of cases and 43.7% of controls were food secure. Children with very low food security had significantly higher odds of PTB compared to those in food-secure households (adjusted odds ratio [AOR] = 5.16; 95% CI: 2.03–13.7). Conclusion: Very low household food security is significantly associated with increased PTB risk in children under five. In TB-endemic settings, food security assessments could guide targeted screening efforts in young children.
Keywords: Pediatric Tuberculosis, Household Food Insecurity, Second-Hand Smoke, Posyandu, Syndemic, Indonesia

CITATION INFORMATION: Sekarini, Y., Kumwichar, P., & Chotipanvithayakul, R. (2025). Association between Household Food Insecurity and Active Pulmonary Tuberculosis among Under-Five Children in Low-Resource Setting: A Matched Case-Control Study in West Sumatera, Indonesia. *Procedia of Multidisciplinary Research, 3*(5), 22.

INTRODUCTION

Tuberculosis (TB) remains a major global health concern, with 10.8 million cases annually, two-thirds involving pulmonary TB (PTB) and 1.3 million affecting children. Over 95% of TB-related deaths occur in low- and middle-income countries (LMICs), including Indonesia. Children under the age of five who are affected by malnutrition are at increased risk of mortality, primarily due to underdeveloped immune systems and heightened susceptibility to severe complications (WHO, 2024a).

Household food insecurity (HFI) is a critical determinant of child health, with malnutrition contributing to 1.9 million new TB cases in 2021 (Walcott et al., 2020). Only 10% of TB patients in 11 southern African cities lived in food-secure households (Frayne et al., 2017), and 36% of TB patients of central Indonesia lived in food-secure households (Purwanti et al., 2016). Understanding HFI's impact on pediatric TB is crucial.

This study aimed to determine if there is a statistically significant association between household food insecurity and the odds of active PTB.

LITERATURE REVIEWS

Studies have shown that HFI is linked to a 2-3 times higher risk of developing TB due to compromised immune function and prolonged exposure to infectious household members (Odoms-Young et al., 2024). Food insecurity disproportionately affects children under five, who rely on adequate nutrition for growth, immune development, and disease resistance. Research in sub-Saharan Africa and Southeast Asia has shown that children living in food-insecure households are at a significantly higher risk of TB infection (Frayne et al., 2017).

Assessing HFI provides an alternative method for identifying at-risk children without requiring complex nutritional assessments (Datta Banik, 2023). The Food Security Supplement (FSS) is a widely used tool to evaluate food availability, access, and coping strategies within households (Rabbitt, 2023). This approach has been validated as an effective method for predicting nutritional risks and health outcomes in children (Coleman-Jensen et al., 2010). Unlike biochemical assessments or anthropometric measures, HFI evaluation is cost-effective, simple to administer, and adaptable for large-scale epidemiological studies (Fautsch Macías & Glasauer, 2014).

RESEARCH METHODS

Study Design and Setting

This study took place in Sumatra Barat Province, Indonesia, a region encompassing 19 cities and regencies. In 2023, Sumatera Barat had an estimated 266 TB cases per 100,000 population (Codingest, 2023). Notably, Padang City served as the municipality and was distinguished as an urban hub with the densest population in the province. Padang Municipality had a higher estimated TB case rate than other cities in Sumatra Barat. Since 2019, Padang Municipality had an estimated 521 cases per 100,000 population (Kementerian Kesehatan RI, 2023a).

Population and sample

Cases were children aged 1 to 5 years diagnosed with active PTB by either microbiological confirmation (positive Xpert MTB/Rif assay) or clinical criteria based on the Indonesian National TB Guidelines (Kementerian Kesehatan RI, 2023b). Clinical diagnosis followed a Ministry of Health scoring system incorporating TB contact history, TST results, prolonged fever (≥2 weeks), chronic cough (≥3 weeks), lymphadenopathy, joint/bone enlargement, and chest X-ray findings. Diagnoses were confirmed by physicians or TB managing doctor at six primary healthcare centre and hospitals. Caregivers of eligible children were then contacted for recruitment.

Controls were children aged 1 to 5 years without presumed PTB (no persistent cough, fever, weight loss, night sweats, or lymphadenopathy) from the same community as cases. Recruited

through Posyandu programs (Child-maternal healthcare) to reduce TB-related stigma, controls were screened by health professionals based on caregiver reports. Eligible caregivers completed the same questionnaire as case participants.

The study population comprised households with children aged 1 to 5 years across Padang City from July to December 2024. Inclusion criteria were: 1) residence in Padang for at least one year, 2) ability to communicate in Bahasa, and 3) if multiple children under five were present, the eldest was selected. Children with health conditions that could affect participation were excluded.

The sample size was determined using an estimated exposure proportion of 22% ($\pi p = 0.22$) (Amrullah et al., 2023), a 95% confidence level ($Z = 1.96$), and a 5% margin of error, following the formula proposed for matched case-control studies (Parker & Bregman, 1986). Additional parameters included a control-to-case ratio (M) of 4, an assumed odds ratio (ψ) of 2.39 (Endalkachew et al., 2021), a two-tailed alpha level (α) of 0.05, and a statistical power of 80% ($\beta = 0.8$).

After substituting the given values, approximately 63 cases were needed for the study. This number was rounded up to ensure sufficient power, resulting in a sample size of 63 cases. Given the 1:4 ratio, the study required 252 controls. This approach was chosen because the incidence of newly active pulmonary TB cases in children under five is low compared to other age groups.

Study Variables and Data Collection

Data were collected through face-to-face interviews with parents using a structured, paper-based questionnaire. The study questionnaire was conducted via the Kobo Toolbox web platform and Kobo Collect application. Consecutive sampling was employed using a household list from the primary health care for newly TB diagnosis patients registered. Interviews, conducted in Bahasa, were administered by the researcher to ensure consistency and enhance the reliability and validity of data collection.

Operational definitions of the study variables were as follow:

Household food insecurity experience: Assessed using the U.S. Department of Agriculture's (USDA) Food Security Supplement (FSS), an 18-item questionnaire evaluating food security over the past year. Indicators included concerns about running out of food, inability to afford balanced meals, meal reduction, skipping meals, and hunger due to financial constraints. Responses included frequency-based and yes/no options. Households were classified as food secure (<3 indicators, the reference level), food insecure (≥3 indicators), or very low food security (≥8 indicators) (Rabbitt, 2023).

Socioeconomic indicators: Measured by caregiver education, employment status, household income, and household crowding.

Health behaviors: Included household tobacco smoking, immunization status, Posyandu attendance (≥4 visits in 6 months), and exclusive breastfeeding (Andriani et al., 2023). Children in households with at least one smoker were classified as exposed to second-hand smoke (Jafta et al., 2019).

Dietary diversity: Evaluated using UNICEF and FAO standards through a 24-hour dietary recall. Dietary diversity scores were calculated based on ten food groups, with a score of <5 indicating low dietary diversity.

Nutritional status: Nutritional status was assessed using anthropometric measurements. Weight was measured with a digital scale (capacity: 150 kg, accuracy: 0.1 kg), while height was measured using a microtoise (accuracy: 0.1 cm). The results were calculated as Weight-for-Age Z-scores (WAZ) and Height-for-Age Z-scores (HAZ) based on the WHO Growth Standards. Children with WAZ < -2 SD were classified as underweight, and those with HAZ < -2 SD were classified as stunted.

Data collection procedures

Following the coordination meeting, a two-week training session, led by a pediatrician, was conducted for local health volunteers and healthcare workers. The training focused on data collection, including anthropometric measurements and physical examinations.

In collaboration with local primary healthcare centers, we obtained a list of under-five children along with their addresses and contact details. Local health volunteers verified the addresses and assisted in scheduling home visits. During visits, written informed consent was obtained from parents or caregivers before conducting interviews, with each child assigned a specific code.

Face-to-face interviews, lasting up to 30 minutes, were conducted. Parents who were literate completed the questionnaire independently. Before the interview, participants were informed about the study's objectives, benefits, and risks. TB officers performed anthropometric measurements and physical examinations. Children's weights were measured without shoes, heavy clothing, or external support. The weighing scale was calibrated daily and recalibrated after every five measurements.

Data Management

Following verification for accuracy and consistency, the collected data was coded, the paper-based questionnaires were imported into Kobo-Toolbox, and analysis performed by R language and environment version 4.4.2 (R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria). To ensure participant confidentiality, no personally identifiable data were entered into the system. Regular data checks were conducted to identify and resolve issues, followed by routine data cleaning to prepare the final dataset for analysis.

Data Analysis

Descriptive statistics were conducted to summarize child, maternal, and household characteristics. Multivariable logistic regression was performed to examine the association between HFI and active PTB, adjusting for potential confounders including socioeconomic status, health-related behaviours, dietary diversity, and nutritional status. Data were analyzed to explain the association between household food insecurity and active pulmonary tuberculosis, using the adjusted odds ratio (AOR) as the measure of association. Household food insecurity and all confounding variables were included in the multivariable model without prior univariate analysis.

Human Research Ethics

The study protocol received ethical approval from the Human Research Ethics Committee of Prince of Songkla University, Thailand (REC.67-359-18-1), and the Ethics Committee of M. Djamil General Hospital, Padang, Indonesia (DP.04.03/D.XVI.XI/367/2024). Written informed consent was obtained from all mothers or caregivers before participation.

RESEARCH RESULTS

Figure 1 illustrates the selection process of study participants, where 315 individuals were assessed for eligibility. Among them, 63 were identified as PTB cases, with 60 clinically diagnosed and 3 confirmed by Xpert MTB/Rif testing. The remaining 252 participants served as controls, all of whom were screened and found not to be presumptive PTB cases.

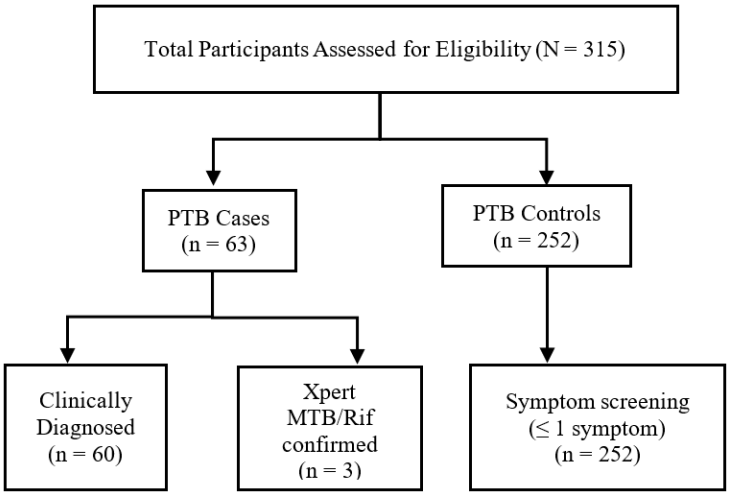

Figure 1 Identification of participants and the definitions of pulmonary tuberculosis cases and controls used in the studies

Table 1 presents the findings on nutritional and socioeconomic factors. The mean weight-for-age z-score (WAZ) was significantly lower among tuberculosis (TB) cases (-2.5 ± 1.6) compared to controls (-1.8 ± 1.4; p = 0.003), indicating that underweight status may be an important risk factor for TB. In contrast, no significant difference was observed in the height-for-age z-score (HAZ) between cases (-2.4 ± 2.5) and controls (-2.2 ± 2.1; p = 0.440). Additionally, there were no significant differences between groups in terms of child's sex, maternal age, marital status, educational attainment, or occupation. Household income and dietary diversity scores were also comparable between cases and controls.

Table 1 Child, Maternal and Household Characteristics in Pediatric Pulmonary Tuberculosis Cases and Controls (N = 315)

Variable	**Cases n (%)**	**Controls n (%)**	**P value**
Total, N	63	252	
Age, years (mean ± SD)	2.3 ± 1.6	2.2 ± 1.5	0.897
Child's Sex			
Male	34 (54)	125 (49.6)	0.632
Female	29 (46)	127 (50.4)	
Mother's Age (mean ± SD)	33.0 ± 9.4	32.7 ± 6.1	0.347
Mother's Marital Status [a]			
Married	61 (96.8)	245 (97.2)	1.000
Widowed [b]	2 (3.2)	7 (2.8)	
Mother's Education			
High school + below	55 (87.3)	204 (81)	0.320
Post high school	8 (12.7)	48 (19)	
Mother's Occupation			
Housewife	49 (77.8)	202 (80.2)	0.447
Office employee [c]	5 (7.9)	10 (4)	
Self-employee	6 (9.5)	20 (7.9)	
Healthcare Worker	3 (4.8)	20 (7.9)	
Household income			
≤ 3,000,000 IDR ($183 USD)	35 (55.6)	148 (58.7)	0.753
> 3,000,000 IDR	28 (44.4)	104 (41.3)	

Variable	Cases n (%)	Controls n (%)	P value
Number of family members			
≤ 6 persons	38 (60.3)	205 (81.3)	< 0.001*
> 6 persons	25 (39.7)	47 (18.7)	
BCG Vaccination			
Yes	37 (58.7)	177 (70.2)	0.110
No	26 (41.3)	75 (29.8)	
Second hand Smoke			
Yes	55 (87.3)	176 (69.8)	0.008*
No	8 (12.7)	76 (30.2)	.
Posyandu attendance [d]			
Yes	31 (49.2)	197 (78.2)	< 0.001*
No	32 (50.8)	55 (21.8)	
Exclusive Breastfeeding			
Yes	46 (73)	178 (70.6)	0.828
No	17 (27)	74 (29.4)	
Household Dietary Diversity (HDDS)			
Low	49 (77.8)	184 (73)	0.542
High	14 (22.2)	68 (27)	
Baseline immunization			
Not completed	44 (69.8)	123 (51.2)	0.004*
Completed	19 (30.2)	129 (48.8)	.
Weight-for-age Z-score (mean ± SD)	-2.5 ± 1.6	-1.8 ± 1.4	0.003*
Height-for-age Z-score (mean ± SD)	-2.4 ± 2.5	-2.2 ± 2.1	0.440

[a]All children are living with mother. [b] Include divorced. [c] Government officer is not included healthcare worker. [d] Attendance should >4 times in 6 months. *Statistical significance at p-value <0.05.

Table 2 shows that the multivariable model revealed children from households with very low food security had significantly higher odds of developing PTB compared to those from food-secure households (AOR = 5.1; 95% CI: 2.02-13.7; p < .001). In contrast, low food security was not significantly associated with PTB risk (p = .438).

Table 2 Multivariable Analysis of Household Food Insecurity and Pediatric Pulmonary Tuberculosis (N =315)

Variable	Cases (n = 63) n (%)	Controls (n = 252) n (%)	Adjusted OR (95% CI)
Household food insecurity			
Food secure	21 (33)	110 (44)	1.0 (Ref)
Low Food secure	18 (29)	104 (41)	1.41 (0.59-3.45)
Very low Food secure	24 (38)	38 (15)	**5.16 (2.03-13.7)**
Weight-for-age Z-score			
Normal (> -2 SD)	24 (38.1)	141 (56)	1.0 (Ref)
Underweight	39 (61.9)	111 (44)	**3.50 (1.47-8.28)**
Height-for-age Z-score			
Normal (> -2 SD)	25 (39.7)	105 (41.7)	1.0 (Ref)
Stunted	38 (60.3)	147 (58.3)	0.64 (0.26-1.54)

Variable	Cases (n = 63) n (%)	Controls (n = 252) n (%)	Adjusted OR (95% CI)
Child's Sex			
Male	34 (54)	125 (49.6)	1.0 (Ref)
Female	29 (46)	127 (50.4)	0.65 (0.33-1.29)
Child's age			
≤ 2 years old	37 (58.7)	149 (59.1)	1.0 (Ref)
> 2 years old	26 (41.3)	103 (40.9)	0.88 (0.43-1.77)
Mother's age			
18-35 years old	46 (73)	171 (67.9)	1.0 (Ref)
More than 35 years old	17 (27)	81 (32.1)	0.63 (0.29-1.30)
Mother's Marital Status			
Married	61 (96.8)	245 (97.2)	1.0 (Ref)
Widowed	2 (3.2)	7 (2.8)	1.25 (0.13-8.38)
Mother's Education			
High school + below	55 (87.3)	204 (81)	1.0 (Ref)
Post high school	8 (12.7)	48 (19)	0.12 (0.01-0.79)
Mother's Occupation			
Housewife	49 (77.8)	202 (80.2)	1.0 (Ref)
Office employee	5 (7.9)	10 (4)	**9.59 (1.25-94.5)**
Self-employee	6 (9.5)	20 (7.9)	1.78 (0.45-6.41)
Healthcare Worker	3 (4.8)	20 (7.9)	4.33 (0.40-67.51)
Household income			
≤ 3,000,000 IDR ($183 USD)	35 (55.6)	148 (58.7)	1.0 (Ref)
> 3,000,000 IDR	28 (44.4)	104 (41.3)	**7.23 (2.67-20.5)**
Number of family members			
≤ 6 persons	38 (60.3)	205 (81.3)	1.0 (Ref)
> 6 persons	25 (39.7)	47 (18.7)	**2.49 (1.19-5.24)**
BCG Vaccination			
Yes	37 (58.7)	177 (70.2)	1.0 (Ref)
No	26 (41.3)	75 (29.8)	1.47 (0.55-3.88)
Second hand Smoke			
Yes	55 (87.3)	176 (69.8)	1.0 (Ref)
No	8 (12.7)	76 (30.2)	**0.09 (0.02-0.27)**
Posyandu attendance [d]			
Yes	31 (49.2)	197 (78.2)	1.0 (Ref)
No	32 (50.8)	55 (21.8)	**2.93 (1.40-6.19)**
Exclusive Breastfeeding			
Yes	46 (73)	178 (70.6)	1.0 (Ref)
No	17 (27)	74 (29.4)	1.54 (0.70-3.35)
Household Dietary Diversity (HDDS)			
Low	49 (77.8)	184 (73)	1.0 (Ref)
High	14 (22.2)	68 (27)	0.70 (0.29-1.59)
Baseline immunization			
Not completed	44 (69.8)	123 (51.2)	1.0 (Ref)
Completed	19 (30.2)	129 (48.8)	0.58 (0.24-1.35)

Bold texts denote statistical significance at 95 level of confidence.

DISCUSSION & CONCLUSION

This study found that children with pulmonary tuberculosis (PTB) were more likely to live in households reporting food shortages, inability to afford balanced meals, and frequent hunger—patterns consistent with prior research linking household food insecurity (HFI) to PTB (Berhe et al., 2013; Vaccaro & Huffman, 2017). Urban households with young children tend to experience higher levels of food insecurity than rural counterparts, likely due to socioeconomic disparities, limited access to healthcare, and reduced availability of public services (Kakaei et al., 2022; Oderinde et al., 2023). The rapid urbanization driving these trends has led to the conversion of agricultural land into residential and commercial spaces, diminishing local food production and increasing reliance on purchased food (Seto & Ramankutty, 2016).

The biological consequences of food insecurity are profound, as undernutrition impairs immune function and heightens susceptibility to infections like TB (Lonnroth et al., 2010). Protein-energy malnutrition and micronutrient deficiencies weaken immunity, which is critical for TB defense (Chandra, 1997). A significant interaction was observed between weight-for-age Z-scores (WAZ) and PTB, with undernourished children facing over three times higher odds of infection—consistent with global evidence that malnutrition increases TB susceptibility (Schwenk & Macallan, 2000). Socially, rising living costs force households to prioritize nutrient-poor foods, reducing dietary diversity. Financial constraints delay healthcare-seeking behavior, prolonging exposure to infectious TB contacts (Hargreaves et al., 2011; Jones et al., 2013).

Children from higher-income households had sevenfold higher PTB odds, contrasting typical income-health gradients. This unexpected association may reflect greater exposure to high-transmission urban environments or contact with domestic workers who may unknowingly transmit TB (Ghosh-Jerath et al., 2021). Working mothers may have less capacity to monitor child health, delaying symptom recognition, while children left with relatives or domestic workers face prolonged exposure to potential TB carriers (Seddon & Shingadia, 2014).

This study demonstrates strong internal validity, with cases and controls matched from the same communities and data collected by trained health workers using validated instruments. The use of the USDA 18-item food security questionnaire further strengthens the reliability of the findings. Nevertheless, several limitations must be acknowledged. The case control design restricts causal inference, and the potential for recall bias may affect the accuracy of food security reporting. Selection bias is also a concern, as control participants were primarily recruited through Posyandu programs, potentially excluding children who do not access these services and may differ systematically from those included.

In conclusion, very low household food security is significantly associated with increased risk of PTB among children under five. In TB-endemic areas where HFI is widespread, food security assessment may serve as a useful indicator for targeted active case-finding among young children.

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Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Conflicts of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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