Trends in Urban Immunization Coverage in India: A Meta-Analysis and Meta-Regression

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Abstract

Objectives To assess the gaps and trends in child immunization coverage among urban and rural areas in India, and compare the success of immunisation program in each.

Methods PubMed, Scopus, and Crossref, and Google Scholar electronic databases were searched on October 9, 2019, and March 21, 2020, for studies that measured and reported immunization coverage indicators in India. Random-effects meta-analyses and meta-regressions were conducted.

Results The authors' search identified 545 studies, and 2 were obtained by expert suggestion. Among these 68 studies and 6 surveys were included. They found that full immunization coverage has grown yearly at 2.65% and 0.82% in rural and urban areas, respectively whereas partial immunization coverage declined by –2.44% and –0.69%, respectively. Percentage of nonimmunized children did not show a statistically significant trend in either.

Conclusion While rural immunization coverage has seen a large increase over the past two decades, the progress in urban areas is weak and negligible. This was largely attributable to a focus on minimizing dropouts in rural areas. However, a lack of significant reduction in unimmunized children may indicate left-out children or pockets in both rural and urban areas. The poor performance of immunization programs in urban areas, coupled with a larger impact of COVID-19, warrants that India urgently adopts urban-sensitive and urban-focused policies and programs.

Keywords Urban immunization · Rural immunization · Immunization coverage · Immunization programme · Immunization trends

Introduction

As the nation's health system battles the COVID-19 pandemic, a diversion of resources [1, 2] along with temporary suspension of vaccination outreach sessions [3, 4] makes the ominous threat of vaccine-preventable diseases (VPDs) more palpable. In addition to this, India already falls short in achieving universal immunization by a significant margin

[5], as indicated by the results of the National Family Health Survey-4 (NFHS-4) [6], that reveal 38% of children may not be fully immunized. Urban immunization coverage is often cited as a key bottleneck to achieving this universal coverage [7], as pockets of squatter settlements and expanding peri-urban zones are often densely populated and have few public services, including health care, thereby increasing the risk of VPD outbreaks [8]. The unique nature of urban areas, hence, makes them a distinct paradigm while formulating, implementing, and evaluating immunization policies.

However, with multiple surveys and studies reporting different coverage results, policymakers have often expressed the need for a singular reference, in order to better study the disparity of immunization programs in urban and rural areas. In this paper, along with arriving at robust estimates of the true value of immunization coverage over time for both rural and urban areas, the authors also explore causes of disparity. Thus, the results of the present study can aid policymakers in

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creating appropriate strategies to achieve universal immunization coverage, in light of the COVID-19 pandemic.

Materials and Methods

First, literature search was conducted using a predefined inclusion-exclusion criteria for localized studies, and expert recommendations for national surveys. Once the data were collected and compiled, a meta-regression was conducted to assess the trends in immunization coverage in a robust manner. To further isolate and understand the factors leading to the intriguing trends observed, a meta-analysis was conducted for immunization coverage measured between 2005 and 2015, and after 2015 that were performed separately for urban and rural areas. The year 2015 was chosen as a reference point, to study the effect of policy reorientation around immunization, specifically Mission *Indradhanush*, as well as the policy impact of publication of the NFHS-4.

Localized Studies on Coverage

Four databases—PubMed, Scopus, and CrossRef, and Google Scholar were queried on 9th October 2019, and subsequently on 21st March 2020 for studies in the past two decades (2000–2020). The keywords used are described in Table 1. After removing duplicates, it yielded a total of 545 studies. Two studies that were not found in the search were included from expert recommendations. The abstracts of all these studies were scanned for suitability according to a predefined inclusion-exclusion criterion.

Selection Criteria

The authors included studies that provided numerical estimates for immunization coverages, and only studies that reported sample size or standard errors were considered. Further, it was also ensured that studies conducted in India were only included. For studies that were community-based rather than being population-based, it was ensured that the cohort of the study was representative of a larger population within that geopolitical zone. Subsequently, the authors included studies that measured the coverages in a specific

group (such as children of migrant workers) only if a comparison with the general population was measured. They included only the baselines of RCTs and intervention-based studies.

As this analysis pertains to the administrative and programmatic aspects of childhood immunization, the authors allowed flexibility in the definition of ‘Full Immunization,’ to suit the local norms. There were very few deviations from the WHO EPI and the National definition of (i) one dose of BCG, (ii) three doses each of oral polio vaccine (OPV), diphtheria, pertussis and tetanus (DPT) and hepatitis B vaccines (HBV), and (iii) one dose of measles (or MMR) before the age of one year. Only the coverage estimates for children who were 12–24 mo old and received these vaccinations within the first 12 mo were analyzed and are presented.

For the verification of immunization, both studies that used recall and immunization cards were included. In the case where a study provided both, the combined estimate was chosen. A child who did not complete full immunization was termed as ‘partially immunized,’ and estimates of children who did not receive any vaccines were also extracted. Estimates for the coverage of any of the individual vaccines were also extracted.

Qualitative Studies or editorial, review article, or meta-analysis were excluded. Along with this, studies that did not pertain to the coverage of immunization or covered a nonrepresentative group were also excluded.

The list of all studies included in the analysis is presented in the Supplementary Table S1.

Nationwide Surveys

The present analysis also included surveys that were performed over the past two decades, obtained through literature search and expert recommendation.

The list of all studies included in the analysis is presented in the Supplementary Table S2.

Model Specification

All statistical analyses were performed on R version 3.6.1 using the ‘metafor’ package. Standard errors were calculated from the reported estimates assuming a binomial distribution.

Random-effects meta-analysis using the DerSimonian and Laird (DL) method was performed and estimates were arrived at. For meta-regression, a mixed-effect model using the DL method was utilized. The results were analyzed, and insightful outcomes are presented and discussed in this paper.

The model specified in the meta-regression was of the form

Table 1 Search criteria

#	Searches
1	India
2	Urban
3	Child/or Children
4	Immunization/or Immunised
5	Vaccine/or Vaccination
6	Coverage

$$y_i = \beta_0 + \beta_1 * Year + \epsilon$$

Where y_i is the reported coverage in a study or survey, β_0 is an intercept, and β_1 indicates the growth or decline of the coverage over Years.

Results

The search, illustrated in Fig. 1, yielded a total of 545 studies, 2 studies were identified through expert recommendation. After preliminary screening based on abstracts, the full text of 272 studies was obtained. Full text studies were excluded for not pertaining to immunization coverage ($n = 132$), not reporting sample sizes or standard errors ($n = 59$), and covering a nonrepresentative group ($n = 13$). Six surveys were added using expert recommendations. Meta-regressions and meta-analyses were performed for the 74 studies and surveys hence obtained [6, 9–79]. The results of these have been presented and discussed in this paper.

Meta-Regression

To examine the trends in immunization coverage in India, the authors first conducted a meta-regression of the full immunization coverage (FIC) with years as the regressor. This was done separately for urban and rural coverages. The regression is displayed graphically in Fig. 2a. Through this, positive growth in FIC in rural areas at a

pace of 2.65% per year ($p = 0.0002$) was observed. This result is statistically significant at $\alpha = .05$. In urban areas, however, the pace of growth in FIC is 0.82% per year with a p value of 0.179. It can, hence, be concluded that urban growth rate is not greater than 0 at any acceptable confidence level.

To further explore trends, another meta-regression was conducted on the partial immunization coverage (PIC) with the year as the regressor (Fig. 2b). The rural PIC showed a decline of -2.44% per year ($p = 0.001$), which is statistically significant at $\alpha = .05$. The urban PIC, on the other hand, showed a decline of -0.69% per year ($p = 0.244$). This cannot statistically be shown to be distinct from 0.

The authors also conducted another meta-regression on children that received no vaccines Fig. 2c). It was found here that nonimmunization has decreased in both rural and urban areas with a decline rate of -0.81% ($p = 0.124$) and -0.04% ($p = 0.895$) per year, respectively. However, these results are not statistically significant at $\alpha = .05$. Through these analyses, it is concluded that rural immunization coverage in India has significantly improved, and the success comes largely via higher rates of completion of the immunization course. The urban immunization coverage, on the other hand, shows no improvement and has stayed constant over the past one and a half-decade. Interestingly, all three meta-regressions indicate that rural immunization coverage seems to have surpassed urban immunization coverage around the year 2012.

Fig. 1 Search criteria diagram

Fig. 2 Results of Meta-Regression for (a) Full immunisation coverage, (b) Partial immunisation coverage, (c) Non-immunisation

Points indicate the reported coverage of each indicator;
 Size of the points indicate relative weightage of each study or survey in the meta-regression;
 Urban coverage is indicated by dark grey points and lines;
 Rural coverage is indicated by light grey points and lines.

Meta-Analysis

A meta-analysis over two time periods yielded summary effects that reflect a good estimate of the indicator coverage over the given period (presented in Table 2) along with forest plots (presented in Table 3), that aid in further analysis.

In Table 2, the authors present against each immunization indicator the estimated coverage in each period, for both rural and urban areas. They then calculate the difference in the growth in rural vis-à-vis urban coverage between the two periods. They present here only the indicators for which estimates were available for both rural and urban areas over both the periods. Many indicators had no study or survey estimating their coverage.

The meta-analysis helps validate the authors' previous findings by looking at coverages of individual vaccines. For instance, in rural areas, they observe that the increase in coverage of the measles vaccine, which is administered at a much later stage, has increased to equal the coverage of the BCG vaccine, which is administered at birth. Similarly, in urban areas, the coverage of OPV1 vaccine shows a drop, and the coverage of OPV2 vaccine shows a mere increase of 0.9%.

These findings indicate that rural areas have been successful in significantly reducing and nearly eliminating dropouts, further strengthening the authors' previous hypotheses. Urban areas show little to no progress across vaccines in this analysis as well.

Table 2 Summary effects as obtained through meta-analyses

Indicator	Location	2005–15	2015–20	Growth	Diff. in growth
FIC	Rural	60.4	79.9	19.5	8.7
	Urban	62.3	73.1	10.8	
PIC	Rural	29.9	13.1	–16.8	–5.8
	Urban	31.0	20.0	–11.0	
None	Rural	10.4	1.0	–9.4	–5.7
	Urban	10.3	6.6	–3.7	
BCG	Rural	82.5	99.5*	17.0	11.7
	Urban	81.4	86.6	5.3	
DPT3	Rural	71.5	84.0	12.5	1.7
	Urban	62.2	73.0	10.8	
OPV1	Rural	79.9	99.8*	19.9	24.9
	Urban	84.9	79.9	–4.9	
OPV2	Rural	75.9	99.3*	23.4	22.4
	Urban	75.9	76.8	0.9	
OPV3	Rural	70.4	99.2*	28.8	22.3
	Urban	67.4	73.9	6.5	
Measles	Rural	65.4	91.3	25.9	21.5
	Urban	63.5	67.9	4.4	

*Not a summary effect as only a single study was available

Discussion

India built its immunization infrastructure and capacities starting with its efforts in smallpox elimination [80], which was harnessed by the Expanded Program on Immunization (EPI) in 1978, followed by the Universal Immunization Programme (UIP) in 1985, expanding in 2006 and 2017 [81, 82]. However, vaccination programs in India have historically experienced not only slow acceptance and reluctance but opposition as well [82]. This slow progression in immunization coverage, has prompted the government to make several policy improvements such as the Mission *Indradhanush*. However, a rigorous quantitative analysis of the outcomes of these programs, and comparison of immunisation progress amongst urban and rural areas was lacking. This is the first time, as far as the authors know, that an evidence-based meta-analysis of immunization coverage has been performed for India.

In the present paper, three main findings are presented, the first being that full immunization coverage in urban areas have shown little to no growth while rural coverage has significantly improved over the past two decades. The second finding is that the dropout rates have declined at a faster rate for rural than for urban areas. The authors' third finding is that neither rural nor urban areas have seen major success in reducing the percentage of unimmunized children.

Through these findings, the authors infer that the improvement in rural immunization coverage over urban can be largely attributed to a focus on minimizing dropouts. However, a lack of reduction in unimmunized children in both rural and urban areas suggests the possibility of under-reached pockets. National policymakers keen on increasing the national immunization coverage would be benefitted through a targeted approach for identifying and reaching children in underserved pockets both for rural and urban areas, as well as enhancing focus on minimizing dropouts in urban slums. To identify underserved pockets and hard to reach areas, states should ensure that areas are demarcated among health facilities and comprehensive headcount surveys and microplans are established and regularly updated. Further, mobile sessions and flexible timings can play a big role in strengthening immunization in these areas. For tracking children, due lists must be regularly prepared and utilized by health workers. A strong communication intervention through advocacy, interpersonal communication and community engagement, thereby creating a cohesive environment for women to take informed decisions related to immunization, would be expected to go a long way in minimizing dropouts in urban slums.

The findings in the present paper verify and corroborate factors postulated in previous literature and provide

Table 3 Forest plots of the meta-analyses of full immunization coverage (FIC) within two time periods and amongst urban and rural areas

Table 3 (continued)

a robust backing for both previous empirical findings as well as highlight the need for urban-oriented policy interventions [8, 83, 84]. This becomes especially critical as immunization services have been disrupted by COVID-19, and lockdown measures have led to a mass exodus of migrant workers to rural areas and smaller towns [85] causing a rapid change in service demand patterns, misplaced/left behind immunization cards and overcrowded villages. When these families return to the slums, there is a high potential for vaccine-preventable disease outbreaks. To compound this, parents would be wary of bringing their children to clinics or outreach immunization sessions, for fear of inadvertently contracting the virus [86].

In addition to the challenges posed by the pandemic, previous literature points out that urban immunization inherently faces two distinct types of issues—supply and demand [87].

The paramount supply-side factor is that urban primary health systems haven't been able to keep pace with the rapidly growing and floating urban population [7], and engagement with medical colleges are minimal and unstructured [88]. Further, as only 40% of slums are formally recognized by the government [89], lack of access to basic municipal services limits holistic improvements in health outcomes [90, 91]. These issues are compounded by shortages in posts for health workers [92], lack of supportive supervision [9], and inadequate microplanning, leading to insufficient quantity of vaccines or overcrowded sessions with long wait times [93].

Urban slums present a multitude of demand-side issues. Researchers find that larger families are less likely to be hesitant towards vaccinations [94]. Compared to rural areas, urban areas are less likely to have joint families, and conflicting priorities often leads to missed vaccination appointments. Further, unawareness of the need of immunization and absence of motivation to avail services [10, 11, 83], false belief that a child being sick or underweight is a contraindication for vaccination [11, 95], refusal to vaccinate the child over religious beliefs, fear of side effects or perceived safety of the vaccine [10, 96] are common issues as a result of poor information circulation in the community.

The insights from this paper can also be extended to adult vaccination programs, which have gained increased importance given the ongoing COVID-19 vaccination program. Interventions to improve adult vaccination coverage can be informed from the success of child immunization programs. These include interventions in raising awareness, mobilizing health systems, building capacities of healthcare workers, and running effective campaigns to reduce vaccine hesitancy. Conversely, COVID-19 vaccination program will help strengthen our immunization programs, especially in urban areas where its success is critical in order to control the pandemic. Subsequently,

we can consider integrating and universalizing immunization programs to cover both child and adult vaccinations, and help improve coverage of both, especially in urban areas [97].

Urban areas present significant inequalities, both amongst, and within. The demographic mix across communities also varies significantly within pockets of a city and between them [98]. It is imperative that urban health policies, especially immunization have a multipronged approach, one that harnesses collective community involvement and ownership, as both service delivery and community perception to the service play key roles. Further research is needed to ascertain the magnitude of each of the factors, and to create appropriate policies to address the disparities found in this paper.

Conclusion

The COVID-19 pandemic threatens us with the reversal of decades of progress in immunization, urban areas being especially susceptible. In the present paper, the authors have attempted to gauge this susceptibility and compare the success of immunization programs between rural and urban areas. They found that rural areas have shown tremendous success in improving immunization coverage, with an annual growth rate of 2.65% in FIC, while urban areas have shown little to no improvement. While this may seem anomalous at first, it is well rationalized by the various special challenges that urban areas face. The increasing disparity in urban-rural immunization coverage, coupled with the rapid urbanization of the country has led to slowing growth in immunization cover in India. Through the present analysis, it is evident that without interventions and policies that are urban-sensitive and tailored to the local context, it would be difficult for India to mitigate the impact of COVID-19 or achieve its universal immunization targets.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s12098-021-03843-0>.

Authors' Contributions Conceptualization of the research was done by MP, DD, and MG. Literature review was performed by SK, VT, DD, MG. Collation of studies and data and meta-analysis was done by SK. Evaluation and interpretation was done by SK and VT. Manuscript was written by SK, VT. Policy analysis was performed by SK, VT, DD, RC, MP. Manuscript was reviewed by RC, MP. The research was conducted under the expertise and supervision of MP. MP is the guarantor for this paper.

Declarations

Ethics Approval As this was a meta-analysis exclusively of published literature, no ethics approval was necessary.

Conflict of Interest None.

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