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# Coverage, quality, and correlates of childhood immunization in slums under national immunization program of India: A cross-sectional study

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ABSTRACT

Adequate and quality immunization coverage plays a key role in controlling the outbreaks of vaccine preventable diseases. Places where immunization coverage is low, vaccine preventable diseases contribute to worse health outcomes. This is especially true in Indian slum dwellings where 33.0% of the urban population live. The aim of the study was to explore the coverage, quality, and correlates of primary immunization under national immunization program among children aged 12–23 months, living in slums of Mumbai. A community based cross-sectional survey was conducted. Parents or caretakers of 550 eligible children aged 12–23 months were interviewed using a structured interview schedule. Regression analysis was used to detect correlates of full immunization coverage (children who received one dose each of BCG, measles, and three doses each of DPT, OPV, and HBV by his/her first birthday) and of quality immunization coverage (children who received primary vaccines at appropriate age and intervals as mentioned above and had filled immunization card). Out of total 550 children, 402 (73.1%), 131 (23.8%), and 17 (3.1%) were fully, partially, and unimmunized, respectively. Almost 86.0% children received quality immunization coverage. In the regression analysis, reminder for immunization services was found to be the single most significant correlate of full and quality immunization coverage.

In this study, full immunization coverage was found to be below the expected level. This study also revealed that the awareness regarding the importance of adequate immunization was still lacking in the slum population. Emphasizing on reminders for immunization services, encouraging institutional deliveries, and scaling up use of postnatal care services may act as keys to improving the immunization coverage in Indian slums.

**What is already known on this subject**

Substantial differences exist in rates of immunization in slums due to various demographic characteristics, socioeconomic factors and healthcare deserts. To improve the immunization coverage, importance has been laid on approaches like enhancing household's socioeconomic conditions, improving literacy, health awareness, gender equality health infrastructure, providers' skills, etc.

**What this study adds**

This study explores the factors which have been ignored so far and which can help in improving immunization coverage. In addition to quantification of immunization coverage, our study also explored quality of the immunization coverage. Emphasis should be laid on reminders to parents or caretakers for improving immunization coverage. Further, encouraging institutional delivery and scaling up use of postnatal care services may play a critical role in improving the immunization in Indian slums.

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## 1. Introduction

In India, about 100 million (33.0%) of the urban population reside in the unorganized slums. These slums are characterized as one of the most vulnerable settings for outbreaks of vaccine preventable diseases (VPDs) due to factors such as overcrowding, poor hygiene and sanitation, healthcare deserts, etc. These unhealthy surroundings provide a fertile ground for microbial growth and are home to a wide array of infectious diseases causing childhood morbidity and mortality [1]. According to the National Family Health Survey (NFHS) data, the under-five mortality rate in India was 50 deaths/1000 live births in 2013, and almost 0.5 million children die every year due to VPDs [1, 2].

India has a vital role to play in global efforts to end the under-five mortality due to VPDs as it is the major contributor [1, 3]. Substantial portion of this is from slums. A survey on health and living conditions in eight Indian cities found that the under-five death rate was about 32 points higher in slums compared to non-slums. This can be partially attributed to lower immunization coverage, which is 2.7–18.3% less compared to non-slums. It is well acknowledged that when immunization coverage is low, VPDs leads to worse health outcomes [1, 4, 5].

Mumbai is among the world's most populous cities with approximately 20.5 million inhabitants, of whom 62.0% live in slums [6]. The immunization coverage in these slums is inadequate making them vulnerable to VPDs' outbreaks [1, 2, 4]. India's national health survey, NFHS in 2015–2016 found 50.0% children age 12–23 months as fully immunized for Mumbai Suburban District and 46.0% for Mumbai City District, which is lower than that of Maharashtra State's coverage of 56.0%. However, this survey did not evaluate the immunization coverage separately for slums in both the districts [2].

Immunization is one of the safest and the most cost-effective public health strategies for controlling and/or eliminating life-threatening infectious diseases [7]. Any factor which may help in improving the immunization coverage in slums will be beneficial to the entire society as a substantial portion of the world population, especially those belonging to low income and low middle-income countries, live in these vulnerable settings [1].

The present study aimed to explore the coverage, quality, and correlates of primary immunization among children aged 12–23 months, under the national immunization program (NIP) in the slums of Mumbai, Maharashtra, India.

## 2. Materials and methods

### 2.1. Study design and centres

This cross-sectional study was conducted in the slums of Mumbai City and Mumbai Suburban districts of Maharashtra State (Fig. 1). The study was approved by the Institutional Ethics Committee of National Institute of Medical Statistics (NIMS), New Delhi. Written informed consents were

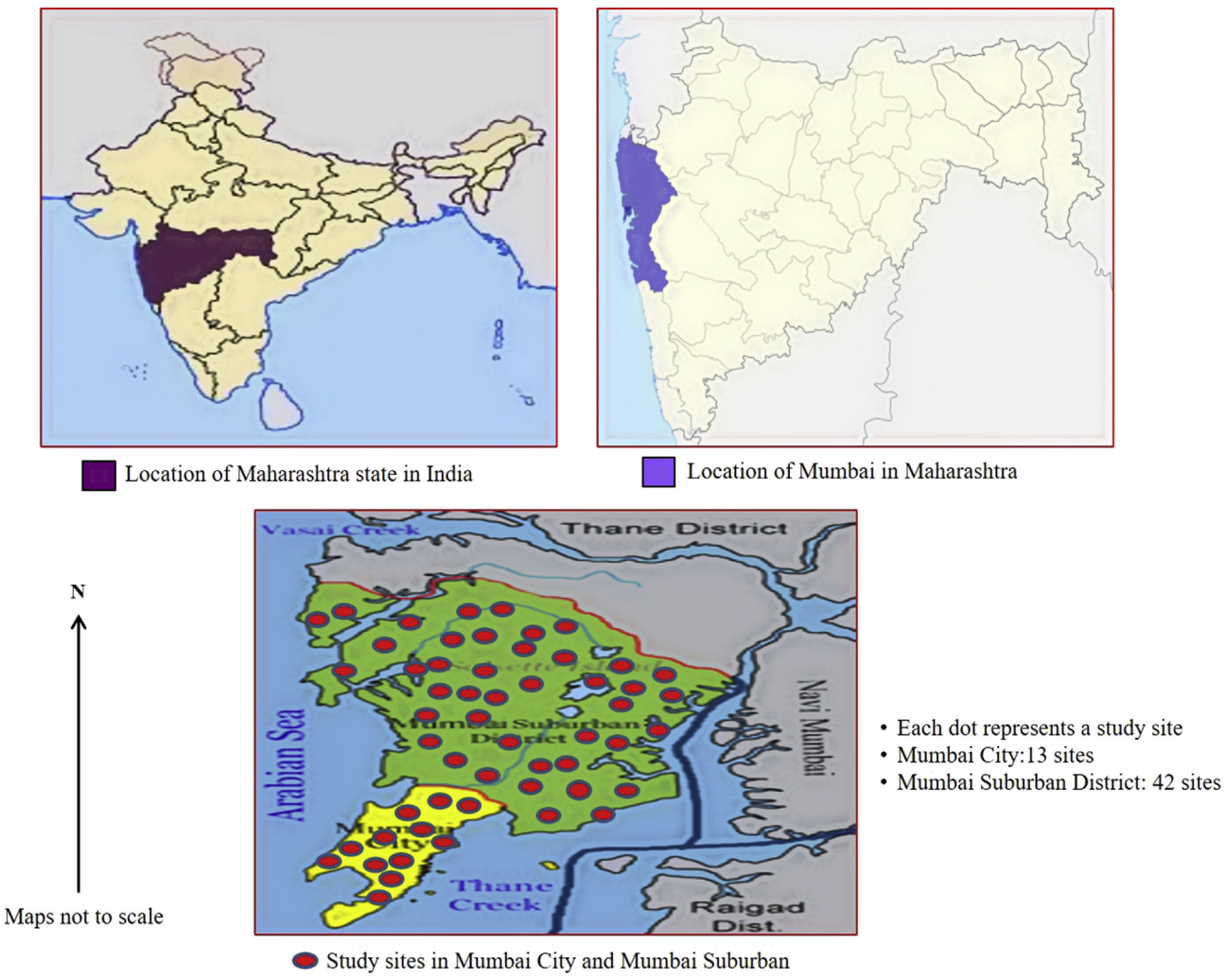


**Fig. 1.** Study location.

obtained from all participants.

### 2.2. Participants

Parents or caretakers of children aged 12–23 months were considered for the interview to evaluate the primary vaccination coverage at 12 months [8]. Primary respondents were mothers or fathers. In their absence, an adult (aged ≥18 years) who remained with the child for most of the days or had taken the child for at least one immunization session was considered eligible for the interview. For this study, slum was defined as a residential area where dwellings are unfit for human habitation by reason of dilapidation, overcrowding, faulty arrangements and design of such buildings, narrowness or faulty arrangement of streets, lack of ventilation, light, or sanitation facilities or any combination of these factors which are detrimental to the health and safety of the inhabitants.

The following inclusion criteria were considered to select the respondent: houses with children aged 12–23 months, parent or primary caretaker of the child as respondents, availability of either a vaccination card and or a caretaker, and age of the respondent ≥18 years. We included residents with eligible children who stayed overnight in the survey area and consented to participate in the study.

The study participants were selected using a multistage cluster sampling method. Health posts in the slums from both districts were considered as clusters. Fifty-five clusters (health posts) from two districts were selected using the 'probability proportional to size (PPS)' method. In each cluster, 10 eligible participants were interviewed. The location of the center of the cluster was identified and one of the streets starting from the center was randomly selected [9]. The first household was randomly selected, and the remaining households were continuously surveyed until 10 participants were identified. The same process was repeated for all 55 clusters. If the eligible participant was absent during the first visit, second visit was made. If more than one respondent aged between 12-23 months were found eligible in a household, all were interviewed as an individual participant as described in the WHO's vaccination coverage cluster survey methodology [9]. One of the authors (SS) interviewed the study participants at their homes during February–November 2017, using a structured interview schedule. The interview schedule was reviewed by the subject experts, translated into local language (Hindi), back translated into English, and pretested before its final use to avoid any potential misunderstandings or potential changed meanings.

### 2.3. Vaccines and definitions considered for evaluation

For assessing the primary immunization coverage, following vaccines and schedules available in the NIP, India were considered.

- Bacillus Calmette Guerin (BCG):at birth,
- Oral Poliovirus Vaccine (OPV): three doses at 6, 10 and 14 weeks,
- Hepatitis B (HBV): three doses at 6, 10 and 14 weeks,
- Diphtheria, Tetanus Toxoids and Pertussis (DPT): three doses at 6, 10 and 14 weeks, and
- Measles: 9–12 months.

To evaluate the outcome of primary immunization, following definitions were considered:

- Fully immunized: A child who received one dose each of BCG, measles, and three doses each of DPT, OPV, and HBV by his/her first birthday,
- Partially immunized: A child who received some vaccines. However, did not complete the schedule, and missed any of the above-mentioned vaccines by his/her first birthday,
- Unimmunized: A child who had not received any vaccines up to 12 months of age, and
- Quality immunization coverage: Includes those children who received primary vaccines at appropriate age and intervals as mentioned above and had filled immunization card.

### 2.4. Statistical analyses

Sample size for this survey was calculated using the World Health Organization (WHO) vaccination coverage cluster survey methodology with vaccine coverage of 57.0% among children aged 12–23 months as reported by the recent NFHS Survey-4 for Maharashtra State. We took ±7% as desired precision level. Total number of interview samples was calculated to be 542, rounded to 550 [6, 8].

Method for determination of the immunization status was recall. The information collected using the above-mentioned method, was converted into a computer-based spreadsheet. Statistical analyses were performed using SPSS version 17 (SPSS Inc, 129 Chicago, IL, USA). For adjustment of possible interaction and confounding factors, we conducted Poisson regression analysis to arrive at a final model. Predictor variables with p-value <0.05 in bivariate analysis were considered for the final model. The net bearing effect of different predictor variables was explained in terms of Prevalence Ratio (PR) with 95% of Confidence Interval (95% CI).

## 3. Results

### 3.1. Baseline characteristics

We visited a total of 4,047 households and contacted 578 eligible respondents. Of these, 550 were enrolled in our study. Among 550 respondents, 524 (95.3%) were mothers, 6 (1.1%) fathers, and 20 (3.6%) respondents were other relatives. Majority of the children (90.0%) were living with both parents and mothers were the primary caretakers (96.0%) of their children. The basic characteristics of the study

**Table 1**
Basic characteristics of the study population (N = 550).

| Characteristics | No. (%) |
|---|---|
| Age 12–23 months | 550 (100.0) |
| Male | 278 (50.5) |
| Birth at health facility | 523 (95.1) |
| Birth at non-health facility | 27 (4.9) |
| Child's primary caretaker | |
| Parents | 539 (98.0) |
| Others[a] | 11 (2.0) |
| Religion | |
| Muslim | 79 (14.4) |
| Non-muslim | 471 (85.6) |
| Community[b] | |
| General | 390 (70.9) |
| Non-general | 160 (29.1) |
| Mother's education | |
| Educated | 437 (79.5) |
| Uneducated | 113 (20.5) |
| Mother's occupation | |
| Employed | 121 (22.00) |
| Unemployed | 429 (78.00) |
| Family size | |
| <5 members | 326 (59.3) |
| ≥5 members | 224 (40.7) |
| Monthly expenditure in INR[c] | |
| High | 274 (49.8) |
| Low | 276 (50.2) |

[a] Grandparents, uncle, aunt, etc.
[b] General community includes upper caste, non-general community includes Other Backward Caste (OBC), Scheduled Caste, and Scheduled Tribe (ST).
[c] Participants were divided into two groups based on whether the expenditure was higher or lower than the median value of 7000 Indian Rupees.

population are presented in Table 1.

Local government's health posts were the major provider of the immunization services. About 96.4% (514/533) received immunization services at these posts. Nurses or midwives were the most common immunization service providers (95.5% [n = 509]). The highest coverage was for BCG 95.8% and the lowest for three doses of DPT vaccine 78.5%. Immunization coverage for measles, hepatitis B, and OPV was 86.7%, 81.5%, and 82.5% respectively.

### 3.2. Immunization coverage and quality

Of the enrolled population, 73.1%, 23.8% and 3.1% children were fully, partially and unimmunized, respectively. Fig. 2 summarizes the details of immunization coverage. In cases of children with partial or no immunization, major reasons quoted were: (i) mothers too busy (35.8%), (ii) fear of side effects (25.0%), (iii) family related problems (20.9%) and (iv) immunization site or time unknown (16.9%).

Of the 533 fully or partially immunized children, 522 children (97.9%) reported to have immunization cards. When requested, only 406 (77.7%) respondents were able to produce the cards. Majority of the respondents (95.5%) who were not able to show the immunization card believed that it was not important to keep the card once the entire schedule was completed.

In our study, we found 349 (85.9%) participants (male: 88.1%; female: 83.4%) children received quality immunization coverage which includes those children who received all primary vaccines at appropriate age and intervals and had filled immunization cards (n = 406).

### 3.3. Correlates of immunization coverage

Table 2 demonstrates the regression analysis of full immunization coverage among children aged 12–23 months. In the bivariate analysis for unadjusted prevalence ratio (uPR), all the factors listed in Table 2 were found to be significant correlates of full immunization. However, Poisson regression analysis for adjusted PR (aPR) found "family received reminder for immunization services" as the single most significant correlate of full immunization (aPR: 9.7 [95% CI: 5.4–17.5]; $p < 0.001$).

### 3.4. Correlates of quality immunization coverage

Table 3 demonstrates the regression analysis of quality immunization coverage among children aged 12–23 months. In the bivariate analysis for uPR, only "family received reminder for immunization services" was found significant correlates of quality immunization coverage (uPR: 4.5; 95% CI [ 2.5–8.3], $p < 0.001$). As only one variable was found to be significant in unadjusted analysis, adjusted analysis was not performed.

## 4. Discussion

Immunization coverage is a multi-sectorial activity. The low coverage in slums suggests that the current immunization delivery systems do not effectively meet the circumstances of those living in these settings. Also, an ever-increasing number of inhabitants in slums along with outbreaks of VPD's with high mortality and morbidity present a challenge for achieving the goal of an immunization program. Thus, a mere inclusion of new vaccines in the immunization program is not enough and one must look beyond by giving special emphasis upon people living in such settings [3]. Our study aimed to address this to a certain extent and explore the factors that can help improve the immunization services in slums.

The present study demonstrated a coverage range of individual vaccine from 78.5% for DPT to 95.8% for BCG among children aged 12–23 months. Administration of BCG at birth is mandatory. Therefore, children born in hospitals are more likely to receive BCG vaccination and coverage is always high. On the other hand, vaccines such as DTP are given repeatedly from 6 weeks onwards. This translates into higher dropouts for various reasons (e.g. difference in the schedule), some of which are discussed below.

In our study, 73.1%, 23.8% and 3.1% were fully, partially and unimmunized, respectively. Also, a greater number of male children were immunized compared to female children (80.2% vs 65.8%). This is probably because gender plays an important role in Indian male favoring society. Though the inequities have improved over past several years it continues to exit in the society, especially, in those with the low socioeconomic status. Similarly, male subjects had higher coverage compared to their female counterparts in studies reported in literature [10, 11].

Immunization coverage demonstrated in our study is comparable to that reported in a study conducted in the urban slums of Mumbai (fully immunized: 70.0%, partially immunized: 25.3%, unimmunized: 4.6%) [12]. Another study conducted in Mumbai slums among children aged 12–23 months also observed similar immunization coverage [13]. Also, similar data is reported from the slums of Western and Eastern parts of India [14, 15, 16]. On the other hand, vaccination coverage in our study was higher compared to the recent NFHS-4, 2015–2016 survey for Mumbai Suburban (50.0%) and Mumbai City (46.0%) districts [2]. Lower coverage has also been reported in studies across different regions

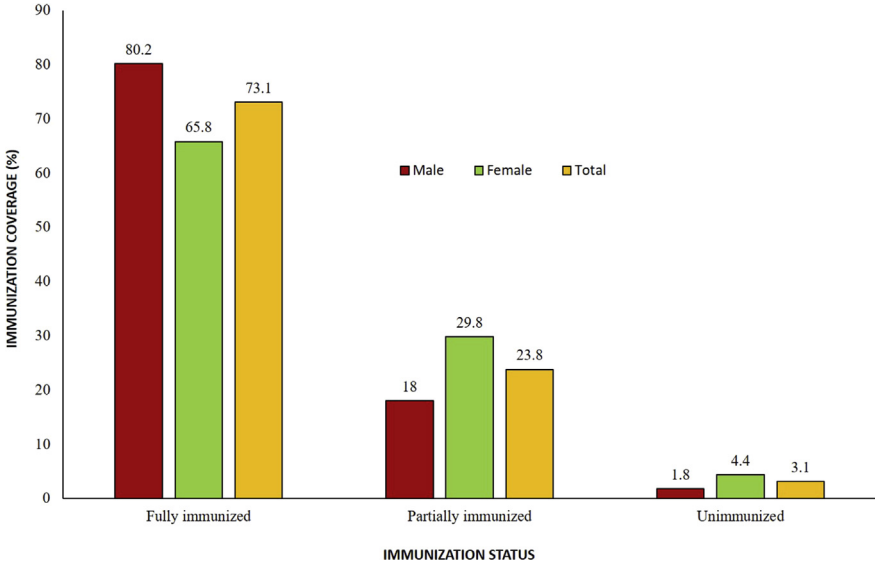


**Fig. 2.** Details of immunization coverage.

**Table 2**
Regression analysis of immunization coverage among children aged 12–23 months.[a]

| Variables | Fully Immunized No. (%) | Partially or unimmunized immunized No. (%) | Unadjusted prevalence ratio with 95 % CI | p-value | Adjusted prevalence ratio with 95 % CI | p-value |
|---|---|---|---|---|---|---|
| Child's gender | | | | | | |
| Female | 179 (65.8) | 93 (34.2) | 1 | | 1 | |
| Male | 223 (80.2) | 55 (19.8) | 1.2 (1.0–1.5) | <0.049 | 1.0 (0.8–1.3) | 0.989 |
| Mother's education | | | | | | |
| Uneducated | 47 (41.6) | 66 (58.4) | 1 | | 1 | |
| Educated | 355 (81.2) | 82 (18.8) | 1.9 (1.4–2.6) | <0.001 | 1.0 (0.7–1.6) | 0.897 |
| Father's education | | | | | | |
| Uneducated | 22 (44.0) | 28 (56.0) | 1 | | 1 | |
| Educated | 380 (76.0) | 120 (24.0) | 1.7 (1.1–2.7)) | 0.013 | 1.0 (0.6–1.6) | 0.991 |
| Monthly household income (in INR) | | | | | | |
| ≤10,000 | 239 (66.6) | 120 (33.4) | 1 | | 1 | |
| >10,000 | 163 (85.3) | 28 (14.7) | 1.3 (1.1–1.6) | 0.014 | 1.0 (0.7–1.4) | 0.947 |
| Monthly household expenditure (in INR) | | | | | | |
| ≤10,000 | 270 (67.7) | 129 (32.3) | 1 | | 1 | |
| >10,000 | 132 (87.4) | 19 (12.6) | 1.3 (1.0–1.6) | 0.016 | 1.0 (0.7–1.5) | 0.910 |
| Child delivered at | | | | | | |
| Non-health facility | 11 (40.7) | 16 (59.3) | 1 | | 1 | |
| Health facility | 391 (74.8) | 132 (25.2) | 1.8 (1.0–3.3) | 0.047 | 1.3 (0.6–1.6) | 0.528 |
| Mother ever received ANC services | | | | | | |
| No | 13 (35.1) | 24 (64.9) | 1 | | 1 | |
| Yes | 389 (75.8) | 124 (24.2) | 2.2 (1.2–3.8) | 0.006 | 0.99 (0.3–2.9) | 0.994 |
| Mother ever received two doses of TT vaccine | | | | | | |
| No | 18 (39.1) | 28 (60.9) | 1 | | 1 | |
| Yes | 384 (76.2) | 120 (23.8) | 1.9 (1.2–3.1) | 0.006 | 1.0 (0.4–2.6) | 0.948 |
| Mothers ever received PNC services | | | | | | |
| No | 70 (49.6) | 71 (50.4) | 1 | | 1 | |
| Yes | 332 (81.2) | 77 (18.8) | 1.6 (1.3–2.1) | <0.001 | 1.1 (0.8–1.6) | 0.547 |
| Child having immunization card | | | | | | |
| No | 3 (13.0) | 20 (87.0) | 1 | | 1 | |
| Yes | 399 (75.7) | 128 (24.3) | 5.8 (1.9–18.1) | 0.002 | 0.9 (0.2–3.6) | 0.913 |
| Service provider's attitude during immunization services | | | | | | |
| Bad | 8 (29.6) | 19 (70.4) | 1 | | 1 | |
| Good | 394 (77.9) | 112 (22.1) | 2.6 (1.3–5.3) | 0.007 | 1.0 (0.5–2.1) | 0.961 |
| Reminder for immunization services | | | | | | |
| No | 12 (9.4) | 115 (90.6) | 1 | | 1 | |
| Yes | 390 (96.1) | 16 (3.9) | 10.2 (5.7–18.1) | <0.001 | 9.7 (5.4–17.5) | <0.001 |

[a] Variables found significant in the unadjusted analysis were considered in the final Poisson regression model for adjusted analysis.

ranging from ~25 to 64% [17, 18, 19, 20, 21, 22, 23, 24, 25, 26]. One explanation for this difference could be fact that NFHS survey include data before 2016, whereas the study was conducted in 2017. Second, the government started a campaign "Mission Indradhanush" which aims to immunize all children <2 years of age which might have created greater awareness leading to greater vaccine coverage. Further, full immunization coverage data in many studies including our study is quite variable and lower than the targeted level of >80.0% as set by the Government of India (GOI) in its multi-year strategic plan for 2013-17 [27].

In addition to full immunization coverage, it also important to explore the quality of the immunization coverage. None of the studies in our literature review explored the same. In our study, 86.0% of the children received quality immunization coverage. The coverage and the quality are results of various associated factors. Most of the previous studies were not large enough to perform an adjusted analysis to explore these factors. In our study, we found "family received reminder for immunization services" to be a strong correlate of full immunization as well as quality immunization coverage. In our study the rate of full immunization coverage was 96.1% in those who received reminders compared with 9.4% in those who did not receive any reminders ($p < 0.001$). In addition, PR of having quality immunization coverage was 4.5 ($p < 0.001$) times higher among those who had received reminders compared to those who had not received any reminders. This observation highlights the importance of sending reminders which is one of the proven healthcare factors with potential to improve full and quality immunization coverage as summarized by Crocker-Buque T et al [28]. We did not find any study in our literature search reflecting this as a significant correlate for full and quality immunization coverage in Indian slums.

Further, various initiatives taken by the GOI to improve the institutional deliveries under National Health Mission (NHM) has also encouraged mothers to immunize their newborns appropriately. In our study, the rate of full immunization coverage was found to be higher (74.8%) among children with institutional deliveries compared to 40.7% among children without institutional deliveries. The rate of quality immunization coverage found to be 86.6% among children delivered at health facilities compared to 63.6% among children delivered at non-health facilities. This observation is concordant with the observations from other recent studies which showed a strong association between institutional delivery and immunization status [14, 29, 30, 31, 32].

Also, our study demonstrated an association between the mothers who ever received postnatal care (PNC) services and the quality immunization coverage among their children aged 12–23 months. The quality immunization coverage was 89.1% for those children whose mothers received PNC services against a figure of 72.4% among those mothers did not received the same. This is in concordance with observations of studies conducted outside India. For example, a study from Indonesia reported that children with mothers having no PNC services had a 50.0% higher chance of being unimmunized [33]. Similarly, studies from Ethiopia and Tanzania also demonstrated the association between utilization of PNC services and completion of childhood immunization [34, 35, 36].

An attempt was also made to find the reasons for not getting their children immunized or not completing the immunization schedule. The most common reported reason for partial or no immunization was

**Table 3**
Regression analysis of immunization quality among children aged 12–23 months.[a]

| Variables | Quality of vaccination | | Unadjusted prevalence ratio with 95 % CI | p-value |
|---|---|---|---|---|
| | Yes(n = 349) | No (n = 57) | | |
| Child's gender | | | | |
| Female | 156 (83.4) | 31 (16.6) | 1 | |
| Male | 193 (88.1) | 26 (11.9) | 1.1 (0.9–1.3) | 0.610 |
| Mother's education | | | | |
| Uneducated | 39 (72.2) | 15 (27.8) | 1 | |
| Educated | 310 (88.1) | 42 (11.9) | 1.2 (0.9–1.7) | 0.243 |
| Father's education | | | | |
| Uneducated | 20 (74.1) | 7 (25.9) | 1 | |
| Educated | 329 (86.8) | 50 (13.2) | 1.2 (0.7–1.8) | 0.491 |
| Monthly household income (in INR) | | | | |
| ≤10,000 | 206 (83.1) | 42 (16.9) | 1 | |
| >10,000 | 143 (90.5) | 15 (9.5) | 1.1 (0.9–1.3) | 0.431 |
| Monthly household expenditure (in INR) | | | | |
| ≤10,000 | 230 (83.9) | 44 (16.1) | 1 | |
| >10,000 | 119 (90.2) | 13 (9.8) | 1.1 (0.9–1.3) | 0.527 |
| Child birth place | | | | |
| Non-health facility | 7 (63.6) | 4 (36.4) | 1 | |
| Heath facility | 342 (86.6) | 53 (13.4) | 1.4 (0.6–2.9) | 0.420 |
| Mother ever visited for ANC | | | | |
| No | 12 (70.6) | 5 (29.4) | 1 | |
| Yes | 337 (86.6) | 52 (13.4) | 1.2 (0.7–2.2) | 0.486 |
| Mothers TT two doses status | | | | |
| No | 17 (70.8) | 7 (29.2) | 1 | |
| Yes | 332 (86.9) | 50 (13.1) | 1.2 (0.8–2.0) | 0.411 |
| Mothers PNC status | | | | |
| No | 55 (72.4) | 21 (27.6) | 1 | |
| Yes | 294 (89.1) | 36 (10.9) | 1.2 (0.9–1.6) | 0.157 |
| Service provider's attitude | | | | |
| Bad | 6 (50.0) | 6 (50.0) | 1 | |
| Good | 343 (87.3) | 50 (12.7) | 1.7 (0.8–3.9) | 0.176 |
| Reminder for vaccination | | | | |
| No | 11 (21.2) | 41 (78.8) | 1 | |
| Yes | 338 (95.8) | 15 (4.2) | 4.5 (2.5–8.3) | <0.001 |

[a] Only one variable 'Reminder for immunization services' was found to be significant in unadjusted analysis thus, adjusted analysis was not performed.

mothers were too busy. Apprehension of adverse effects was also cited as one of the important reasons by substantial number of respondents. Other noteworthy reasons were family related problems, and immunization site or time unknown. Our observations were comparable to those found in other studies [14, 20, 26, 37].

Adequate and quality immunization coverage is key to prevent VPD outbreaks especially, in vulnerable settings like slums. In our study, full immunization coverage was found below the expected level of >80.0%, which indicates that the importance of adequate and quality immunization coverage is still not felt by the slum population. The immunization services can be improved by taking simple steps such as sending regular reminders to parents and caretakers, encouraging institutional deliveries, and scaling up use of postnatal care services. In addition, the reasons for partial or no immunization may be rectified by establishing a mechanism for regular tracking of due doses and by generating awareness on value of immunization.

## Declarations

### *Author contribution statement*

Sanjeev Singh, Damodar Sahu, Ashish Agrawal, Lakshmanan Jeyaseelan, Ambily Nadaraj, Meeta Dhaval Vashi: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

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### *Competing interest statement*

The authors declare no conflict of interest.

### *Additional information*

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