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Predictors of vaccination in India for children aged 12–36 months

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A B S T R A C T

Introduction: India has one of the lowest immunization rates worldwide despite a longstanding Universal Immunization Program (UIP) that provides free childhood vaccines. This study characterizes the predictors for under- and non-vaccination among Indian children aged 12–36 months.
Methods: This study utilized District Level Household and Facility Survey Data, 2008 (DLHS3), from India. DLHS3 is a nationally representative sample collected from December 2007 through December 2008; this analysis was conducted during 2014. Children's vaccination status was categorized as fully, under-, and non-vaccinated based on whether children received all, some, or none of the UIP-recommended vaccines (one dose each of bacillus Calmette–Guérin and measles, and three doses of diphtheria–pertussis–tetanus). A multinomial logistic regression model estimated the odds of under-vaccination compared with full vaccination, and odds of non-vaccination compared with full vaccination. Analytic predictors included socioeconomic, cultural, household, maternal, and childhood characteristics.
Results: The analysis included 108,057 children; the estimated proportions of fully, under-, and non-vaccinated children were 57%, 31%, and 12%, respectively. After adjusting for state of residence, age, gender, household wealth, and maternal education, additional significant predictors of children's vaccination status were religion, caste, place of delivery, number of antenatal care visits, and maternal tetanus vaccination, all of which demonstrated large effect sizes.
Conclusions: India's immunization coverage remained low in 2008, with just slightly more than half of all children aged 12–36 months fully vaccinated with UIP-recommended vaccines. A better understanding of the predictors for vaccination can help shape interventions to reduce disparities in full vaccination among children of differing demographic/cultural groups.

1. Introduction

Approximately one quarter of the 6.6 million deaths among children under age 5 years worldwide in 2012 occurred in India [1]. No other country experiences this level of childhood mortality. The most recent data on vaccine-preventable mortality in India is from a 2008 study [2], which estimated that of the 826,000 deaths in children aged 1–59 months, almost three quarters or 604,000 deaths were due to vaccine-preventable diseases including diarrhea, pertussis, measles, meningitis, and pneumonia. Collectively, the burden of these diseases highlights the significant human cost of the poor vaccination coverage among infants and children in India.

India has the world's largest annual birth cohort, comprising 26 million newborns, while also reporting one of the lowest immunization rates of any country in the world [1]. WHO estimates that more than 22 million infants worldwide had not received the third dose of the diphtheria–pertussis–tetanus (DPT3) vaccine in 2012, a frequently used proxy for the success of a country's immunization program, with 7 million or 30% of those children residing in India [3].

The Indian Government's Universal Immunization Program (UIP) provides vaccines against six diseases to all infants free of charge: one dose of bacillus Calmette–Guérin (BCG; tuberculosis); three doses of DPT3; three doses of oral polio vaccine (OPV); and one dose of measles-containing vaccine (MCV) [4]. All of these vaccine doses should be administered by age 12 months. Indian children who receive all recommended doses of these four UIP vaccines are considered fully vaccinated by WHO; a child lacking any of the recommended doses is considered under-vaccinated, and

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children who have not received any vaccinations are considered non-vaccinated. The Indian government's nationally representative District Level Household and Facility Survey 2008 (DLHS3) reported that only 54% of children aged 12–23 months were fully vaccinated, 41% were under-vaccinated, and the remaining 5% were non-vaccinated [5]. The challenge of meeting the demands of appropriately and fully immunizing children in India becomes ever more daunting as the country adds a pool of 12.5 million partially immunized children each year [6].

Against this backdrop of low vaccination coverage, significant variation exists in the estimated coverage for children aged 12–23 months across the 34 Indian states and Union Territories. For example, based on the DLHS3 report, the percentage of fully vaccinated children ranged widely, from a low of 13% in the Indian state of Arunachal Pradesh to a high of 82% in Tamil Nadu.

The causes of low vaccination coverage in India have recently received more scholarly attention. Numerous studies have focused on individual predictive factors for vaccination including gender, age, and birth order, and others on household factors such as family size, number of children below age 3 years, household wealth, caste, and maternal education [7–14]. However, many of these studies [7,8] did not control for potential confounders such as religion, caste, or state-level effects. Moreover, although it is well documented that the epidemiology of non-vaccination may differ substantially from the epidemiology of under-vaccination [9,10], most of these studies [7,11,12] dichotomize vaccination status into complete (i.e., full) versus incomplete (i.e., under- or non-vaccinated). The few studies [13] investigating predictors of childhood vaccination in India that utilized three distinct vaccination categories (i.e., full, under-, and non-vaccination) were limited by small sample sizes drawn from narrowly defined geographic areas such as a specific state, city, urban slum(s), or a village(s), potentially impacting the generalizability to the national population.

In this study, we sought to identify individual-level sociodemographic and cultural factors related to vaccination status in Indian children aged 12–36 months using a nationally representative sample from the DLHS3. Based on prior studies in countries other than India [9,10], we hypothesized that the predictors associated with childhood under- and non-vaccination would be different. To avoid confounding the relationship between vaccination status and individual characteristics by healthcare infrastructure availability, accessibility, and prevailing policy environment in the state, we controlled for state of residence.

2. Methods

2.1. Data source and sample design

India's 2008 DLHS3 was used for this study and is the most recent countrywide immunization data set on children available to outside researchers. The DLHS3 is a nationally representative sample collected from December 2007 through December 2008 from 720,320 households located in 601 distinct districts from 34 states. This analysis was conducted in 2014. The DHLS3 sampling featured a multistage, stratified, systematic sample design with two stages in rural and three stages in urban areas. In rural areas, villages served as the primary sampling unit within each state and households were systematically selected within each village. In urban areas, wards served as the primary sampling unit and were selected using probability proportional to size. Within a ward, census blocks were further selected using probability proportional to size and then households were systematically sampled within census blocks. The first stage of the sampling design stratified villages and wards by the total number of households in the primary sampling unit, percentage of scheduled caste and scheduled tribe population, and female literacy. Sampling weights were calculated for each district and permitted unbiased estimation of population characteristics. These design weights incorporated the selection probabilities at each stage of randomization. Additional details regarding the weight calculations and sampling methodology of the DLHS3 are published elsewhere [5].

The DLHS3 utilized interviewer-administered questionnaires comprising separate surveys for ever-married women within the households, and a second, complementary survey for the entire household. Any adult aged >18 years who lived in the household was permitted to respond for the household. Household questionnaires requested information on all household members, including sociodemographic characteristics and financial assets. Women were only asked about children born on or after January 1, 2004; specific information on their children's immunization status was obtained from the vaccination card for the child. If an immunization card was not available, then reported immunization data were based on maternal recall.

2.2. Measures

The population used for this analysis consisted of the most recently born child per household who was aged 12–36 months at the time of data collection. The primary outcome of vaccination status was classified into three categories: fully vaccinated, under-vaccinated, and non-vaccinated. Using the WHO standards, we defined children who received one dose of BCG, three doses of DPT3, and one dose of MCV as fully vaccinated; children who received one or more but not all of these recommended doses as under-vaccinated; and children who did not receive any vaccinations as non-vaccinated.

The individual-level variables used as predictors of vaccination coverage were broadly classified into four categories: childhood, maternal, household, and sociocultural factors. The three childhood variables were age, gender, and place of birth, all of which have been shown to be associated with vaccination status [8]. Maternal variables were maternal age at childbirth; education level; participation in antenatal care (ANC) services; and mother's receipt of tetanus toxoid (TT) vaccine, which are also known to be associated with their children's immunization status [14–17]. Household characteristics included residence type (rural or urban); household wealth; and household size. The DLHS3 used a standard wealth index based on factor analyses and classified into five quintiles (poorest to wealthiest) based on household amenities, assets, and durables, representing direct and indirect measures of household economic status. In the absence of direct information on income or expenditures, wealth index is considered a robust measure of income at the household level [18–20].

Religion and caste reflect deeply rooted cultural designations that influence parental beliefs and attitudes toward health-seeking behaviors, including vaccination decisions about their children, and impact access to health care [21–23]. Low caste is also an indicator of social discrimination.[24,25] In this study, caste was used as a four-category variable: scheduled tribe[a] (ST); scheduled

[a] Scheduled castes/tribes are identified by the government of India as socially and economically disadvantaged and in need of special protection from social injustice and exploitation.