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Research Article

Analysis of Sociodemographic Risk Factors in Pediatric Drug-Resistant Tuberculosis: A Single-Center Study

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Abstract

Background: Drug-resistant tuberculosis (DR-TB) in children presents a growing public health challenge, particularly in urban metropolises. The intersection of sociodemographic factors with DR-TB in pediatric populations remains understudied, especially in rapidly urbanizing environments.

Objective: To investigate the relationship between sociodemographic factors and DR-TB in pediatric patients at a tertiary care center in New Delhi, India.

Methods: We conducted a prospective observational study examining 200 children (aged 1 month to 14 years) diagnosed with culture-confirmed or GeneXpert-confirmed DR-TB between June 2017 and June 2019 at a tertiary care hospital in New Delhi.

Results: Key findings revealed significant correlations between residences in unauthorized colonies (45%), exposure to high air pollution levels (72%), malnutrition (75%), and the development of resistant disease. The study population showed a male predominance (male: female ratio 1.2:1), with a mean age of 8.7 years (SD: 3.28). MDR-TB constituted 76% of cases, with a success rate of 93%.

Conclusion: These results highlight the unique challenges of pediatric DR-TB in a rapidly urbanizing megacity and emphasize the need for targeted interventions addressing social determinants of health.

Keywords: *Sociodemographic Risk Factors; Drug-Resistant Tuberculosis; Pediatrics*

Introduction

The emergence of drug-resistant Mycobacterium tuberculosis strains represents a significant obstacle in tuberculosis control, particularly in metropolitan cities [1,2]. Delhi, India's capital territory, presents unique challenges in pediatric DR-TB management due to its population density of 11,320 persons per square kilometer and varying socioeconomic conditions [3,4]. The city's rapid urbanization, coupled with environmental challenges such as air pollution, creates a complex ecosystem for TB transmission and treatment [5,6].

Recent data from the Delhi State TB Control Office indicates an increasing trend in pediatric DR-TB cases, with significant variations across different socioeconomic strata [7,8]. While India continues to report high DR-TB numbers nationally, limited research exists on the sociodemographic patterns associated with pediatric DR-TB cases in urban settings like Delhi [9,10].

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Literature Review

Global Context

Recent epidemiological data from Delhi indicates that childhood TB accounts for approximately 13% of all TB cases, higher than the national average of 11% [11,12]. Sachdeva et al [13] reported that urban areas show distinctive patterns of DR-TB transmission, influenced by population density and social determinants of health. Global studies have demonstrated increasing rates of DR-TB in pediatric populations, with particular concerns in densely populated urban areas [14,15].

Environmental Factors

Research by Gupta et al [16] demonstrated that Delhi's air pollution significantly influences respiratory disease patterns, including TB transmission in urban settings. Their study found that areas with PM2.5 levels exceeding 100 $\mu g/m^3$ showed higher rates of respiratory infections in children. Recent environmental health studies have established strong correlations between air quality indices and TB infection rates in metropolitan areas [17,18].

Socioeconomic Determinants

Sharma et al [19] conducted a comprehensive analysis highlighting the role of unauthorized colonies and slum dwellings in DR-TB transmission within the Delhi-NCR region. Their case-control study demonstrated that children from lower socioeconomic strata had 2.3 times higher odds of developing DR-TB compared to those from middle-income neighborhoods [20]. Housing density and ventilation patterns have been identified as critical factors in disease transmission [21,22].

Nutritional Aspects

Singh et al [23] reported increased susceptibility to DR-TB among undernourished children in Delhi's urban slums, while Kumar et al [24] found significant correlations between socioeconomic status and treatment adherence in the National Capital Region's pediatric populations. Nutritional status has been established as a key modifier of treatment outcomes [25].

Materials and Methods

Study Design and Setting

We conducted a prospective observational study at a tertiary care hospital in New Delhi, following standardized protocols for pediatric TB research [26,27]. The study period (June 2017 to June 2019) was selected to account for seasonal variations in disease presentation [28].

Study Population

Selection criteria were based on WHO guidelines for pediatric DR-TB diagnosis [29] and national protocols [30]. Inclusion and exclusion criteria were adapted from previous successful pediatric TB studies [31,32].

Data Collection

We employed validated tools for:

- Socioeconomic classification using modified Kuppuswamy scale [33]
- Nutritional assessment using WHO growth standards [34]
- Environmental exposure assessment using standardized questionnaires [35]
- Clinical evaluation following international guidelines [36]

Statistical Analysis

Statistical methods were selected based on current epidemiological research standards [37,38]. Sample size calculation ensured adequate power for primary outcome measures [39].

Results

Demographic Characteristics

Age and gender distribution patterns aligned with regional epidemiological trends [40,41]. The male predominance observed (1.2:1) reflects documented healthcare-seeking behaviors in North India [42].

Socioeconomic Distribution

Residential patterns showed significant clustering in unauthorized colonies [43], consistent with previous urban TB studies [44]. Economic stratification revealed predominance of lower socioeconomic groups [45].

Environmental Factors

Air quality measurements were conducted following CPCB guidelines [46]. Seasonal variations in case detection correlated significantly with air pollution levels [47,48].

Clinical Patterns and Outcomes

Drug resistance patterns showed concerning trends [49], with treatment outcomes comparable to other tertiary centers [50,51].

Discussion

Sociodemographic Impact

Our findings demonstrate strong associations between Delhi's urban environmental conditions and pediatric DR-TB development. The high proportion of cases from unauthorized colonies (45%) aligns with previous urban studies [52,53] and underscores the impact of unplanned urbanization on disease transmission. This pattern supports findings by Verma et al [54], who identified Delhi's rapid urbanization as a key factor in TB spread, with unauthorized colonies showing 2.8 times higher transmission rates compared to planned settlements [55].

Environmental Considerations

The significant exposure to high air pollution levels (72%) represents a unique challenge in the Delhi context. Sinha et al [56] reported a 1.8-fold increased risk of respiratory infections in children exposed to PM2.5 levels >100 $\mu g/m^3$, consistent with our observations. The seasonal variation in case detection, particularly during winter months, correlates with Delhi's air quality crisis periods [57,58]. Recent studies have established clear links between air pollution and compromised respiratory immunity [59,60].

Nutritional Aspects

The high prevalence of malnutrition (75% combined moderate and severe) among our study population supports existing literature on nutrition-infection interactions [61,62]. Mehta et al [63] reported similar findings in their North Indian cohort, with malnutrition associated with delayed treatment response and poorer outcomes. Nutritional status significantly influenced treatment success rates ($p<0.001$) [64], highlighting the need for integrated nutritional interventions [65].

Clinical Patterns

The predominance of pulmonary TB (45%) with significant cavity disease (38%) suggests delayed diagnosis [66], potentially related to healthcare access barriers in unauthorized colonies [67]. This pattern differs from previous studies in planned urban areas, where earlier presentation was more common [68,69]. The high proportion of disseminated disease (32%) aligns with other studies from similar socioeconomic settings [70].

Treatment Outcomes

Our observed mortality rate (7%) shows improvement compared to historical data [71,72], possibly reflecting enhanced diagnostic capabilities and treatment protocols [73]. However, the high proportion of MDR-TB cases (76%) suggests ongoing challenges in primary prevention and contact management [74,75].

Limitations

1. Methodological Constraints:

- Single-center design limitations acknowledged in similar studies [76]
- Potential referral bias common to tertiary care settings [77]
- Seasonal variations impact as noted in environmental health literature [78]

2. Technical Limitations:

- Challenges in pediatric TB diagnosis well-documented [79,80]
- Limited drug susceptibility testing capacity affecting result interpretation [81]
- Resource constraints in contact investigation typical of urban settings [82]

Conclusion

Our research establishes critical links between sociodemographic factors and pediatric DR-TB in Delhi [83,84], demonstrating complex interactions between urbanization, environmental conditions, and disease patterns [85].

Key Findings and Recommendations

- Based on our results and supported by current literature [86,87], we recommend:
- Enhanced screening programs in unauthorized colonies [88]
- Integration with Delhi's air quality management initiatives [89]
- Targeted nutritional interventions [90]
- Strengthened contact investigation protocols [91]

Conflicts of Interest

The author declare no conflicts of interest.

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