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# IMMUNIZATION COVERAGE AND DETERMINANTS OF INCOMPLETE VACCINATION AMONG CHILDREN AGED 12–23 MONTHS ATTENDING A TERTIARY CARE HOSPITAL IN RAJASTHAN: A HOSPITAL-BASED CROSS-SECTIONAL ANALYTICAL STUDY

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## ABSTRACT

**Background**: Childhood immunization remains one of the most effective public health interventions for preventing vaccine-preventable diseases and reducing under-five mortality. Although India's Universal Immunization Programme has substantially improved vaccination coverage, incomplete immunization continues to be a significant public health concern, particularly in resource-constrained settings. Identification of factors associated with incomplete vaccination is essential for developing targeted interventions to improve immunization coverage.

**Objectives**: To assess the immunizationcoverage among childrenaged 12–23 months attending a tertiary care hospital in Rajasthan and to identify factors associated with incomplete vaccination.

**Methods**: A hospital-based cross-sectional analytical study was conducted from January 2025 to June 2025 among 380 children aged 12–23 months attending the Pediatric Outpatient Department and Immunization Clinic of a tertiary care hospital in Rajasthan. Participants were selected using systematic random sampling. Data were collected using a pretested structured questionnaire, and immunization status was verified primarily through the Mother and Child Protection (MCP) card or immunization card. Descriptive statistics were used to summarize the data. Associations between independent variables and immunization status were assessed using the Chi-square test or Fisher's exact test. Variables significant in bivariate analysis were included in multivariable logistic regression. A p-value <0.05 was considered statistically significant.

**Results**: Among the 380 enrolled children, 302 (79.5%) were fully immunized and 78 (20.5%) were incompletely immunized. Rural residence, maternal education below the secondary level, home delivery, fewer than four antenatal care visits, and absence of an MCP/immunization card were significantly associated with incomplete immunization. Multivariable logistic regression identified absence of an MCP/immunization card, home delivery, lower maternal education, inadequate antenatal care, and rural residence as independent predictors of incomplete vaccination. The most commonlyreportedreasons for incomplete immunizationwere caregiver forgetfulness, child illness on the scheduled vaccination day, inadequate awareness regarding subsequent vaccine doses, and difficulty accessing vaccination services.

**Conclusion**: Although immunization coverage among children attending the tertiary care hospital was encouraging, a substantial proportion of children remained

incompletely vaccinated. Maternal education, utilization of maternal healthcare services, documentation of immunization, and place of residence significantly influenced vaccination completion. Strengthening caregiver counselling, promoting institutional deliveries, improving antenatal education, implementing reminder systems, and enhancing outreach services in rural areas may improve vaccine completion and contribute to achieving universal immunization coverage.

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***Keywords****: Immunization coverage; Incomplete vaccination; Children; Universal Immunization Programme; Vaccine-preventable diseases; Rajasthan; Cross-sectional study.*

## INTRODUCTION

Immunization is one of the most cost-effective and successful public health interventions for preventing childhood morbidity and mortality due to vaccine-preventable diseases (VPDs). Globally, vaccines are estimated to prevent approximately 3.5–5 million deaths each year from diseases such as diphtheria, tetanus, pertussis, influenza, and measles. Despite remarkable progress inexpanding immunization services, millions of childrenworldwide continue to miss essential vaccines, leaving them vulnerable to preventable illnesses and contributing to persistent health inequities. Ensuring complete immunization during the first two years of life remains a key strategy for achieving the Sustainable Development Goals (SDGs), particularly those related to child survival and universal health coverage [1,2].

The Expanded Programme on Immunization (EPI), initiated by the World Health Organization (WHO) in 1974, laid the foundation for universal childhood vaccination and has significantly reduced the burden of infectious diseases across the globe. However, disparities in vaccine coverage persist between and within countries due to socioeconomic inequalities, geographical barriers, inadequate health infrastructure, parental misconceptions, and interruptions in health service delivery. The COVID-19 pandemic further disrupted routine immunization services in many regions, resulting in declines in vaccine coverage and increasing the risk of outbreaks of vaccine-preventable diseases [2,3].

India has made substantial progress in strengthening its Universal Immunization Programme (UIP), one of the largest public immunization programmes in the world. The programme provides free vaccination against multiple vaccine-preventable diseases through an extensive network of healthcare facilities. Initiatives such as Mission Indradhanush and Intensified Mission Indradhanush have further improved immunization coverage, particularly among underserved populations. According to the National Family Health Survey-5 (NFHS-5), the proportion of children aged 12–23 months who received full immunization has improved nationally compared with previous surveys; however, considerable inter-state and intra-state variations continue to exist, highlighting persistent gaps in equitable vaccine access and utilization [4,5].

Incomplete immunizationamong childrenis influenced by a complexinterplayof demographic, socioeconomic, healthcare, and behavioral factors. Maternal education, parental occupation, household income, birth order, place of delivery, institutional antenatal care, vaccine awareness, accessibility of health facilities, and maintenance of immunization records have consistently been reported as important determinants of vaccination completion. Identifying these factors is essential for designing targeted interventions aimed at improving vaccine uptake and reducing missed opportunities for immunization [6,7].

Rajasthan, one of India's geographically diverse states, has demonstrated gradual improvement in childhood immunization indicators over the past decade. Nevertheless, disparities remain between urban and rural populations, tribal communities, and socioeconomically disadvantaged groups. Although statewide surveys provide estimates of immunization coverage, hospital-based assessments offer valuable insights into the characteristics of healthcare-seeking families and enable detailed evaluation of factors associated with incomplete vaccination. Such information is particularly useful for tertiary care hospitals, which often serve as referral centers catering to populations from multiple districts with varying sociodemographic backgrounds [5,8].

Evidence regarding determinants of incomplete vaccination among children attending tertiary healthcare facilities in Rajasthan remains limited. Most available studies have been community-based or conducted in selected geographic settings, with relatively few evaluating immunization status and associated factors among children presenting to tertiary care hospitals. Understanding local determinants is necessary to identify vulnerable groups, strengthen counselling strategies, improve vaccination tracking, and support evidence-based public health planning. Findings from the present study may contribute to strengthening routine immunization services and guide policymakers in developing context-specific interventions to improve vaccine coverage among young children [7–9].

Therefore, the present study aimed to assess the immunization coverage among children aged 12–23 months attending a tertiarycare hospital in Rajasthan and to identifythe sociodemographic, maternal, and healthcare-relatedfactors associated with incomplete vaccination.

## METHODOLOGY

**Study Design:** A hospital-based cross-sectional analytical study was conducted to assess immunization coverage and identify factors associated with incomplete vaccination among children aged 12–23 months attending a tertiary care hospital in Rajasthan. The study was reportedin accordance with the Strengthening the Reportingof Observational Studies in Epidemiology (STROBE) guidelines.

**Study Setting:** The study was conducted in the Immunization Clinic and Pediatric Outpatient Department (OPD) of a tertiary care teaching hospital in Rajasthan, India. The hospital serves as a referral center for urban, peri-urban, and rural populations from the surrounding districts and provides routine immunization services under the Universal Immunization Programme (UIP).

**Study Duration:** The study was conducted over a period of six months, from January 2025 to June 2025.
**Study Population:** The study population comprised children aged 12–23 months attending the Pediatric OPD or Immunization Clinic during the study period, accompanied by their parents or primary caregivers.

**Inclusion Criteria**

- Children aged 12–23 months attending the Pediatric OPD or Immunization Clinic during the study period.
- Parent or primary caregiver available for interview.
- Parent/caregiver willing to provide written informed consent.
- Availability of immunization records (Mother and Child Protection card/immunization card) or reliable caregiver recall when records were unavailable.

**Exclusion Criteria**

- Children younger than 12 months or older than 23 months.
- Children with severe illness requiring emergency management at the time of interview.
- Caregivers unwilling to provide informed consent.
- Children whose caregivers were unable to provide adequate vaccination history despite probing.

**Sample Size:** The sample size was calculated using the formula for estimation of a single population proportion:

$$n = \frac{Z^2pq}{d^2}$$

Where:
**Z** = 1.96 (95% confidence level)
**p** = 0.59 (estimated full immunization coverage)
**q** = 1 − p = 0.41
**d** = 5% (absolute precision)

$$n = \frac{(1.96)^2 \times 0.59 \times 0.41}{(0.05)^2}$$

n = 372

Considering a small allowance for non-response and incomplete information, the final sample size was rounded to 380 children.

**Sampling Technique:** A systematic random sampling technique was employed. Based on the average patient attendance in the Pediatric OPD and Immunization Clinic during the study period, every *4*th eligible child was selected after choosing the first participant randomly. Recruitment continued until the required sample size of 380 was achieved.

**Data Collection Tools and Procedure:** Data were collected using a pre-designed, pretested, interviewer-administered structured questionnaire developed after reviewing relevant literature and national immunization guidelines. The questionnaire included information on sociodemographic characteristics, parental education and occupation, socioeconomic status, birth history, place of delivery, antenatal care utilization, birth order, family type, immunization status, accessibility to vaccination services, and caregiver knowledge regarding routine immunization.

Immunization status was verified primarily using the Mother and Child Protection (MCP) card or immunization card. In the absence of documentary evidence, caregiver recall was considered after detailed probing regarding the vaccines received. Children were classified as fully immunized if they had received all vaccines recommended under the Universal Immunization Programme appropriate for 12–23 months of age and incompletely immunized if one or more recommended

vaccine doses had been missed by the time of assessment. Datawere collectedbytrainedinvestigators under the supervision of the principal investigator to ensure uniformity and quality. Completed questionnaires were reviewed daily for completeness and consistency before data entry.

**Study Variables:** The dependent variable was immunization status, categorized as fully immunized or incompletely immunized according to the national immunization schedule.
The independent variables included the child's age and sex, place of residence (urban/rural), religion, family type, socioeconomic status, parental education, parental occupation, birth order, place and mode of delivery, birth weight, antenatal care visits, possession of an MCP/immunization card, distance from the health facility, caregiver awareness regarding immunization, previous adverse events following immunization, and history of missed vaccination sessions.

**Statistical Analysis:** Data were entered into Microsoft Excel 2021 and analyzed using IBM SPSS Statistics version 26.0. Continuous variables were summarized as mean ±standard deviation (SD) or median with interquartile range, depending on data distribution. Categorical variables were expressed as frequencies and percentages. Associations between immunization status and categorical independent variables were assessed using the Chi-square test or Fisher's exact test, wherever appropriate. Variables demonstrating statistical significance in bivariate analysis were entered into multivariable binary logistic regression to identify independent predictors of incomplete immunization. Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were reported. A two-tailed p-value $<0.05$ was considered statistically significant.

**Ethical Considerations:** Written informed consent was obtained from the parent or legal guardian of every participating child before enrollment. Participation was voluntary, and confidentiality of participants' information was maintained throughout the study by anonymizing the collected data and restricting access to the research team. Participants were informed of their right to withdraw from the study at any stage without affecting the healthcare services received. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki (2013 revision) and adhered to national ethical guidelines for biomedical research involving human participants.

## RESULTS

A total of 380 children aged 12–23 months were included in the analysis. Immunization status was assessed using the Mother and Child Protection (MCP) card/immunizationcard whenever available, supplemented by caregiver recall where necessary. Slightly more than half of the participants were aged 12–17 months, and males constituted a marginal majority. Most children belonged to rural areas, nuclear families, and lower-middle socioeconomic households (Table 1).

**Table 1. Sociodemographic characteristics of the study participants (N = 380)**

| Variable | Category | Frequency (n) | Percentage (%) |
|---|---|---|---|
| **Age (months)** | 12–17 | 198 | 52.1 |
| | 18–23 | 182 | 47.9 |
| **Sex** | Male | 208 | 54.7 |
| | Female | 172 | 45.3 |
| **Residence** | Urban | 148 | 38.9 |
| | Rural | 232 | 61.1 |
| **Family type** | Nuclear | 214 | 56.3 |
| | Joint | 166 | 43.7 |
| **Socioeconomic status*** | Upper/Upper middle | 86 | 22.6 |
| | Lower middle | 158 | 41.6 |
| | Upper lower | 104 | 27.4 |
| | Lower | 32 | 8.4 |
| **Mother's education** | Secondary or above | 224 | 58.9 |
| | Primary/Middle | 96 | 25.3 |
| | Illiterate | 60 | 15.8 |
| **Father's education** | Secondary or above | 256 | 67.4 |
| | Primary/Middle | 82 | 21.6 |
| | Illiterate | 42 | 11.0 |

*Modified B.G. Prasad Socioeconomic Classification (updated).

Overall, 79.5% of children were fully immunized, while 20.5% were incompletely immunized. Institutional delivery, four or more antenatal care visits, possession of an MCP/immunization card, and adequate caregiver awareness regarding routine immunization were observed in the majority of participants (Table 2).

**Table 2. Immunization coverage and maternal/healthcare-related characteristics (N = 380)**

| Variable | Category | Frequency (n) | Percentage (%) |
|---|---|---|---|
| **Immunization status** | Fully immunized | 302 | 79.5 |
| | Incompletely immunized | 78 | 20.5 |
| **Place of delivery** | Institutional | 338 | 88.9 |
| | Home | 42 | 11.1 |
| **Antenatal care visits** | ≥4 visits | 290 | 76.3 |
| | <4 visits | 90 | 23.7 |
| **Birth order** | First | 176 | 46.3 |
| | Second | 132 | 34.7 |
| | Third or higher | 72 | 18.9 |
| **Possession of MCP/immunization card** | Yes | 326 | 85.8 |
| | No | 54 | 14.2 |
| **Caregiver awareness regarding routine immunization** | Adequate | 262 | 68.9 |
| | Inadequate | 118 | 31.1 |

Bivariate analysis demonstrated that rural residence, lower maternal educational status, home delivery, fewer than four antenatal care visits, and non-availability of an MCP/immunization card were significantly associated with incomplete immunization ($p < 0.05$) (Table 3).

**Table 3. Factors associated with incomplete immunization among children aged 12–23 months (N = 380)**

| Variable | Fully immunized n (%) | Incompletely immunized n (%) | $\chi^2$ | p-value |
|---|---|---|---|---|
| **Residence** | | | | |
| Urban | 129 (87.2) | 19 (12.8) | 8.5 | **0.004** |
| Rural | 173 (74.6) | 59 (25.4) | | |
| **Mother's education** | | | | |
| Secondary or above | 192 (85.7) | 32 (14.3) | 13.6 | **0.001** |
| Primary/Middle | 72 (75.0) | 24 (25.0) | | |
| Illiterate | 38 (63.3) | 22 (36.7) | | |
| **Place of delivery** | | | | |
| Institutional | 278 (82.2) | 60 (17.8) | 12.1 | **0.001** |
| Home | 24 (57.1) | 18 (42.9) | | |
| **ANC visits** | | | | |
| ≥4 | 242 (83.4) | 48 (16.6) | 11.3 | **0.001** |
| <4 | 60 (66.7) | 30 (33.3) | | |
| **MCP card available** | | | | |
| Yes | 272 (83.4) | 54 (16.6) | 20.8 | **<0.001** |
| No | 30 (55.6) | 24 (44.4) | | |

On multivariable logistic regression analysis, absence of an MCP/immunization card (AOR 3.1, 95% CI: 1.6–6.0), home delivery (AOR 2.5, 95% CI: 1.2–5.0), maternal education below the secondary level (AOR 2.3, 95% CI: 1.3–4.1), fewer than four antenatal care visits (AOR 2.0, 95% CI: 1.1–3.6), and rural residence (AOR 1.9, 95% CI: 1.1–3.4) remained independent predictors of incomplete immunization (Table 4).

**Table 4. Multivariable logistic regression analysis for predictors of incomplete immunization (N = 380)**

| Variable | Adjusted Odds Ratio (AOR) | 95% Confidence Interval | p-value |
|---|---|---|---|
| Rural residence | 1.9 | 1.1–3.4 | 0.028 |
| Maternal education below secondary | 2.3 | 1.3–4.1 | 0.005 |
| Home delivery | 2.5 | 1.2–5.0 | 0.012 |
| <4 ANC visits | 2.0 | 1.1–3.6 | 0.019 |
| No MCP/immunization card | 3.1 | 1.6–6.0 | 0.001 |

Among incompletely immunized children, the most frequently reported reason for missed vaccination was caregiver forgetting the scheduled vaccination date, followed by child illness on the scheduled day, lack of awareness regarding subsequent doses, and difficulty accessing vaccination services (Table 5).

**Table 5. Reported reasons for incomplete immunization among incompletely immunized children (n = 78)***

| Reason | Frequency (n) | Percentage (%) |
|---|---|---|
| Caregiver forgot vaccination date | 24 | 30.8 |
| Child was ill on scheduled vaccination day | 16 | 20.5 |
| Lack of awareness regarding subsequent doses | 14 | 17.9 |
| Difficulty accessing vaccination services | 10 | 12.8 |
| Family-related constraints | 8 | 10.3 |
| Fear of adverse events following immunization | 6 | 7.7 |

*Multiple responses were not permitted; caregivers reported the principal reason for incomplete vaccination.

## DISCUSSION

The present hospital-based cross-sectional analytical study assessed immunization coverage and factors associated with incomplete vaccinationamong childrenaged 12–23 months attendinga tertiarycare hospital inRajasthan. Overall, 79.5%of the childrenwere fully immunized, while 20.5% had incomplete immunization. Rural residence, maternal educationbelow the secondary level, home delivery, fewer than four antenatal care visits, and non-availability of an MCP/immunization card were identified as independent predictors of incomplete vaccination. Caregiver forgetfulness, child illness at the scheduled vaccination visit, and inadequate awareness regarding subsequent vaccine doses were the most commonly reported reasons for missed immunization.

The full immunization coverage observed in the present study is comparable with the estimates reported by the National Family Health Survey-5 (NFHS-5), which demonstrated a substantial improvement in childhood immunization coverage across India while highlighting persistent interstate and intrastate disparities [5]. The relatively high coverage in the present study may be attributed to the hospital-based setting, where caregivers have better access to healthcare services, routine immunization sessions, and health education. Nevertheless, approximately one-fifth of eligible children remained incompletely immunized, indicating that important gaps continue to exist despite the availability of free vaccination services under the Universal Immunization Programme (UIP) [2,4].

Residence emerged as an important determinant of immunization status. Children residing in rural areas had significantly higher odds of incomplete vaccination than their urban counterparts. Similar observations have been reported in previous Indian studies, where geographical barriers, transportation difficulties, limited outreach services, and reduced accessibility to healthcare facilities contributed to lower vaccine uptake in rural populations [5,9]. These findings underscore the need to strengthen outreach immunization activities and improve accessibility in underserved areas.

Maternal education showed a significant association with vaccination completion, with children of mothers having educationbelow the secondarylevel demonstratinghigher odds of incomplete immunization. Maternal education is widely recognized as a determinant of healthcare utilization because educated mothers are generally more aware of the benefits of vaccination, recommended immunization schedules, and the importance of timely completion of vaccine doses [6,7]. Similar associations have been documented in studies from different regions of India and other low- and middle-income countries, emphasizing that educational empowerment of women has long-term benefits for child health outcomes [10,11].

Institutional delivery was also associated with improved immunization coverage. Children delivered at health facilities were more likely to receive birth-dose vaccines, early counselling regarding routine immunization, and scheduled follow-up visits. Conversely, home deliveries were independently associated with incomplete vaccination. Comparable findings have been reported in previous studies evaluating childhood immunization determinants in India, where institutional childbirth facilitated early contact with healthcare providers and strengthened continuity of preventive services [4,10].

Adequate antenatal care utilization was another important predictor identified in the present study. Mothers who attended four or more antenatal visits were significantly more likely to have fully immunized children. Antenatal visits provide opportunities for counselling regarding infant feeding, newborn care, vaccination schedules, and the importance of completing all recommended immunizations. Earlier studies have similarly demonstrated positive associations between antenatal care utilization and childhood vaccination completion [6,11].

The strongest predictor identified in this study was the absence of an MCP/immunization card. Caregivers without documentedvaccination records were more likelyto have incompletelyimmunized children. Immunization cards serve not only as documentation of administered vaccines but also as reminder tools for future vaccination visits and facilitate continuity of care across different healthcare facilities. Strengthening documentation practices and promoting retention of immunization cards may therefore contribute to improved vaccine completion rates.

Among incompletely immunized children, caregiver forgetfulness was the most frequently reported reason for missed vaccination, followed by child illness and inadequate awareness regarding subsequent doses. Similar barriers have been reported in several studies evaluating immunization practices in developing countries [7,10]. These findings suggest that reminder systems, mobile-phone-based vaccination alerts, caregiver counselling, and regular community outreach could reduce missed opportunities for vaccination.

From a public health perspective, the findings highlight that improving vaccine availability alone may not be sufficient to achieve universal immunization coverage. Strategies addressing maternal education, antenatal counselling, institutional delivery, documentation of vaccination, and targeted interventions in rural populations are equally important. Integration of digital immunization tracking systems with routine maternal and child health services may further enhance vaccine completion and reduce dropout rates.

The present study has several strengths. It employed an adequate sample size, standardized data collection procedures, and analytical methods that enabled identification of independent predictors of incomplete vaccination. Verification of immunization status using MCP/immunization cards whenever available improved data reliability. Furthermore, the study provides contemporary evidence from a tertiary care setting in Rajasthan, contributing valuable local information for programme planning.

However, certain limitations should be be acknowledged. As a hospital-based cross-sectional study, the findings may not be fully generalizable to the wider community. The cross-sectional design precludes establishing causal relationships between identified factors and incomplete immunization. In a small proportion of participants, caregiver recall was used in the absence of immunization records, introducing the possibility of recall bias. Additionally, factors such as vaccine supply interruptions or healthcare provider practices were not evaluated and may have influenced immunization status.

## CONCLUSION

The present study demonstrated that nearly four-fifths of children aged 12–23 months attending a tertiary care hospital in Rajasthan were fully immunized, while approximately one-fifth remained incompletely vaccinated. Despite satisfactory overall immunization coverage, significant disparities persisted among children residing in rural areas, those born at home, those whose mothers had lower educational attainment, those whose mothers had fewer than four antenatal care visits, and those without an available Mother and Child Protection(MCP) card. These findings indicate that incomplete immunization is influenced by multiple sociodemographic and healthcare-related factors rather than vaccine availability alone. Strengthening routine immunization services shouldfocus onimproving maternal health education, promotinginstitutional deliveries, enhancing antenatal counselling regarding childhood vaccination, ensuring retention and use of immunization records, and implementing effective reminder and follow-up systems for caregivers. Targeted outreach strategies for rural and underserved populations are essential to reduce missed opportunities for vaccination. Continuous monitoring of immunization coverage and locally tailored public health interventions will be instrumental in achieving equitable and sustained improvements in childhood vaccination and reducing the burden of vaccine-preventable diseases.

## DECLARATIONS

**Funding**: The authors received no external funding for this study.

**Conflict of Interest**: The authors declare that there is no conflict of interest.

**Informed Consent**: Written informed consent was obtained from the parent or legal guardian of each participating child before enrollment.

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