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Demand- and supply-side determinants of diphtheria-pertussis-tetanus nonvaccination and dropout in rural India

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ABSTRACT

Background: Although 93% of 12- to 23-month-old children in India receive at least one vaccine, typically Bacillus Calmette–Guérin, only 75% complete the recommended three doses of diphtheria-pertussis-tetanus (DPT, also referred to as DTP) vaccine. Determinants can be different for nonvaccination and dropout but have not been examined in earlier studies. We use the three-dose DPT series as a proxy for the full sequence of recommended childhood vaccines and examine the determinants of DPT nonvaccination and dropout between doses 1 and 3.

Methods: We analyzed data on 75,728 6- to 23-month-old children in villages across India to study demand- and supply-side factors determining nonvaccination with DPT and dropout between DPT doses 1 and 3, using a multilevel approach. Data come from the District Level Household and Facility Survey 3 (2007–08).

Results: Individual- and household-level factors were associated with both DPT nonvaccination and dropout between doses 1 and 3. Children whose mothers had no schooling were 2.3 times more likely not to receive any DPT vaccination and 1.5 times more likely to drop out between DPT doses 1 and 3, compared with children whose mothers had 10 or more years of schooling. Although supply-side factors related to availability of public health facilities and immunization-related health workers in villages were not correlated with dropout between DPT doses 1 and 3, children in districts where 46% or more villages had a healthcare subcentre were 1.5 times more likely to receive at least one dose of DPT vaccine compared with children in districts where 30% or fewer villages had subcentres.

Conclusions: Nonvaccination with DPT in India is influenced by village- and district-level contextual factors over and above individuals' background characteristics. Dropout between DPT doses 1 and 3 is associated more strongly with demand-side factors than with village- and district-level supply-side factors.

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1. Introduction

Coverage with the third dose of diphtheria-pertussis-tetanus vaccine (DPT3) is a widely used indicator of the performance of countries' routine immunization services [1,2]. In 2014, Indian children accounted for 22% of the 18.7 million children worldwide who had not received three doses of DPT by age one [3]. Low DPT3 coverage is caused by a combination of low uptakes of dose 1 and high dropout rates among infants who receive the first dose but not the second or third. During 2014, nearly 2.5 million children in India did not receive a single DPT dose, while more than 1.5 million received only one or two DPT doses [3]. Our hypothesis is that the barriers to immunization for children who have never received a single dose of DPT may be different from those for children who have received one or two doses but not completed the full series.

Studies conducted worldwide and in India have documented the determinants of vaccination coverage and have catalogued the strategies that have proven effective in improving immunization coverage [4–7]. Supply-side factors include availability and access to healthcare facilities, infrastructure, staffing, vaccine and service delivery management, budget allocation, and knowledge of the workers who administer vaccines [8–12]. On the demand

Abbreviations: ANM, auxiliary nurse midwife; ASHA, accredited social health activist; CES, Coverage Evaluation Survey; DLHS, District Level Household and Facility Survey; DPT, diphtheria-pertussis-tetanus; OPV, oral polio vaccine; PHC, primary health centre; UNICEF, United Nations Children's Fund.

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side, the factors associated with vaccination coverage in children typically include child's birth order and sex, parents' level of education, their employment status and type of occupation, immunization-related beliefs, mother's general health knowledge and awareness, health-seeking behavior, caste, religion, and household wealth index [10–27]. Rammohan et al. in their ecological analysis show that district-level differences in immunization coverage are correlated with district-level per capita income and maternal education [28]. Studies using a multilevel approach revealed associations with contextual factors, such as urban place of residence, countries with high fertility rates, communities with high illiteracy rates, municipalities with religious objection to vaccination, communities with fewer deliveries attended by health personnel, and postcode areas with lower socio-economic status [15,17,25,29–31]

Risk factors for incomplete vaccination may be different from the risk factors for nonvaccination. A global review of the grey literature by Favin et al. found that the main reasons for incomplete vaccination were bad experiences at the immunization centre (health workers' poor treatment of mothers, long waiting time, unavailability of drugs), missed opportunities (health workers' refusal to immunize sick children, turning away a child who lacked a vaccination card), fear of side effects, and not knowing whether to return or when. Rainey et al. in their systematic review noted that factors such as parental education, cultural mores, and religious beliefs were more likely to be associated with nonvaccination than with incomplete vaccination [32,33].

A handful of studies have investigated reasons behind dropout after the first dose of DPT or oral polio vaccine (OPV), albeit within a very limited scope. Usman et al. in their cohort study involving 366 mother-infant pairs from six rural immunization centres around Karachi, Pakistan, found that children who received DPT dose 1 in a timely manner and lived closer to the immunization site were more likely to receive the subsequent doses [34]. A prospective cohort study in 21 health facilities in Ibadan North, Nigeria, found that the type of health facility attended was the only significant factor for completion of DPT3 among infants who received the first dose of OPV and/or DPT [35]. Randomized controlled trials in Pakistan demonstrated that providing mothers with a redesigned immunization card and home- or centre-based education on the importance of vaccines help improve DPT3 completion rates [36–38]. Predictors of nonvaccination with DPT and dropout between doses 1 and 3 have not been systematically studied in India. We sought to address this gap by analyzing vaccination data on 6- to 23-month-old Indian children from a nationally representative survey.

2. Methods

2.1. Data

We use data from the third round of the District Level Household and Facility Survey (DLHS-3), conducted during 2007–08. In this survey, 643,944 ever-married women aged 15–49 years from 720,320 households in 34 Indian states and union territories were interviewed on reproductive services and child health. Receipt of vaccination doses was recorded from children's vaccination cards shown to the enumerator. If a card was not available, the mother was asked about the vaccines the child had received. Village questionnaires yielded information on availability of health, education, and other facilities in villages, and the facility-level survey gathered information on human resources, infrastructure, and services in the health facilities. Details on the survey methodology, sampling design, and the questionnaires are available elsewhere [39] and described briefly in the Appendix.

2.2. Variables

Combining data from the immunization cards and maternal recall, we defined three DPT vaccination outcomes: receipt of at least one dose of DPT (denoted by DPT1), receipt of all three DPT doses (denoted by DPT3), and receipt of all three DPT doses versus receipt of only one or two DPT doses (denoted by DPT3|DPT1). Typically, studies have modeled either nonvaccination with DPT or receipt of all three DPT doses. That $P(DPT3)$ can be modeled as $P(DPT1)P(DPT3|DPT1)$, which essentially means that receipt of at least one DPT dose and receipt of all three doses among infants who received at least one DPT dose are events contributing to and culminating in the completion of the three-dose DPT series, is not effectively used in standard analyses. Factors that affect nonvaccination with DPT, or $1 - P(DPT1)$, may be different from factors that affect dropout from DPT vaccination, or $1 - P(DPT3|DPT1)$. We examine the probability of receiving all three DPT doses among infants who had received at least one DPT dose, or $P(DPT3|DPT1)$, to directly examine the risk factors for dropout between doses 1 and 3.

We included individual- and household-level risk factors such as characteristics of the child, mother, and the household: the child's sex, birth order, and their interaction; the mother's and her partner's years of schooling; her knowledge of diarrhoea management, awareness of immunization-related messages and colostrum feeding practices; religion and caste of the head of the household; and household wealth quintile. In addition, we considered indicators of village-level infrastructure, such as availability of electricity; availability of a subcentre and primary health centre (PHC) in the village and all-weather road connectivity with the subcentre or PHC; and availability in villages of auxiliary nurse midwives (ANMs) and accredited social health activists (ASHAs)—community health workers who help mobilize and vaccinate the rural population in India. We also included variables summarizing the district's demographic and socioeconomic profile and the health infrastructure: percentages of fourth or higher birth order children, women with six or more years of schooling, households belonging to the richest wealth quintile, and villages with a subcentre. We considered a state-level dummy variable indicating the nine 'high-focus' states with poor infrastructure and low public health indicators. Further details on variables are provided in the Appendix.

2.3. Statistical analyses

All analyses were confined to the 75,728 youngest living children, 6–23 months old, from villages across India, except union territories and Goa. We considered children 6 months or older so that all children have had opportunity to receive all three recommended DPT doses and also children less than two years old so that mothers would be able to recollect their vaccination history. For studying the effects of village-level structural determinants on vaccine uptake, we restricted the analyses to children from rural areas only and therefore excluded union territories and Goa, which have very few villages. Coverage for DPT1 and DPT3 was calculated by dividing the number of children receiving at least one DPT dose and all three DPT doses, respectively, by the total number of children aged 6–23 months. Coverage for DPT3|DPT1 was calculated by dividing the number of children receiving all three DPT doses by the number of children who received at least one dose of DPT. Estimates of prevalence and coverage rates were calculated using survey weights to account for unequal selection probabilities, and standard errors were adjusted for clustering at the village level. We performed multivariate logistic regressions to identify determinants of nonvaccination with DPT and dropout between doses 1 and 3. To account for the hierarchical nature of the data,

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