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# MIGRATION PROCESSES AND THEIR IMPACT ON THE SPREAD OF TUBERCULOSIS IN CHILDREN: A GLOBAL PUBLIC HEALTH PERSPECTIVE

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**Abstract**
Tuberculosis (TB) remains a major global health concern, particularly among vulnerable populations such as children. In recent decades, migration has emerged as a significant factor influencing the epidemiology of TB. This review examines the relationship between migration processes and the spread of tuberculosis in children, focusing on biological, social, and healthcare-related determinants. Migrant children are exposed to multiple risk factors, including overcrowding, malnutrition, interrupted vaccination, and limited access to healthcare services, all of which contribute to increased susceptibility to TB infection and progression to active disease. Additionally, migration disrupts continuity of care and contributes to delayed diagnosis and treatment interruption, thereby facilitating ongoing transmission and the emergence of drug-resistant tuberculosis. The review highlights the importance of integrated public health strategies, including early screening, vaccination coverage, improved living conditions, and cross-border healthcare coordination. Addressing migration-related determinants is essential for reducing the burden of pediatric tuberculosis and achieving global TB control goals.

**Keywords**: Tuberculosis; children; migration; pediatric TB; public health; migrant health; TB transmission; risk factors; drug-resistant tuberculosis; global health.

## Introduction

Tuberculosis remains one of the most persistent infectious diseases worldwide and continues to pose a major public health challenge despite significant advances in diagnostics and treatment. According to the World Health Organization, tuberculosis remains among the leading causes of death from infectious diseases, with millions of new cases reported annually. Within this global burden, children represent a particularly vulnerable group, not only because of their biological susceptibility but also because pediatric tuberculosis often reflects ongoing transmission within communities. The epidemiology of tuberculosis in children is therefore closely linked to social determinants and population dynamics, among which migration has become increasingly important [1.2].

Over the past decades, global migration has intensified significantly due to economic disparities, political instability, armed conflicts, and environmental changes. The International Organization for



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Migration reports a steady increase in the number of international migrants, many of whom are families with young children. These population movements create new epidemiological patterns and contribute to the redistribution of infectious diseases, including tuberculosis, across regions and countries. Migration does not simply involve geographic relocation; it is accompanied by profound changes in living conditions, access to healthcare, and exposure to risk factors that directly influence disease transmission [3.4].

Children in migrant populations are particularly exposed to unfavorable conditions that facilitate tuberculosis transmission. During migration, families often experience overcrowded living environments such as refugee camps, temporary shelters, or poorly ventilated housing. Tuberculosis, being an airborne infection transmitted through droplets, spreads more efficiently in such conditions. Prolonged exposure to infected individuals, especially within households, significantly increases the likelihood of infection in children. Since children are usually infected by close contacts, primarily adults with active pulmonary tuberculosis, the presence of undiagnosed or untreated cases among migrant adults becomes a key driver of pediatric infection [2.5].

In addition to increased exposure, migrant children frequently suffer from malnutrition and psychosocial stress, both of which compromise immune function. The immature immune system of a child is already less capable of containing Mycobacterium tuberculosis, and when combined with nutritional deficiencies, the risk of progression from latent infection to active disease increases substantially. This is particularly important in early childhood, where tuberculosis tends to progress rapidly and may manifest in severe forms such as disseminated tuberculosis or tuberculous meningitis [6.7].

Another critical factor linking migration and tuberculosis is the disruption of healthcare access. Migrant populations often face numerous barriers, including legal status, language differences, financial constraints, and lack of awareness of available health services. These barriers lead to delayed diagnosis and treatment of tuberculosis both in adults and children. Infected individuals may remain untreated for extended periods, continuing to transmit the disease within families and communities. For children, delayed diagnosis is especially dangerous, as the disease may progress quickly and become more difficult to manage [3.6].

Vaccination coverage is also affected by migration. The Bacillus Calmette–Guérin (BCG) vaccine plays an important role in protecting children against severe forms of tuberculosis. However, migrant children may miss routine immunization due to interrupted healthcare services or lack of documentation. As a result, they remain unprotected during critical periods of vulnerability. The combination of increased exposure, weakened immunity, and insufficient vaccination creates a high-risk environment for tuberculosis development [5.7].

The epidemiological impact of migration extends beyond individual risk factors and affects tuberculosis control at the population level. Migrants may originate from regions with high TB prevalence and move into areas with lower incidence, introducing new cases into the host population. At the same time, the conditions encountered during migration may facilitate the activation of latent tuberculosis infection. This dual effect — importation of cases and increased transmission — complicates efforts to control the disease [7.9].

Overcrowding, which is one of the most significant determinants of tuberculosis transmission, deserves particular attention. In migrant settings, multiple family members often share limited living



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space, and ventilation is frequently inadequate. Under such circumstances, airborne pathogens accumulate in the environment, increasing the probability of inhalation by susceptible individuals. Children, who spend most of their time indoors and in close proximity to caregivers, are disproportionately affected. Studies consistently demonstrate that household exposure remains the primary source of infection in pediatric tuberculosis, and this risk is amplified in migrant populations.

**Table 1 Major Risk Factors, Mechanisms, and Consequences of Tuberculosis in Migrant Children**

| Risk factor | Mechanism | Consequence in children |
|---|---|---|
| Overcrowded housing | Increased inhalation of infectious droplets | High infection risk |
| Malnutrition | Reduced immune defense | Rapid disease progression |
| Interrupted vaccination | Lack of protective immunity | Severe TB forms |
| Limited healthcare access | Delayed diagnosis and treatment | Advanced disease stages |
| Close contact with infected adults | Continuous exposure | Primary infection |

Migration also introduces challenges in maintaining continuity of care. Tuberculosis treatment requires long-term adherence to multidrug regimens, often lasting six months or longer. Migrant families, due to frequent movement or unstable living conditions, may interrupt treatment, leading to incomplete therapy. This not only reduces treatment effectiveness but also contributes to the development of drug-resistant strains of Mycobacterium tuberculosis. Children infected with such strains face more complex and prolonged treatment, often with less favorable outcomes [10.11].

The social environment of migrant populations further exacerbates the situation. Poverty, limited access to education, and poor health literacy reduce the likelihood of early healthcare-seeking behavior. Symptoms of tuberculosis in children are often non-specific, including mild cough, low-grade fever, and weight loss, which may not be recognized as signs of a serious illness. In migrant settings, these symptoms are frequently overlooked or attributed to general poor health, delaying medical consultation.

Another important aspect is the invisibility of migrant children in health surveillance systems. Due to lack of official registration or documentation, many migrant families remain outside formal healthcare structures. Consequently, cases of pediatric tuberculosis may go unreported, leading to underestimation of disease burden and insufficient allocation of resources. This hidden nature of the problem further complicates public health interventions.

At the same time, migration can alter the natural history of tuberculosis infection. Stress associated with displacement, changes in climate, and exposure to new environmental factors may influence host immunity and pathogen behavior. These changes can contribute to the reactivation of latent tuberculosis infection, both in adults and in older children. As a result, migration acts not only as a factor for transmission but also as a trigger for disease activation.

Thus, the relationship between migration and tuberculosis in children is shaped by a complex interplay of biological, environmental, and social determinants. Increased exposure to infection, weakened immune defenses, disrupted healthcare access, and socio-economic vulnerability collectively create conditions that favor the spread and progression of tuberculosis in migrant



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pediatric populations. This interconnected system of factors forms a continuous chain, where each element reinforces the others, ultimately leading to sustained transmission within communities.

These processes become even more pronounced when examining the underlying biological and epidemiological mechanisms that connect migration to the development of tuberculosis in children. Following exposure to *Mycobacterium tuberculosis*, the outcome of infection depends largely on the host immune response. In children, especially those under five years of age, the immune system is not fully mature, which limits the ability to contain the pathogen within granulomas. As a result, the probability of progression from latent infection to active disease is significantly higher compared to adults. In migrant children, this vulnerability is further intensified by chronic stress, nutritional deficiencies, and coexisting infections, all of which impair cellular immunity, particularly T-cell–mediated responses that are critical for controlling tuberculosis [11.13].

Malnutrition plays a central role in this process. Protein-energy deficiency and micronutrient insufficiency, including deficiencies in vitamin D, iron, and zinc, directly affect immune competence. In migrant populations, irregular food supply and poor diet quality are common, leading to a state of chronic undernutrition. This condition not only increases susceptibility to initial infection but also accelerates disease progression and worsens clinical outcomes. Moreover, malnutrition and tuberculosis form a vicious cycle: infection leads to metabolic disturbances and appetite loss, which in turn exacerbate nutritional deficits [12.14].

In parallel with biological susceptibility, environmental exposure remains a decisive factor. During migration, families often spend extended periods in transit environments such as temporary shelters, detention facilities, or informal settlements. These settings are characterized by high population density, inadequate ventilation, and limited infection control measures. Under such conditions, the concentration of airborne bacilli increases, raising the risk of inhalation by susceptible individuals. Children, due to their close proximity to caregivers and limited mobility, are continuously exposed to infected adults, making household transmission the dominant pathway of infection.

The dynamics of transmission are further complicated by delays in diagnosis. Tuberculosis in children is notoriously difficult to detect due to its paucibacillary nature and non-specific clinical presentation. Symptoms such as persistent cough, low-grade fever, fatigue, and weight loss may be subtle and easily overlooked. In migrant populations, these diagnostic challenges are compounded by structural barriers to healthcare access. Language differences, lack of documentation, fear of legal consequences, and financial constraints often prevent families from seeking timely medical care. As a result, both adult and pediatric cases remain undiagnosed for prolonged periods, allowing continuous transmission within communities [14.15].

An additional critical dimension is the emergence and spread of drug-resistant tuberculosis. Migration has been identified as an important factor in the global dissemination of multidrug-resistant tuberculosis (MDR-TB). Treatment interruption, which is common among mobile populations, creates favorable conditions for the selection of resistant strains. Patients who initiate therapy in one location may be unable to complete it due to relocation, lack of access to medications, or insufficient follow-up. In such cases, partially treated infections persist and evolve into drug-resistant forms. Children infected with MDR-TB face particularly serious challenges, as treatment regimens are longer, more toxic, and less effective compared to drug-susceptible tuberculosis.



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**Table 2. Differences in Tuberculosis Burden and Clinical Outcomes Between Migrant and Non-Migrant Children**

| Indicator | Migrant children | Non-migrant children |
|---|---|---|
| TB incidence | Significantly higher | Lower |
| Latent TB infection | Widespread | Moderate |
| Progression to active TB | Rapid | Slower |
| Treatment interruption | Frequent | Rare |
| MDR-TB prevalence | Increased | Limited |

The diagnostic process in migrant children is also affected by limited availability of modern technologies. While advanced tools such as molecular assays and rapid diagnostic tests have improved TB detection globally, their accessibility remains uneven. Migrant populations often rely on under-resourced healthcare systems where diagnostic capacity is restricted. Furthermore, the absence of medical history and vaccination records complicates clinical decision-making. For instance, it may be difficult to determine whether a child has received BCG vaccination, which influences both susceptibility to disease and interpretation of diagnostic tests such as the tuberculin skin test [12.13].

Another important issue is the disruption of preventive strategies. Contact tracing, which is a cornerstone of tuberculosis control, becomes extremely challenging in migrant settings. Identifying and monitoring individuals who have been exposed to an infectious case requires stable residence and reliable communication, both of which are often lacking among migrant families. Consequently, many infected children remain undetected until the disease becomes clinically apparent.

The interaction between migration and tuberculosis is not limited to individual-level factors but also involves broader systemic and structural determinants. Health systems in host countries may be unprepared to address the specific needs of migrant populations. Limited cultural competence among healthcare providers, lack of targeted screening programs, and insufficient integration of migrant health services contribute to gaps in care. These systemic weaknesses allow tuberculosis to persist as a public health problem, particularly among marginalized groups [13.14].

At the same time, migration can influence the epidemiology of tuberculosis at the population level by altering transmission networks. The introduction of new strains, including drug-resistant variants, into previously low-incidence areas can lead to localized outbreaks. Children, as a sentinel population, often reflect these changes early, as their infections typically indicate recent transmission. Therefore, an increase in pediatric TB cases in a given region may signal underlying epidemiological shifts associated with migration.

The cumulative effect of these mechanisms can be conceptualized as a continuous transmission cycle, in which migration acts as both a driver and amplifier of tuberculosis spread. Overcrowding increases exposure, malnutrition weakens immunity, delayed diagnosis prolongs infectiousness, and treatment



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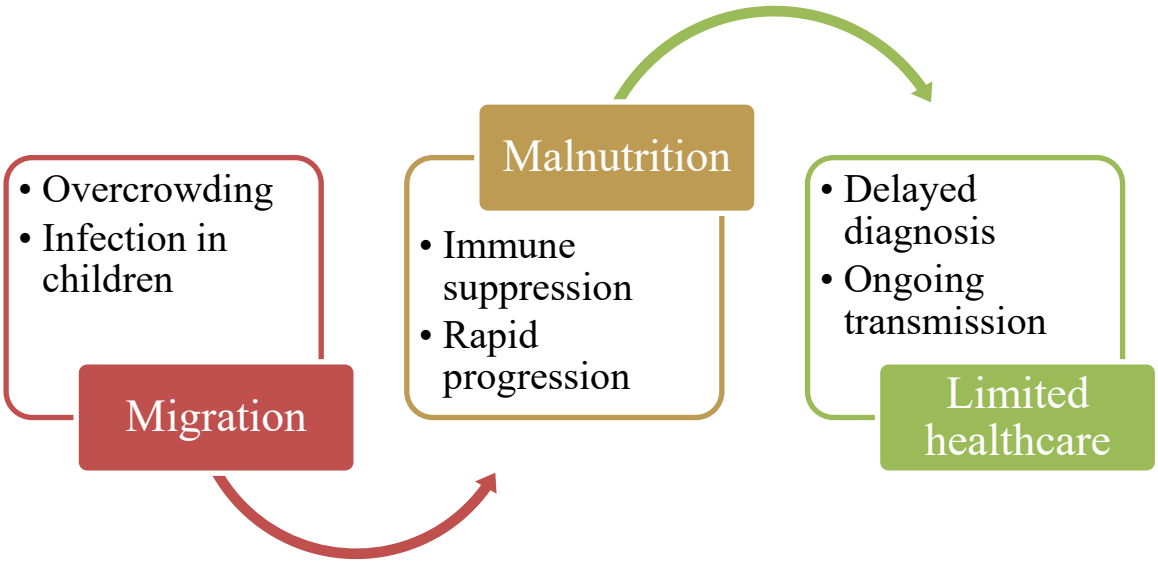
interruption fosters resistance. These factors interact dynamically, reinforcing each other and sustaining the disease within vulnerable populations.




Within this framework, children occupy a central position, as they are both highly susceptible to infection and indicative of active transmission. Their health outcomes depend not only on biological factors but also on the broader social and structural environment shaped by migration. Consequently, understanding these mechanisms is essential for developing effective interventions aimed at reducing the burden of tuberculosis in migrant pediatric populations.

In this context, the need for comprehensive and coordinated public health strategies becomes increasingly evident. Addressing tuberculosis in migrant children requires not only medical interventions but also systemic approaches that take into account the continuity of care, social protection, and cross-border collaboration. Traditional tuberculosis control models, which are primarily designed for stable populations, are often insufficient in the face of dynamic migration patterns. Therefore, adapting these models to the realities of migrant populations is essential for effective disease control.

One of the most critical components of tuberculosis control in migrant children is early detection. Screening strategies must be implemented at multiple stages of the migration process, including pre-departure, transit, and arrival in the destination country. Active case finding, particularly among high-risk groups such as children in close contact with infected adults, is crucial. In this regard, international guidelines developed by organizations such as the World Health Organization emphasize the importance of systematic screening and prompt diagnosis to interrupt transmission chains. However, the effectiveness of these measures depends on their accessibility and cultural acceptability within migrant communities [1.2].

Equally important is the continuity of treatment. Tuberculosis therapy requires strict adherence to long-term multidrug regimens, and any interruption can lead to treatment failure and the development of drug resistance. For migrant populations, ensuring continuity of care is particularly challenging due to frequent relocation and fragmentation of healthcare services. To address this issue, coordinated systems that allow transfer of medical information across regions and countries are needed. The



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International Organization for Migration has highlighted the importance of cross-border health initiatives and digital health records in maintaining treatment continuity among mobile populations.

Vaccination remains a cornerstone of tuberculosis prevention in children. The Bacillus Calmette–Guérin vaccine provides protection against severe forms of pediatric tuberculosis, including miliary TB and tuberculous meningitis. However, as previously noted, migrant children often experience interruptions in routine immunization. Strengthening vaccination programs and ensuring universal coverage among migrant populations is therefore a critical priority. This requires not only logistical support but also community engagement to overcome vaccine hesitancy and improve awareness [10.12].

Beyond medical interventions, social determinants must be addressed to effectively reduce tuberculosis transmission. Improving living conditions is particularly important in migrant settings. Overcrowding, poor ventilation, and inadequate sanitation create an environment conducive to the spread of airborne infections. Policies aimed at providing safe and adequate housing for migrant families can significantly reduce transmission risk. In addition, nutritional support programs are essential to enhance immune function and improve treatment outcomes in children affected by tuberculosis.

Health education also plays a vital role in tuberculosis control. Increasing awareness about the symptoms of TB, the importance of early diagnosis, and the necessity of completing treatment can empower migrant communities to seek care in a timely manner. Culturally sensitive communication strategies are required to ensure that information is accessible and relevant. Involving community leaders and using multilingual educational materials can improve outreach and effectiveness.

Another important aspect is the integration of migrant health into national healthcare systems. Migrants often face legal and administrative barriers that limit their access to healthcare services. Removing these barriers and ensuring equitable access to diagnosis and treatment is essential not only for protecting individual health but also for preventing the spread of tuberculosis at the population level. Inclusive health policies that recognize the rights of migrants to healthcare are therefore fundamental to effective disease control.

At the same time, surveillance systems must be strengthened to better capture the burden of tuberculosis among migrant children. Accurate data collection is necessary for understanding epidemiological trends and allocating resources appropriately. This includes improving registration systems, enhancing reporting mechanisms, and integrating data across different regions. Without reliable data, the true scale of the problem remains underestimated, and interventions may be insufficient or misdirected.

Importantly, interventions targeting migrant children must adopt a multidisciplinary approach that combines medical, social, and policy-level measures. Addressing only one aspect of the problem is unlikely to produce sustainable results. For example, improving diagnostic capacity without ensuring treatment adherence will not reduce transmission, just as providing medication without addressing malnutrition may limit recovery. A comprehensive strategy that simultaneously tackles multiple determinants is therefore necessary.

The long-term goal of tuberculosis control is elimination, yet this objective cannot be achieved without addressing the specific challenges posed by migration. Migrant children represent a key population in this context, as their health status reflects both current transmission dynamics and the



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effectiveness of public health interventions. Reducing tuberculosis incidence in this group will require sustained commitment, resource allocation, and innovative approaches tailored to the realities of migration.

## Conclusion

The relationship between migration and tuberculosis in children illustrates the broader connection between health and social conditions. Infectious diseases do not occur in isolation; they are shaped by the environments in which people live, move, and interact. Migration, as a defining feature of the modern world, will continue to influence disease patterns, making it essential for health systems to adapt accordingly. By addressing the complex interplay of factors that link migration to tuberculosis, it is possible to reduce the burden of disease and improve health outcomes for children worldwide.

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