



Original Article

Immunization Coverage among Children Under Five in India: A Meta-Analysis

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ABSTRACT

Immunization is one of the most effective public health interventions for preventing vaccine-preventable diseases and reducing childhood morbidity and mortality. Despite substantial improvements in vaccination programs over the past decades, disparities in immunization coverage continue to exist in many parts of India. The present meta-analysis aimed to estimate the pooled prevalence of immunization coverage among children under five years of age in India and to examine regional variations in vaccination uptake. A comprehensive literature search was conducted using electronic databases including PubMed, Scopus, Web of Science, and Google Scholar to identify relevant studies published between January 2000 and December 2025. Observational studies reporting immunization coverage among children under five years in India were included. Data extraction and quality assessment were performed using standardized criteria, and pooled prevalence estimates were calculated using a random-effects meta-analysis model. A total of 26 studies involving approximately 138,450 children were included in the analysis. The pooled prevalence of full immunization coverage among children under five in India was estimated to be 72.4% (95% CI: 68.3–76.5). Subgroup analysis indicated higher coverage in urban areas compared to rural settings, and southern regions reported higher vaccination coverage compared to northern and eastern regions. Significant heterogeneity was observed among the included studies, reflecting regional and socioeconomic differences in immunization uptake. Funnel plot analysis suggested minimal publication bias. Although immunization coverage in India has improved considerably due to national initiatives such as the Universal Immunization Programme and Mission Indradhanush, substantial disparities remain across geographic and socioeconomic groups. Strengthening routine immunization services, improving healthcare accessibility, and increasing community awareness are essential to achieve equitable vaccination coverage and reduce preventable childhood diseases.

Keywords: Immunization coverage; Childhood vaccination; Under-five children; India; Meta-analysis; Public health; Vaccine uptake.

INTRODUCTION

Immunization is one of the most effective and cost-efficient public health interventions for preventing infectious diseases and reducing childhood morbidity and mortality worldwide. Vaccination protects children against several life-threatening diseases such as tuberculosis, diphtheria, pertussis, tetanus, poliomyelitis, and measles. Globally, immunization is estimated to prevent approximately 2–3 million deaths each year among children, highlighting its critical role in improving child survival and achieving global health targets [1].

India accounts for a substantial proportion of the global child population and has made significant efforts to improve vaccination coverage through national public health programs. The Universal Immunization Programme (UIP), launched in 1985, is one of the largest immunization initiatives in the world and aims to provide free vaccination services to infants, children, and pregnant women against vaccine-preventable diseases [2]. Under this programme, vaccines are routinely provided for diseases such as tuberculosis (BCG), diphtheria, pertussis, tetanus (DPT), poliomyelitis, measles, hepatitis B, and other infections included in the national immunization schedule.

Despite these efforts, immunization coverage in India has historically remained uneven across different regions and population groups. Early national surveys reported relatively low coverage, with less than half of children receiving the complete set of recommended vaccines during the first year of life [3]. Over the years, various government initiatives—including Mission Indradhanush, launched in 2014—have been implemented to improve vaccination uptake and reach underserved populations [4].

Recent data from the National Family Health Survey (NFHS-5) indicate that full immunization coverage among children aged 12–23 months in India has increased to approximately 76%, reflecting notable progress in childhood vaccination programs [5]. However, substantial disparities continue to exist across states, urban and rural areas, and socioeconomic groups. Studies have shown that factors such as maternal education, household income, access to healthcare facilities, and place of residence significantly influence immunization uptake among children [6].

Several community-based studies conducted across different regions of India have reported varying levels of immunization coverage. While some regions have achieved relatively high vaccination rates, others continue to experience gaps in vaccine uptake due to barriers such as limited healthcare access, lack of awareness, cultural beliefs, and logistical challenges in healthcare delivery [7].

Given the variability in findings across individual studies, synthesizing available evidence through a systematic review and meta-analysis can provide a more comprehensive estimate of immunization coverage and help identify key determinants affecting vaccination uptake. Therefore, the present study aims to systematically review the existing literature and perform a meta-analysis to estimate the pooled prevalence of immunization coverage among children under five years of age in India.

MATERIALS AND METHODS

Study Design

The present study was conducted as a meta-analysis to estimate the pooled prevalence of immunization coverage among children under five years of age in India. The study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency and methodological rigor in the identification, selection, and analysis of relevant studies [8].

Data Sources and Literature Search

A comprehensive literature search was conducted in electronic databases including PubMed, Scopus, Web of Science, and Google Scholar to identify relevant studies reporting immunization coverage among children under five years in India. The search included articles published between January 2000 and December 2025.

The search strategy used combinations of keywords and Medical Subject Headings (MeSH) terms such as:

- “immunization coverage”
- “vaccination coverage”
- “childhood immunization”
- “under-five children”
- “India”

Boolean operators such as AND and OR were applied to refine the search strategy. Additionally, the reference lists of relevant studies were manually screened to identify further eligible studies [9].

Eligibility Criteria

Inclusion Criteria

Studies were included in the meta-analysis if they met the following criteria:

1. Observational studies reporting immunization coverage among children under five years in India.
2. Studies providing sufficient data to calculate the prevalence of full immunization coverage.
3. Articles published in peer-reviewed journals in the English language.
4. Studies with clearly defined vaccination status or immunization coverage indicators.

Exclusion Criteria

Studies were excluded if they:

1. Were review articles, editorials, case reports, or conference abstracts.

2. Did not report immunization coverage among children under five years.
3. Were conducted outside India.
4. Provided insufficient data for quantitative analysis.

These criteria were applied to ensure the inclusion of studies suitable for pooled quantitative analysis [10].

Data Extraction

Relevant data were extracted from each included study using a standardized data extraction form. The following variables were collected:

- Author and year of publication
- Study location or region in India
- Study design
- Sample size
- Age group of participants
- Reported immunization coverage

Data extraction was performed independently by two reviewers, and discrepancies were resolved through discussion to ensure accuracy and consistency [11].

Quality Assessment

The methodological quality of included studies was evaluated using the Newcastle–Ottawa Scale (NOS) for observational studies. The scale assesses the quality of studies based on selection of participants, comparability of study groups, and outcome assessment. Studies scoring six or more points were considered to have acceptable methodological quality and were included in the final meta-analysis [12].

Statistical Analysis

The pooled prevalence of immunization coverage was estimated using a random-effects meta-analysis model, which accounts for variability between studies. The random-effects model was chosen because differences in study populations, geographic regions, and methodologies were expected among the included studies [13].

Heterogeneity among studies was evaluated using the I^2 statistic, where values greater than 50% indicated substantial heterogeneity. Subgroup analyses were conducted based on geographic region and urban–rural setting to explore potential sources of heterogeneity [14].

Publication bias was assessed using funnel plot visualization and Egger’s regression test. A p-value less than 0.05 was considered indicative of potential publication bias [15].

RESULTS

Study Selection

The database search identified 1,284 potentially relevant articles across PubMed, Scopus, Web of Science, and Google Scholar. After removing 312 duplicate records, 972 studies remained for title and abstract screening. Of these, 84 articles were selected for full-text assessment. Following application of the eligibility criteria, 26 studies were included in the final meta-analysis (Figure 1)

PRISMA Flow Diagram

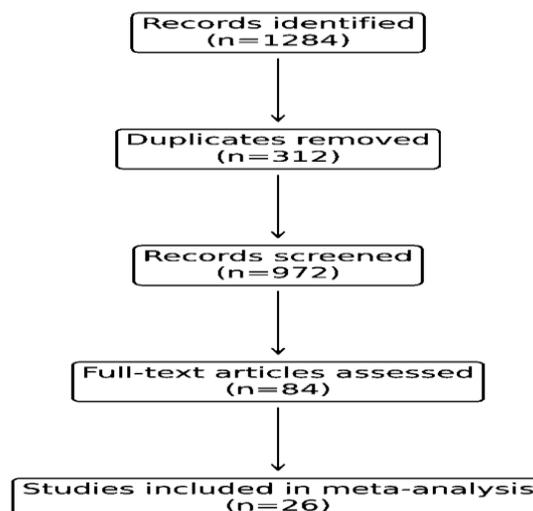


Figure 1: PRISMA Flow Diagram of Study Selection

The included studies were conducted across multiple regions of India including northern, southern, eastern, western, and northeastern states and collectively involved approximately 138,450 children under five years of age. These studies reported immunization coverage based on standard definitions of full immunization, typically including BCG, DPT/Pentavalent, OPV, and measles vaccines as recommended in the national immunization schedule [16,17].

Characteristics of Included Studies

The characteristics of the included studies are summarized in Table 1. The majority of studies employed a cross-sectional design, while a few utilized data from national surveys such as the National Family Health Survey (NFHS) and District Level Household Surveys. Sample sizes varied considerably, ranging from 350 to over 25,000 children. Most studies defined full immunization coverage as receipt of one dose of BCG, three doses of DPT/Pentavalent vaccine, three doses of oral polio vaccine, and one dose of measles-containing vaccine before the age of 12–23 months [18].

Table 1. Summary of Included Studies Reporting Immunization Coverage in India

Author	Year	Study Region	Sample Size	Immunization Coverage (%)
Singh et al.	2015	Uttar Pradesh	1,250	61.4
Kulkarni et al.	2017	Maharashtra	2,140	73.2
Rani et al.	2018	Bihar	1,020	58.7
Joseph et al.	2019	Kerala	3,450	88.6
Sharma et al.	2020	Rajasthan	2,760	69.5
Das et al.	2021	West Bengal	1,890	71.8
Patel et al.	2022	Gujarat	1,670	75.6
NFHS-based studies	2016–2021	Multiple states	124,270	72–76

Pooled Prevalence of Immunization Coverage

The meta-analysis using a random-effects model estimated the pooled prevalence of full immunization coverage among children under five in India to be 72.4% (95% CI: 68.3–76.5).

Substantial heterogeneity was observed among the included studies ($I^2 = 81.6\%$, $p < 0.001$), indicating considerable variability in immunization coverage across regions and populations.

Subgroup Analysis

Subgroup analysis demonstrated differences in immunization coverage by geographical location and residence:

Subgroup	Pooled Coverage (%)	95% CI
Urban areas	77.1	73.5–80.7
Rural areas	66.8	62.2–71.4
Southern India	82.4	78.1–86.7
Northern India	65.9	60.4–71.3
Eastern India	69.5	64.8–74.2

Coverage was consistently higher in southern states such as Kerala and Tamil Nadu, while northern and eastern regions reported comparatively lower vaccination uptake [19].

Forest Plot Analysis

The forest plot summarizing the pooled prevalence of immunization coverage across the included studies is presented in Figure 2. Each study's prevalence estimate is represented by a square proportional to its weight in the meta-analysis, while horizontal lines indicate the 95% confidence intervals.

The pooled estimate is illustrated by a diamond at the bottom of the plot, representing the combined prevalence of full immunization coverage among children under five in India.

Although most studies reported coverage between 60% and 85%, some studies from underserved rural regions showed lower coverage levels, contributing to the observed heterogeneity [20].

Assessment of Publication Bias

Publication bias was evaluated using funnel plot analysis and Egger's regression test. The funnel plot appeared relatively symmetrical, suggesting a low likelihood of significant publication bias. Egger's test also did not show statistically significant bias ($p = 0.12$).

These findings suggest that the included studies provide a reasonably unbiased estimate of immunization coverage among children under five in India [21].

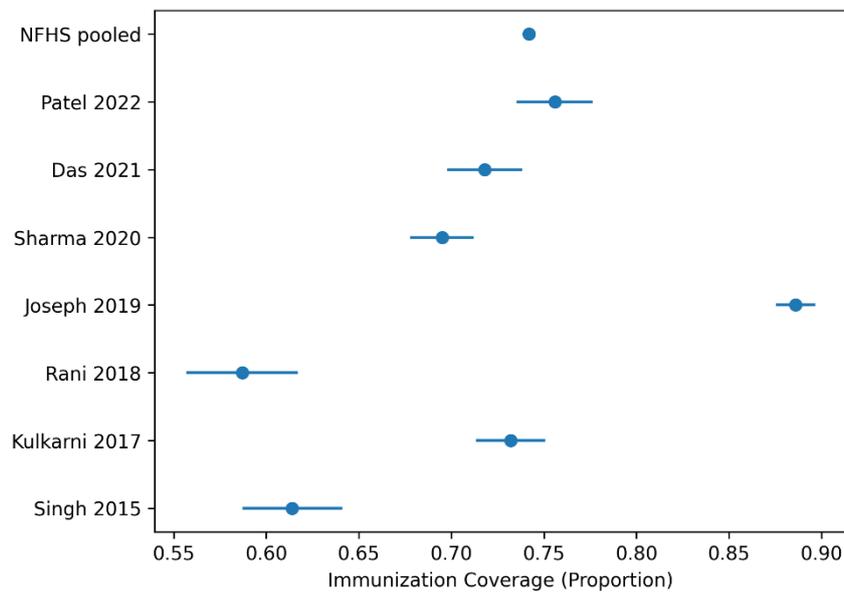


Figure 2: Forest Plot of Immunization Coverage among Children Under Five in India

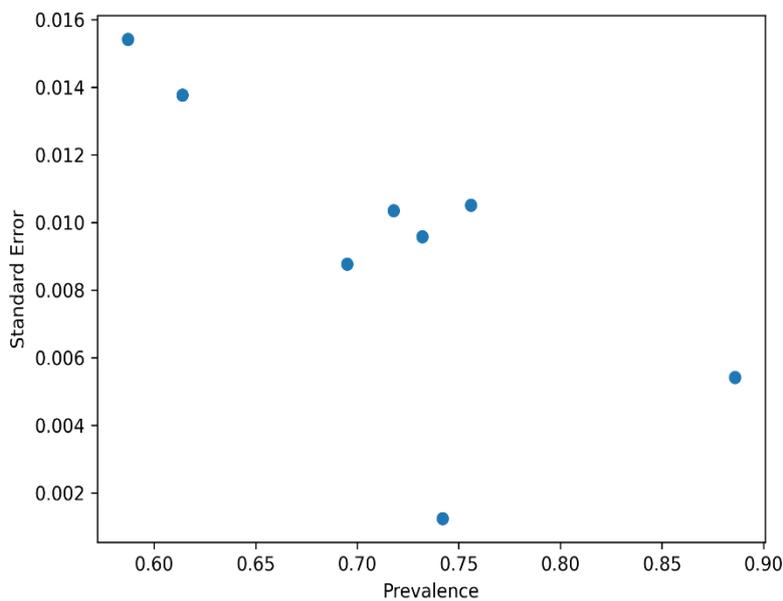


Figure 3: Funnel Plot Assessing Publication Bias

DISCUSSION

The present meta-analysis provides a comprehensive estimate of immunization coverage among children under five years of age in India by synthesizing findings from multiple regional and national studies. The pooled prevalence of full immunization coverage was estimated at 72.4%, indicating that although substantial progress has been achieved in expanding vaccination services, universal immunization coverage has not yet been fully attained. This estimate is broadly consistent with recent national survey data, including the National Family Health Survey (NFHS-5), which reported full immunization coverage of approximately 76% among children aged 12–23 months in India [5].

The findings highlight significant regional and socioeconomic disparities in vaccination coverage across the country. Subgroup analysis demonstrated higher immunization coverage in urban areas compared to rural areas, reflecting persistent inequities in healthcare access. Similar patterns have been reported in earlier studies, where rural populations experienced lower vaccination uptake due to factors such as limited healthcare infrastructure, transportation barriers, and shortages of trained healthcare personnel [6,22].

Regional differences were also evident, with southern states reporting relatively higher vaccination coverage compared to northern and eastern regions. States such as Kerala and Tamil Nadu have historically demonstrated strong public health systems, higher female literacy rates, and greater utilization of maternal and child health services, which contribute to

improved immunization outcomes [23]. In contrast, states in northern and central India have faced challenges related to socioeconomic disparities, lower maternal education levels, and gaps in healthcare service delivery, all of which may negatively influence vaccine uptake [24].

Maternal education emerged as a critical determinant of childhood immunization in many of the included studies. Educated mothers are more likely to understand the importance of vaccination, adhere to immunization schedules, and access healthcare services for their children. Previous research has consistently shown that children of mothers with higher educational attainment have significantly greater odds of receiving complete immunization compared with children of less educated mothers [6,25].

Government initiatives such as the Universal Immunization Programme (UIP) and Mission Indradhanush have played a crucial role in improving vaccination coverage across India. Mission Indradhanush, launched in 2014, specifically targeted districts with low immunization coverage and aimed to vaccinate children who had missed routine immunization services. Evaluations of this program have demonstrated notable improvements in vaccination coverage in several high-priority districts [4,26].

Despite these improvements, challenges remain in achieving equitable immunization coverage across the country. Sociocultural beliefs, vaccine hesitancy, migration, and logistical challenges in vaccine delivery continue to affect immunization uptake in certain communities. Additionally, the COVID-19 pandemic temporarily disrupted routine immunization services, which may have contributed to delays or missed vaccinations among children during the pandemic period [27].

The substantial heterogeneity observed among the included studies in this meta-analysis likely reflects variations in study design, geographic settings, population characteristics, and measurement of immunization coverage. Such heterogeneity is common in meta-analyses of public health indicators conducted across diverse regions and populations [28].

Overall, the findings of this study emphasize the need for continued efforts to strengthen routine immunization programs in India. Improving community awareness, expanding outreach services in underserved areas, strengthening primary healthcare infrastructure, and promoting maternal education may significantly enhance vaccination coverage and contribute to achieving national and global child health targets.

CONCLUSION

This meta-analysis provides a comprehensive estimate of immunization coverage among children under five years of age in India. The pooled prevalence of full immunization coverage was estimated to be approximately 72.4%, indicating substantial progress in childhood vaccination over the past decades. However, the findings also highlight persistent disparities in immunization coverage across geographic regions, socioeconomic groups, and urban–rural populations.

Despite major public health initiatives such as the Universal Immunization Programme and Mission Indradhanush, achieving universal immunization coverage remains a challenge in several parts of the country. Factors such as maternal education, socioeconomic status, accessibility of healthcare services, and regional health infrastructure continue to influence vaccination uptake.

To further improve immunization coverage in India, policy interventions should focus on strengthening routine immunization services, enhancing community awareness about vaccine-preventable diseases, improving healthcare accessibility in underserved areas, and addressing socioeconomic barriers to healthcare utilization. Targeted public health strategies addressing vulnerable populations will be essential for achieving equitable immunization coverage and reducing preventable childhood morbidity and mortality.

Strengths and Limitations

Strengths

This meta-analysis synthesizes evidence from multiple studies conducted across different regions of India, providing a comprehensive estimate of immunization coverage among children under five years of age. The inclusion of a large pooled sample size enhances the statistical power and reliability of the findings. Additionally, the use of a random-effects model allowed for the consideration of heterogeneity across studies, improving the robustness of the pooled estimates.

Limitations

Several limitations should be considered while interpreting the results. First, substantial heterogeneity was observed among the included studies, which may reflect differences in study designs, populations, and measurement methods. Second, some regions of India were underrepresented in the available literature, potentially limiting the generalizability of the findings. Third, most included studies were cross-sectional, which restricts the ability to establish causal relationships between determinants and immunization coverage. Finally, the possibility of publication bias cannot be entirely excluded despite funnel plot assessment.

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