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GLOBAL EVIDENCE ON RISK FACTORS FOR CHILDHOOD TUBERCULOSIS: A SCOPING REVIEW

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Abstract

Childhood tuberculosis (TB) remains a major global public health concern, particularly in developing countries, due to children's immature immune systems and frequent exposure to infectious adults within households. This scoping review aimed to identify and synthesize global evidence on risk factors associated with TB among children aged 0–19 years, following the Joanna Briggs Institute (JBI) methodology and PRISMA-ScR guidelines. Unlike previous systematic reviews that focused on specific regions or populations, this study comprehensively mapped risk factors using evidence from PubMed, Scopus, and Garuda databases up to March 2025. Eleven primary studies meeting the inclusion criteria were analyzed thematically. The most frequently reported risk factors included close contact with adult TB patients, lack of Bacillus Calmette–Guérin (BCG) vaccination, malnutrition, overcrowded housing, and poor ventilation. Additional factors such as HIV infection, exposure to cigarette smoke, low parental education, and poor household income further increased susceptibility. The findings indicate that childhood TB arises from a complex interplay of biological, social, and environmental determinants. Therefore, effective prevention strategies should integrate immunization, active contact tracing, family health education, and improvement of living conditions. This review provides valuable insights for strengthening community-based TB control programs, highlights the need to prioritize children as a vulnerable population, and identifies research gaps to guide future policy and interventions toward TB elimination.
Keywords: Children; Risk factors; Tuberculosis.

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1. INTRODUCTION

Tuberculosis (TB) remains a major challenge in global public health, particularly in low- and middle-income countries. Children are especially vulnerable to TB due to their immature immune systems and the difficulty of making an accurate diagnosis, as clinical symptoms in children are often non-specific. According to the Global TB Report 2023, approximately 8.75% of TB cases treated between 2018 and 2022 occurred in children under the age of 15 (1).

In addition, many children who are exposed to TB do not receive adequate diagnosis or treatment due to various barriers, such as social stigma, lack of parental awareness, limited access to healthcare services, and socioeconomic disparities (2). This situation is further exacerbated by the low coverage of contact tracing in the child's living

environment, especially in high-burden TB areas. Previous studies have shown that risk factors such as malnutrition, close contact with adults with TB, HIV infection, and poor living conditions significantly contribute to the rising incidence of TB in children (3).

Understanding and identifying these risk factors systematically through a scoping review approach is essential for developing more effective and targeted prevention strategies. Several systematic reviews have previously explored childhood TB risk factors, but most were restricted to certain populations, regions, or study designs, and often treated children only as a subgroup. By employing a scoping review methodology, this study provides a broader mapping of evidence across diverse contexts and determinants, thereby complementing and extending prior reviews.This review aims to summarize the various risk factors associated with childhood TB based on empirical evidence and to provide a foundation for designing community-based public health interventions (4).

2. METHODS

Study Design

This scoping review was developed based on the methodological guidance from the Joanna Briggs Institute and followed the principles of PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews). The aim of this review is to systematically explore various risk factors that contribute to the incidence of tuberculosis (TB) in children. The PCC (Population, Concept, Context) framework was used to define the focus of the literature search and selection:

a. Population: Children (ages 0–19 years)
b. Concept: Tuberculosis risk factors
c. Context: Household environment, socio-economic factors, healthcare access, and immunological status

Search Strategy

A systematic literature search was conducted in three electronic databases: PubMed, Scopus, and Garuda, up to March 3, 2025. Three major databases (PubMed, Scopus, and Garuda) were chosen as they provide wide coverage of international peer-reviewed literature and national publications. Other databases such as Web of Science, Embase, or Cochrane were not included due to access limitations; however, previous methodological studies have shown that PubMed and Scopus together capture the majority of biomedical literature. Garuda was included to ensure representation of Indonesian research not indexed elsewhere.The keywords used included Boolean combinations such as: ("tuberculosis" OR "TB") AND ("risk factors") AND ("children" OR "pediatric") The search was conducted in English and aimed to capture articles relevant to the topic of TB risk factors in children.

Inclusion and Exclusion Criteria

Inclusion criteria:

a. Primary studies (quantitative, qualitative, or mixed methods) that explore TB risk factors in children
b. Articles published in peer-reviewed journals
c. Studies involving children as the primary participants (ages 0–19 years)
d. Articles published within the last 10 years

Exclusion criteria:

a. Studies focusing exclusively on adult populations
b. Review articles, meta-analyses, commentaries, editorials, or opinion pieces
c. Animal studies or studies without primary data

Study Selection

The selection process consisted of three stages: (1) title and abstract screening, (2) full-text review, and (3) resolution of discrepancies by a third reviewer in cases of disagreement. All selected articles were exported to reference management software to avoid duplication.

Data Extraction and Synthesi

Data extraction was conducted using a standardized form, collecting the following information:

a. Author(s), year of publication, and study location
b. Study design and target population
c. Types of risk factors examined

Key findings related to the association between risk factors and TB incidence in children. The extracted data were then thematically analyzed to identify common patterns and categorize the various risk factors.

The extracted data were analyzed descriptively and presented through thematic narrative synthesis and summary tables. The PRISMA-ScR flow diagram was used to illustrate the study selection process (Figure 1).

3. RESULTS AND DISCUSSION

Results

Childhood tuberculosis (TB) remains one of the major challenges in global TB control. Unlike TB in adults, pediatric TB has more complex clinical and epidemiological characteristics (5). Children, particularly those under five years of age, have immature immune systems, making them more susceptible to rapid progression from latent infection to active disease (6). The findings of this scoping review reinforce this understanding by highlighting a range of risk factors consistently identified across studies conducted in both high and middle TB burden countries.

The included studies originated from diverse regions, including South Asia, Sub-Saharan Africa, Latin America, and Southeast Asia, with three studies conducted in Indonesia. While this distribution captures a range oh high- and middle-burden contexts, it does not provide equal representation of all global regions. This geographic imbalance should be considered when applying the findings to broader populations.

One of the most prominent findings is the history of close contact with adult TB patients, especially within the household environment. Nearly all the studies analyzed report that

exposure to individuals with active pulmonary TB—particularly those who are sputum-positive—is the strongest determinant of TB occurrence in children. This aligns with the basic concept of TB transmission via droplets, which primarily occurs in enclosed spaces with poor ventilation. Children living in the same household as TB patients are often repeatedly exposed without adequate protection, thereby increasing the likelihood of primary infection and progression to active disease (7).

Additionally, BCG immunization status has been shown to significantly affect the prevention of severe forms of TB in children. Several studies included in this review demonstrate that children who did not receive the BCG vaccine had a higher risk of developing TB, particularly disseminated forms such as miliary TB or TB meningitis. While the effectiveness of BCG in preventing primary infection remains debated, the vaccine provides clear protective benefits against severe TB manifestations, especially in early childhood. This underscores the importance of achieving full coverage of basic immunizations as a primary prevention strategy (8).

Nutritional status, particularly malnutrition, also plays a key biological role in increasing a child's vulnerability to TB. Children with nutrient deficiencies—especially in protein and micronutrients—exhibit impaired cellular immunity, which is essential for controlling *Mycobacterium tuberculosis* infection. Malnutrition can serve a dual role: as a risk factor for infection and as a factor that worsens disease progression (9). The studies reviewed consistently identify malnutrition as a statistically significant independent variable associated with pediatric TB (10).

From an environmental perspective, household overcrowding and poor ventilation are important indicators that increase the risk of TB transmission within the home. Residences that accommodate many family members in cramped spaces with inadequate airflow create ideal conditions for the spread of infectious droplets (11). Some studies also identify household exposure to tobacco smoke as an additional factor, contributing to respiratory mucosal damage and weakening the natural defenses of children against respiratory infections, including TB.

Socioeconomic factors also play a significant role. Parental education level—particularly maternal education is often associated with awareness of the importance of immunization, hygiene, and adherence to treatment. Low socioeconomic status often limits access to healthcare services, adequate nutrition, and healthy living environments (12). These findings suggest that childhood TB is not merely a medical issue but also a reflection of ongoing social inequities.

The heterogeneity across studies may reflect differences in study settings, measurement of variables, and contextual factors such as health system capacity or cultural practices. Despite these variations, the

overall evidence still points toward a multifactorial interplay of biological, environmental, and social determinants.

Nevertheless, not all studies report uniform findings. Some did not find significant associations between factors such as age, BCG immunization status, or economic status and the incidence of pediatric TB. These discrepancies may result from variations in study design, operational definitions of risk factors, population characteristics, and sample sizes. However, the overall pattern continues to support the need for multidimensional interventions in TB prevention among children (13).

This review also emphasizes that although children are generally not considered major sources of TB transmission due to their typically negative sputum status and non-productive cough—they serve as important indicators of ongoing community transmission. The presence of pediatric TB cases reflects active transmission from adults within their immediate environment. Therefore, household- and community-based interventions are crucial, including routine screening of child household contacts, provision of TB preventive therapy, and improvement of living conditions (14).

Several limitations of the included must be acknowledged. Most employed cross-sectional designs, which restrict causal inference. Small sample sizes in some studies may limit generalizability, while recall bias and variation in definitions of risk factors could influence the consistency of results.

This review highlights the importance of integrating biomedical, environmental, and social approaches. In particular, strengthening household contact tracing, expanding BCG coverage, and improving nutrition programs should be prioritized as complementary strategies. In conclusion, the findings of this scoping review underscore that childhood TB results from a complex interaction between exposure, immunity, and social determinants. Thus, prevention and control of pediatric TB cannot rely solely on medical approaches but require cross-sectoral collaboration, including education, nutrition, housing, and social protection (15).

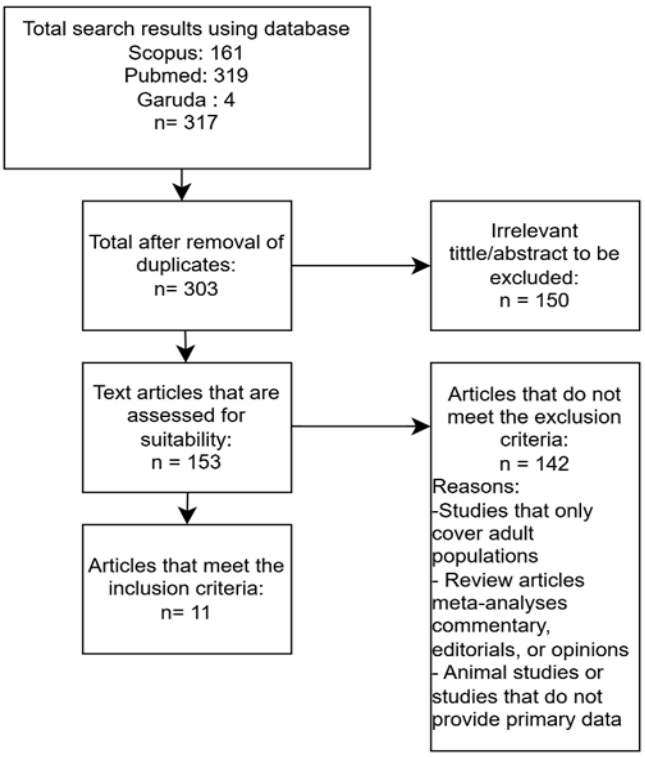

Figure 1. PRISMA flowchart for selection

Table 1. Results of Included Studies

Author	Country/ Study	Study design	Population	Risk factors found	Main findings
Getaneh Endalew et al (2025)(16)	Ethiopia (Bahir Dar)	Retrospective cohort	415 HIV-positive children receiving ART	1) Contact with active TB cases 2) No IPT (isoniazid preventive therapy) 3) Advanced WHO HIV stage 4) Poor ART adherence 5) Incomplete vaccination	TB incidence was 3.37 per 100 person-years. Contact with TB patients, lack of IPT, advanced HIV stage, and poor ART adherence were major predictors of TB among HIV-infected children.
Burusie et al (2024)(17)	Ethiopia (Addis Ababa, Adama, Bishoftu)	Matched case-control	512 children	1) not received BCG in 2 weeks p-value= 0,003 2) household contact with patient p-value= 0,000 3) living with a smoker at home p-value= 0,037 4) infected with HIV p-value= 0,004 5) household size	All factors are significant except household size (number of members) and gender (male)

Author	Country/ Study	Study design	Population	Risk factors found	Main findings
				(number of members) p-value= 0,339 6) gender (male) p-value=0,544	
N. Siddalingaiah et al. (2023)(18)	India	Prospective/national database analysis	Children	1) Contact with TB cases 2) Passive smoke exposure 3)Overcrowding 4) Low socioeconomic status	Environmental and socioeconomic factors—especially contact with TB cases, overcrowding, and passive smoking—were strongly associated with TB occurrence in children.
Khan et al (2016)(19)	Malawi	Cross sectional (survey TST populasi)	3170 children	1)distance to adult tuberculosis cases (<200 m) p-value= 0,03 2) HIV-positive mother during childbirth p-value= 0,05 3) number of adult household members p-value=0,02	All significant factors
K.N. Hidayanti et al. (2024)(20)	Indonesia	Cross-sectional	Community-based sample of children	1) Stunting 2) Contact with TB cases 3) Passive smoke exposure	Stunting, household TB contact, and passive smoking exposure significantly increased the risk of childhood TB in rural areas.
Attah et al (2018)(21)	Nigeria (Nasarawa State)	Cross-sectional	150 children	1)No cross ventilation p-value= 0,001 2)Contact with adult tuberculosis cases p value= 0,005 3) high residential density p-value= 0,029 4)low socioeconomic status p-value= 0,012 5)number of household members	All factors were significantly significant except severe malnutrition

Author	Country/ Study	Study design	Population	Risk factors found	Main findings
				≥ 10 p-value= 0,001 6) drink unpasteurized milk p-value= 0,006 7) severe malnutrition p-value= 0,107	
Stosic et al. (2021)(22)	Serbia	Retrospektif (2005-2016)	596 children	1)male gender p-value= 0,000 2) age < 5 years p-value=0,000 3) pulmonary tuberculosis p-value=0,000 4) new case p-value= 0,000 5)have comorbidities p-value= 0,000 6)social vulnerability p-value= 0,000	All factors are not significant
Yustikarini & Sidhartani (2015)(23)	Semarang, Indonesia	Case control	80 children	1) Contact history p-value=0,000 2) residential density p-value= 0,044 3) age < 5 years p-value= 0,043 4) BCG immunization p-value=0,210 5) low socioeconomic p-value= 0,084 6) parents knowledge is lacking p-value= 0,431	Contact history and residential density proved significant, other factors did not prove significant in multivariate analysis
A. Fitri Agustin & Lilis (2023)(24)	Surabaya, Indonesia	Case control	84 children (42 TB cases, 42 controls)	1) History of TB contact 2) Low family knowledge 3) Poor family hygiene practices	Children with TB contact history and families with poor knowledge and hygiene practices had 3–4 times higher risk of developing TB.
Carroll, H., Plewes, K., Turner, C., et al. (2022)(25)	Thailand–Myanmar border (Mae Sot and Maw Ker Thai clinics)	Retrospective cohort study	290 children aged ≤ 15 years diagnosed with tuberculosis (clinical or	Migration and displacement; poor living conditions; overcrowdin; socioeconomic vulnerability; limited access to	The study found a high burden of childhood TB among migrant children. Most cases were pulmonary TB

Author	Country/ Study	Study design	Population	Risk factors found	Main findings
			bacteriological confirmation) between 2013–2019	healthcare; malnutrition	(82%) and 12% were bacteriologically confirmed. Treatment success was 88%, but loss to follow-up was common (6%). Socio-environmental factors such as migration, limited healthcare access, and poor living conditions were highlighted as key contributors to TB risk.
Tantri Muharam et al. (2023)(26)	Gorontalo, Indonesia	Case control	34 children	1) Parental knowledge p-value= 0,000 BCG 2)immunization history p-value= 0,006 3) History of smoking in the family p-value= 0,042	Significant

4. CONCLUSION

This scoping review underscores that childhood tuberculosis (TB) arises from complex interactions among biological, environmental, and socioeconomic factors. The most consistent risk factor is close household contact with adults with active pulmonary TB, alongside lack of BCG vaccination, malnutrition, overcrowding, poor ventilation, tobacco smoke exposure, and low socioeconomic status. Overall, the evidence highlights the need for multidimensional interventions integrating health, nutrition, housing, education, and social protection to prevent pediatric TB and address underlying social inequities.

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