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Research Article

Gender differentials in the timing of measles vaccination in rural India

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Gender-differentials in the timing of measles vaccination in rural India

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Abstract

BACKGROUND
Measles is a highly contagious but vaccine-preventable disease. Gender differences in measles vaccination outcomes have been widely reported in India.

OBJECTIVE
An overlooked factor is whether female children are less likely to be vaccinated age-appropriately.

METHODS
In this paper we use data from the nationally representative 2008 District Level Household Survey (DLHS) to analyse if there are any gender differences in the propensity to vaccinate a child for measles, and, among the vaccinated sample, whether there are any gender differences in the probability of age-appropriate measles vaccination.

RESULTS
Our analysis confirms that girls have both a significantly lower probability of being vaccinated and of being vaccinated age-appropriately.

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1. Introduction

Measles is a highly contagious yet vaccine-preventable respiratory infection, and a major cause of child morbidity and mortality in developing countries.[4] The risk of developing severe or fatal measles increases for those who are aged less than 5 years, live in overcrowded conditions, and are malnourished. The complications of infection, including severe diarrhoea, protein-energy malnutrition, blindness, respiratory infection, and encephalitis, are often the ultimate causes of measles-related mortality in developing countries (WHO 2013a). Vaccination against measles is regarded as a safe and cost-effective strategy to prevent measles-related morbidity and deaths. One dose of age-appropriately administered measles-containing vaccine is considered to be 95% effective in preventing clinical measles, and 92% effective in preventing secondary cases among household contacts (Demicheli et al. 2011). Globally, immunization is estimated to have helped prevent nearly 7.5 million measles-related deaths over the period 1999–2005 (Wolfson et al. 2007). Furthermore, regardless of setting, measles-related deaths are consistently higher among unvaccinated children. However, despite these benefits, measles immunization rates continue to be sub-optimal in many developing countries, and measles remains a leading cause of childhood morbidity and mortality, particularly among vulnerable populations (Kouadio et al. 2010).

India has among the lowest number of children vaccinated against measles, accounting for more than a third of all measles deaths worldwide (around 56,000 in 2011). Of the estimated 20 million children worldwide who did not receive the first dose of vaccine in 2011, 6.7 million lived in India (WHO 2013b).

Furthermore, previous literature shows that there is wide heterogeneity in vaccination status by the child's gender, socio-economic characteristics, rural/urban location, and state of residence (see Murhekar et al. 2011; Pande and Yazbeck 2003; Mathew 2012 for a review). Inequities in vaccination coverage can have adverse consequences, since measles is a highly infectious disease, and the risk of an outbreak increases in the presence of susceptible children in the population. These issues are of particular concern in India, which has the highest number of children who missed out on the measles vaccination. Black et al. (2010) and Morris et al. (2013) estimate that 63,000–137,000 Indian children died in 2005 due to measles and its complications accounting for 4%–6% of under-5 deaths.

In this paper we investigate the factors influencing the probability of a rural Indian child being vaccinated for measles, and the probability of being vaccinated at the

[4] Measles is transmitted via droplets from the nose, mouth, or throat of infected persons. Initial symptoms, which usually appear 10–12 days after infection, include high fever, runny nose, bloodshot eyes, and tiny white spots on the inside of the mouth. Several days later a rash develops, starting on the face and upper neck and gradually spreading downwards.

appropriate age, focusing on the role of gender. We use the rich, nationally representative 2008 *District Level Household Survey* (DLHS) dataset from India for our analyses.

Gender-induced disparities are of particular concern in India, given the widely documented evidence of pro-son bias and its influence on child health outcomes. The existence of discrimination against girls and the resulting excess female child mortality and adverse sex ratios for females in India are well documented in the literature (see Maitra and Rammohan 2011; Bhat and Zavier 2003; Das Gupta 1987). Previous research has attributed this to discriminatory intra-household resource allocations, particularly in terms of food, nutrition, and medical care (Bardhan 1988; Harriss 1999; Kishor 1993). Critically, girls face lower access to preventive care and treatment of disease compared to boys (Fikree and Pasha 2004).

Consistent with these findings of gender discrimination in the uptake of health seeking behaviour, recent studies from India have found measles vaccination scores for girls to be significantly lower than those for boys (see Singh 2012; Morris et al. 2013; Pande and Yazbeck 2003; Pande 2003; Borooah 2004). For example, Pande and Yazbeck (2003) find evidence of large rural/urban differentials in measles vaccination coverage, even in wealthier states where coverage is better. These findings are echoed in recent studies such as Singh (2013), who notes considerable variations in vaccination coverage between 1992–2006 in six geographical regions in India, attributable to gender preferences and rural/urban factors. Similarly, Morris et al. (2013) found that measles-related mortality among Indian children in 2005 was nearly 70% greater for girls than for boys (4.2 vs. 2.5 per 1000 live births), and 90% of all deaths occurred in rural areas. Furthermore, Corsi et al.'s (2009) non-parametric study found that the lower vaccination coverage experienced by girls extended to other diseases such as BCG, polio, tetanus, and whooping cough. They also found that higher birth order girls and girls with older sisters were at higher risk of missing vaccinations.

The current paper contributes to the above literature in several ways. First, our analysis distinguishes between (i) the propensity for a child to be vaccinated for measles, and (ii) whether the vaccination was given age-appropriately. This distinction is important because both premature and late vaccination against measles can have adverse consequences. While a number of studies have examined the socio-economic factors influencing the probability of being vaccinated, important temporal, cultural, health-system, and socio-economic factors influencing the timing of measles vaccination coverage remain under-researched. The very few studies that have explored vaccination timing have focused on delays in vaccination, a major reason for measles-related mortality (Dombkowski et al. 2004; Morris et al. 2013). However, it is also critical to examine the role of premature vaccination, especially prior to 5 months of age, due to the possibility of reduced protection against measles at best, or greater susceptibility to all-cause mortality at worst.

The appropriate age for measles vaccination is typically determined by weighing the risk of measles disease and complications at a given age with vaccine efficacy at that age. The Indian measles vaccination schedule recommends that the first dose of vaccination should be administered at 9 months following birth (IAP, 2012). Previous research shows that the administration of measles vaccination prior to 9 months of age may result in the neutralisation of the vaccine by maternal antibodies (Halsey et al. 1985; Gans et al. 1998). Studies further show that seroconversion for measles is slightly lower among children who receive the first dose before or at 12 months of age (87% at 9 months, 95% at 12 months, and 98% at 15 months), because of persisting maternal antibodies (Gomber et al. 2011). However, others such as Aaby et al. (2012a) posit that when measles vaccination is mapped to child survival and the risk of measles infection, the optimal age for a single dose of measles vaccine would probably be 6 or 7 months of age. This is because even vaccinated and seronegative children have modest protection against measles infection. The longer such immunization is delayed, the greater the risk of severe measles infection (Moss 2007). Apart from reduction or loss of vaccine potency due to the failure of the cold chain system (Gupta et al. 2009), age-inappropriate vaccination is a major constraint in optimising measles vaccination outcomes in India (Bhanot et al. 2004; Prinja et al. 2010).

Second, the issue of gender differentials in the timing of measles vaccination has hitherto received limited attention. Previous research from India (discussed above) has explored whether there are gender differences in the propensity to vaccinate a child against measles, and the role of socio-economic and household characteristics in influencing measles vaccination. Even after barriers to vaccination uptake are addressed, gender discrimination and health system constraints may pose additional challenges to vaccination timing. Previous research has shown that measles vaccine administered prior to the third dose of DPT may increase girl-child mortality rates in countries like India (Aaby et al. 2004; Benn and Aaby 2012; Halsey et al. 1985; Gans et al. 1998). In particular, low and age-inappropriate vaccination appears to have disproportionately greater adverse effects on girls. In India the 2005 Million Death study found that among children in the 1−59 month age category there were nearly 50% more deaths among girls than among boys (56,000 vs. 36,000), and the overall measles mortality rate was nearly 70% higher in girls. This suggests that there is gender inequality in access to protection from measles vaccines in particular and child health services in general. However, to our knowledge, there is no analysis of these issues using household-level nationally representative data. Our paper aims to fill this gap in knowledge.

Third, our analysis extends the research on gender differentials in measles vaccination coverage amongst rural children by analysing a unique dataset that has, for the first time, linked household level data to the health facilities survey. This makes it possible to study the role of access to health services in measles vaccinations for children, even after controlling for households' socio-economic characteristics. In the Indian context it is also important to consider access to health infrastructure, since previous research has also noted substantial diversity in vaccination coverage across the Indian states. For example, poor age-specific timing of measles vaccination is often attributed to India's poorly functioning public health system (Rao and Mant 2012). A 2004 World Bank study of India's public health system found that major management flaws encumber effective use of resources, including inadequate focus on evaluation - on assessing the quality of services (Das Gupta and Rani 2004). So far, insufficient attention has been devoted to the monitoring of age-appropriate vaccination as an indicator of vaccination programme quality. The uniqueness of our dataset makes it possible for us to identify the household's access to vaccination services.

Finally, our analysis explores if resource-constrained households are more likely to immunize their boy child rather than their girl child at the appropriate age. We provide evidence that even within the same household, after controlling for the household's socio-economic characteristics, the girl child has a lower likelihood of being immunized age-appropriately.

From a policy perspective, the fact that measles outbreaks continue to occur among vaccinated children in Indian districts and states with high measles vaccination coverage (Lawrence et al. 2012) highlights the adverse impact of low vaccine efficacy on measles control. Unfortunately, no active monitoring of age-appropriate vaccination or of gender equity in vaccination is incorporated in the programme. As of 2008, only in 26% of districts was coverage with first dose of measles-containing vaccine (MCV-1) above 90%, while state-level coverage ranged from 48% to 96% (UNICEF 2009). It was also determined that immunisation coverage varies from one vaccine to another and declines over the schedule prescribed by the WHO, and that children of the poorest and most illiterate mothers have the lowest rate of full immunization (Yadav and Shekar 2013).

The current measles catch-up campaign focuses on a target group of children aged 9 months to 10 years in the 14 states with the lowest measles vaccination coverage (i.e., below 80%), irrespective of previous vaccination status or measles disease history (John and Choudhury 2009; Van den Ent et al. 2009; and Gupta et al. 2009). In 2011 the Indian government established a vaccination monitoring system to ensure that every child who receives a first dose of the vaccine routinely gets a second. They also initiated 'catch-up' campaigns in areas where first-dose coverage was less than 80%. Partly as a result of better programme management, measles vaccination coverage in low coverage states like Bihar and Uttar Pradesh has increased significantly (WHO 2013c).

2. Methods

The data used in this paper come from the 2008 District Level Household Survey (DLHS-3), which is the third in a series of nationwide surveys conducted by the International Institute for Population Sciences (IIPS), Mumbai, on behalf of the Ministry of Health and Family Welfare (MoHFW), Government of India. It is a household survey at the district level and in DLHS-3 the survey covered 611 districts in India.

Our analysis is based on a sample of 22,960 rural children aged between 12–59 months from the 15 major Indian states. We only include those children for whom complete information was available for our variables of interest and whose mothers were able to show the vaccination cards to the field enumerators, since health workers' documentation provides objective evidence of vaccination and reduces the possibility of recall errors. Moreover, we were also interested in the timing of measles vaccination, and this information is only available for children with vaccination cards. By the age of 12 months this cohort of children should have received their measles vaccination.

We acknowledge that by focusing on only those children with verifiable vaccination cards we may have missed a large number of cases where the mother is unable to show a vaccination card but the child may have been vaccinated. As a robustness check we have estimated models for the likelihood of being vaccinated for measles, including the sample of children whose vaccination information is based on the mother's recall. The information on mother's recall only indicates if the child has been vaccinated for measles or not, and not the age at which the child is vaccinated. Therefore, given the critical influence of the timing of vaccination on measles incidence and mortality, we focus only on the sample of rural children with vaccination cards.

Furthermore, our analysis is restricted to rural children since: (i) 75% of the Indian population lives in rural areas, vaccination outcomes are poorer for children from rural areas, and higher measles-case fatality ratios have been reported in rural areas (Sudfeld and Halsey 2009), (ii) in our dataset, information on community and health infrastructure is only available for the rural sample and, (iii) regional differences in vaccination uptake are common in India, and are often linked to the availability of healthcare services and socioeconomic factors.

3. Measuring vaccination status

The main aim of our analysis is to address two questions: (i) are there any gender differences in the propensity to be vaccinated for measles among rural Indian children? And (ii) are there any systematic gender differences in the probability of being vaccinated age appropriately?

To address these questions data is required on two dimensions of a child's vaccination status: (i) whether or not a child has been vaccinated for measles and, (ii) amongst vaccinated children, the timing of the measles vaccination. The dependent variable 'measles' is based on responses from the ever-married women's questionnaire, where all mothers who had given birth in the five years prior to the survey were asked about the immunization status of their children, and requested to show their vaccination cards to the enumerators. Information on vaccinations is only available for the last two births. Specifically, the question asks, "Do you have a card where (Name's) vaccination details are written down? (IF YES, MAY I SEE IT, PLEASE?)". The vaccination card contains details of all the vaccinations that the child has received, not just the measles vaccination.

(i) Probability of being vaccinated for measles

Firstly, we examine the probability of a child receiving the measles vaccination using a binary choice reduced form Probit model. The probit model for V (conditional on explanatory variables x) can be derived from a latent variable model. Assume that the latent variable V^* is determined by $V^*=x'\beta+\varepsilon$, where x is a vector of individual, household, parental, and community-level characteristics entering the equation and ε refers to the error term, which we assume is normally distributed across observations. V^*, the propensity to receive a vaccination for measles, is, however, unobserved. What we do observe is V, the child's vaccination status. So the observed aspects of a child's vaccination status can equivalently be written as:

$$V_i^* = x_i'\beta + \varepsilon_i \qquad V = 1 \textit{ if vaccinated for measles, } 0 \textit{ otherwise} \tag{1}$$

The empirical specification takes the following general form:

$$V_i = \alpha_0 + \alpha_1 c_i + \alpha_2 h_i + \alpha_3 \inf_i + State + \varepsilon_i \tag{2}$$

where V, our dependent variable, is an indicator variable which takes on a value of 1 if a child from household i is vaccinated for measles and 0 otherwise. This information is based on entries in the child's vaccination card.

The probability of being vaccinated for measles depends on a set of child-specific characteristics (c_i), parental/household characteristics (h_i), access to health-related infrastructure (inf_i), and regional (*state*) characteristics. The term c_i is a vector of child-specific variables incorporating a gender dummy, indicator variables for child's birth-order categories, dummy variable for whether the child was part of a twin-birth, mother's age at the time of the child's birth, and mother's age-squared to take into account non-linearities. For the child's birth order we use the birth order of each child in the household to compute five dichotomous birth-order dummy variables – second-born, third-born, fourth-born, fifth-born or higher (with the first-born child being the reference category). The influence of birth order on the probability of vaccination is ambiguous. On the one hand, higher birth order (later born) children are born to older mothers, who may be more experienced and have greater knowledge of vaccinations. On the other hand, higher parity children and girls in particular may be neglected due to resource constraints and strong son preference.

The term h_i is a vector of household characteristics including an indicator variable for whether or not the child's mother and father have received some schooling, the household head's religion, caste, female children as a proportion of total children in the household, and indicator variables for wealth quintiles. To get a measure of the household's economic status we include the wealth index that was available in the DLHS dataset, which is produced by combining as many indicators of household assets and utilities as possible. Indicator variables are then weighted and the wealth index is produced. The wealth index is divided into population quintiles, with the lowest quintile representing the poorest 20% and the highest quintile representing the wealthiest 20% of households (see Filmer and Pritchett 2001). These wealth quintiles have the advantage of providing a reasonably reliable measure of the household's economic status, and are less likely to be affected by the transitory nature of labour income.

The vector inf_i includes an array of variables to capture access to key health infrastructure and personnel. Specifically, we include variables to incorporate variables to measure distance from the child's village to key health facilities that are responsible for administering vaccinations such as *Sub-centres* (SC), *Primary Health Centres* (PHC), *Community Health Centres* (CHC), and *District hospitals* (DH); an indicator variable for whether the village is electrified to take into account the level of village development; and a variable to indicate whether the village has *Anganwadi* (literally, courtyards), which are part of the Integrated Child Development Service (ICDS) programme. The ICDS services are provided through a vast network of ICDS centres, better known as Anganwadi (Lokshin et al. 2005). Immunization of children is one of the core services offered by the ICDS Programme.

We also include a dummy variable to indicate if the household is a participant in the *Janani Suraksha Yojana* (JSY) Programme, an important initiative launched in 2005 to improve maternal and child health outcomes. Although it does not have any direct bearing on the vaccination campaign, the scheme provides pregnant women and new mothers with access to health workers called *ASHA* (Associated Social Health Activists).

(ii) Timing of vaccination

For those mothers who are able to produce the vaccination card, we then enter the age at which the child received the measles vaccination. There are three distinct categories of child vaccination: premature (below 7 months), late vaccination (above 12 months of age), and age-appropriate vaccination (7−12 months).[5]

More formally, we estimate a series of single-equation probit models that capture the probability of a child being vaccinated prematurely, late, or age-appropriately using the following form:

$$measles_j^* = x_j^{'}\beta + \varepsilon_j \qquad j = premature, late \;\; and \;\; age\ appropriate \tag{3}$$

Each child can only belong to one of the three discrete categories of the dependent variable, which can be explained by the same set of explanatory variables.

All our analyses were conducted using STATA 12.

4. Results

4.1 Descriptive statistics

The descriptive statistics for the key variables included in the regression analysis are presented in Table 1. From Table 1 we observe that 78% of the children have been vaccinated against measles, as verified by the information entered by the health workers on the vaccination cards. Among vaccinated children we observe that 5% have been vaccinated before 7 months of age, whereas 15% have been vaccinated after 12 months of age. We further observe that girls have a slightly lower probability of being vaccinated age appropriately (45%) compared to being vaccinated late (48%).

To better understand the gender differences in the timing of the measles vaccination, in Table 2 we present gender-disaggregated information on the timing of

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[5] In India the recommended age for administering the first dose of measles vaccine is 9 months (IAP, 2012). Following Aaby et al. (2012b), we regard 7 months as being the lower bound for our definition of premature vaccination.

the vaccination. It is noteworthy that only 28.73% of the vaccinated children have been vaccinated at the recommended age, which is 9 months in India. We observe that among the sample of girls, 15.94% received their vaccination after 12 months of age, whereas the figure is 14.61% for boys.

4.2 Regression results

The main results of our regression analysis are reported in Tables 3 to 5. Table 3 reports the probit estimation results for the probability of a child being vaccinated for measles. In Table 4, for the sample of vaccinated children, we present results for the probability of being vaccinated prematurely [1], the probability of receiving vaccinations late [2], and finally the probability of being vaccinated age appropriately [3]. In Table 5 we present the logit estimation results for a sample of children from 2-child households (with at least a boy and a girl).

4.3 Probit results

As discussed previously, the issue of age-appropriateness of measles vaccination outcomes remains understudied, and a key contribution of this paper is to analyse whether there is a female disadvantage in the probability of being age inappropriately vaccinated. Our findings confirm the existence of female disadvantage in vaccination outcomes, with girls having a significantly lower probability of being vaccinated for measles compared to boys across all our models, and in the vaccinated sample girls are shown to have a higher probability of being vaccinated late. According to the probit results presented in Table 3, girls have a 1.8 percentage point lower probability of being vaccinated for measles relative to boys (Column 1, Table 3), and a 1.4 percentage point higher probability of being vaccinated late relative to boys (Column 3, Table 3). There are no significant differences between girls and boys in the propensity to be vaccinated prematurely. One explanation for this finding with regards to late vaccination for girls may be that health workers may be administering vaccines during vaccination drives, and they may be picking up some of the older children (typically girls) who have not been vaccinated.

Turning to sibling characteristics, we find that higher-birth-order children are disadvantaged both in terms of receiving the vaccination and with regards to being vaccinated in an age-appropriate manner. From Table 3 we observe that, relative to a first-born child, children from higher birth orders have a significantly lower probability of being vaccinated for measles, and from Table 4 we further note that higher-birth-order children also have poorer vaccination outcomes. More specifically, these children have a higher probability of being in the 'no vaccination' category and a lower probability of being vaccinated age appropriately.

4.4 Influence of household characteristics

Our analysis shows that household wealth and mother's education significantly improve vaccination outcomes for children, while father's education has no statistically significant influence. The results from Table 3 show that having a mother who has ever attended school improves the probability of the child being vaccinated for measles by over 5 percentage points, compared to having a mother who has never attended school.

Similarly, household wealth is significantly and positively related to better vaccination outcomes. In particular, compared to a child from the poorest wealth quintile, the probability of a child being vaccinated increases monotonically with each higher wealth quintile. More specifically, according to Table 3, relative to a child from the poorest wealth quintile a child from the richest wealth quintile has a 7.8 percentage point higher probability of being vaccinated for measles and a 5 percentage point lower probability of receiving a measles vaccination after 12 months of age, with no statistically significant associations found between premature vaccinations and wealth in the probit analysis.

4.5 Role of infrastructure

The third set of results relate to the role of government programmes and access to health infrastructure. As explained previously, this aspect has not been previously studied in the context of India (see Pande and Yazbeck 2003; Singh 2012), mainly due to a lack of information on health infrastructure in the National Family Health Survey (NFHS) datasets that were used in those studies. The ordered probit results presented in Table 4 confirm the important role played by the JSY program in improving the vaccination outcomes of children. More specifically, JSY participation is statistically significant and associated with a higher probability of a child being vaccinated for measles and being vaccinated at the right time, and is significantly associated with a lower likelihood of a child being vaccinated prematurely. Variables on various health facilities are largely insignificant, with the exception of the Primary Health Centre (PHC) where our results show that proximity to primary health care is statistically significant in improving measles vaccination coverage rates. If the PHC is brought one kilometre closer to the village, the probability of a child being vaccinated increases by about 0.13 percentage points. Note that the average distance of a PHC from a village is about 9.56 kilometres.

A particularly important finding of our analysis is the role of the Government of India's maternal and child initiative (the JSY Programme), which was introduced in 2005. Our analysis shows JSY participation to be positively associated with better measles vaccination outcomes for children. For example, from Table 3 we observe that a child from a household that participates in the JSY programme has a 2.6 percentage point higher probability of being vaccinated for measles, and a 3.31 percentage point lower probability of being vaccinated late.

4.6 Regional variations

Our final set of results shows significant regional variations in measles vaccination coverage across Indian states. These results by and large confirm a priori expectations, and show that only children from the state of Madhya Pradesh have poorer vaccination outcomes than children from the state of Uttar Pradesh.

4.7 Logit fixed effects model

To test the robustness of these gender-differentiated outcomes across the national sample, we re-estimate household fixed effects models for a sample of households where there are two children, a boy and a girl in the age group 12 months to 5 years. This allows us to examine if there is any evidence of gender discrimination in vaccination outcomes amongst children from the same household. The coefficients for the gender dummy variable presented in Table 6 confirm that, even in households with a boy and a girl, girls are significantly more likely to be vaccinated late compared to boys. This result may indicate that in resource-constrained households, boys are given preferential treatment in the allocation of health resources.

5. Conclusion

In this paper we have examined if there are gender differences in the timing of measles vaccination among children in rural India using a nationally representative dataset, which has for the first time linked household-level information with access-to-health infrastructure. By taking into account the timing of measles vaccination, an important but overlooked factor, our paper provides new insight into gender-differentiated inequities in child health outcomes in rural India. This allows us to identify not only the propensity for the children being vaccinated age-appropriately, but also the health facilities where the age-inappropriate vaccinations are being given.

Our analysis confirms gender differences in the probability of being vaccinated against measles, and goes on to show that girls have a significantly lower probability of being vaccinated age appropriately compared to boys. Importantly, these differences persist in households with at least one boy and one girl, consistent with the evidence on son-preference. Other important results relate to the influence of household wealth, parental schooling, and the role of access to health facilities.

A number of policy implications arise from our findings. First, in keeping with the findings from previous studies, our analysis confirms the important role of mothers' schooling in improving vaccination outcomes for children. Second, the positive externalities from public health programmes such as the JSY suggest that this is an avenue that policy makers could potentially use to address gender inequities in vaccination outcomes. Finally, the finding that children from wealthier households have both a higher probability of being vaccinated for measles and of being vaccinated age appropriately indicates that poverty is a key factor constraining attempts to improve measles vaccination coverage.

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Appendix

Table 1: Key descriptive statistics

		Vaccinated sample		
Variables	**Full sample**	**Premature vaccination (<7 months)**	**Late vaccination (>12 months)**	**Age appropriate (7–12 months)**
Measles vaccination given	0.78	0.05	0.15	
Sex of the child (female)	0.46	0.46	0.48	0.45
Hindu	0.80	0.77	0.78	0.80
Muslim	0.14	0.19	0.19	0.12
Scheduled caste/tribe	0.35	0.31	0.33	0.34
Ratio of daughter to total children	0.49	0.48	0.50	0.49
Wealth quintile 1: poorest	0.20	0.18	0.26	0.17
Wealth quintile 2: poor	0.24	0.26	0.28	0.21
Wealth quintile 3: middle	0.23	0.24	0.23	0.24
Wealth quintile 4: rich	0.20	0.21	0.16	0.23
Wealth quintile 5: richest	0.12	0.10	0.07	0.15
Husband ever attended school	0.78	0.77	0.73	0.82
Mother ever attended school	0.59	0.54	0.50	0.67
Mother’s age at birth	24.18	24.72	24.17	24.02
Birth order first	0.38	0.38	0.32	0.42
Birth order second	0.28	0.27	0.26	0.30
Birth order third	0.15	0.15	0.18	0.14
Birth order fourth	0.09	0.08	0.10	0.07
Birth order fifth and above	0.10	0.11	0.14	0.07
Village is electrified	0.79	0.77	0.69	0.83
Anganwadi worker available in	0.93	0.93	0.94	0.94
Household is a beneficiary of JSY	0.11	0.11	0.09	0.12
Dist. to District Hospital (DH) in	35.77	34.56	35.09	35.55
Dist. to Community Health Centre	17.13	18.57	18.42	16.34
Dist. to Primary Health Centre	8.74	9.00	8.83	8.42
Dist. to Sub Centre (SC)	2.65	2.53	2.66	2.57
Dist. to private health clinic/hospital	11.06	12.31	11.22	10.88
Observations	19,948	1001	3035	

Note: The figures represent sample means.

Table 2: Timing of vaccination

Months	Both children (%)	Boys (%)	Girls (%)
0-6	1001 (5.02)	543 (5.00)	458 (5.04)
7	475 (2.38)	256 (2.36)	219 (2.39)
8	1,673 (8.39)	911 (8.41)	762 (8.34)
9	5,731 (28.73)	3,208 (29.55)	2,523 (27.74)
10	4,867 (24.40)	2,637 (24.29)	2,230 (24.53)
11	2,101 (10.53)	1,125 (10.36)	976 (10.73)
12	1,065 (5.34)	590 (5.43)	475 (5.22)
12+	3035 (15.21)	1586 (14.61)	1,449 (15.94)
All	19,948	10,856	9092

Source: DLHS-3 (author's calculations).

Table 3: Probability of being vaccinated for measles

Variables	Marginal effects	Standard errors
Female	-0.018**	(0.008)
Child's age	-0.006***	(0.001)
Child's age- squared	0.0001***	(0.000)
Hindu	0.025	(0.018)
Muslim	-0.045**	(0.022)
Scheduled caste/tribe	-0.024***	(0.007)
Daughter/total children	0.008	(0.011)
Wealth quintile: poor	0.025***	(0.008)
Wealth quintile: middle	0.036***	(0.009)
Wealth quintile: rich	0.060***	(0.009)
Wealth quintile: richest	0.077***	(0.011)
Father ever attended school	0.011	(0.007)
Mother ever attended school	0.051***	(0.007)
Mother's age at birth	0.024***	(0.005)
Mother's age at birth: square	-0.0004***	(0.0001)
Birth order 2	-0.040***	(0.008)
Birth order 3	-0.073***	(0.011)
Birth order 4	-0.081***	(0.014)
Birth order 5 and above	-0.089***	(0.015)
Village has electricity	0.030***	(0.009)
Village has Anganwadi worker	0.016	(0.011)

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3: (Continued)

Variables	Marginal effects	Standard errors
Hh is JSY participant	0.023***	(0.009)
Dist. to District hospital	-0.0003*	(0.0002)
Dist. to Community Health Centre	0.0003	(0.0002)
Dist. to Primary Health Centre	-0.001***	(0.001)
Dist. to Sub Centre	-0.001	(0.001)
Dist. to pvt. clinic/hospital	0.0002	(0.0003)
Jammu and Kashmir	0.172***	(0.009)
Himachal Pradesh	0.150***	(0.011)
Punjab	0.153***	(0.011)
Uttar Khand	0.103***	(0.018)
Haryana	0.029	(0.026)
Rajasthan	0.073***	(0.024)
Bihar	0.082***	(0.013)
Assam	0.112***	(0.013)
West Bengal	0.193***	(0.008)
Jharkand	0.128***	(0.015)
Orissa	0.103***	(0.015)
Chhattisgarh	0.035*	(0.018)
Madhya Pradesh	-0.035*	(0.020)
Gujarat	0.016	(0.023)
Maharashtra	0.067***	(0.018)
Andhra Pradesh	0.063**	(0.027)
Karnataka	0.109***	(0.016)
Goa	0.125***	(0.024)
Kerala	-	
Tamil Nadu	-0.0004	(0.026)
Observations	22,960	

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 4: Probability of being vaccinated age appropriately

	Probability of being vaccinated prematurely before 7 months		Probability of being vaccinated above 12 months		Probability of being vaccinated between 7–12 months	
	ME	**SE**	**me**	**se**	**me**	**se**
Female	0.003	(0.004)	0.016**	(0.008)	-0.021**	(0.009)
Child's age	-0.001	(0.001)	-0.003***	(0.001)	0.004***	(0.001)
Child's age (squared)	0.000	(0.000)	0.0001***	(0.000)	-0.0001***	(0.000)
Hindu	0.007	(0.008)	0.024	(0.018)	-0.031	(0.019)
Muslim	0.027*	(0.014)	0.112***	(0.028)	-0.129***	(0.027)
Scheduled caste/tribe	0.002	(0.003)	0.006	(0.007)	-0.011	(0.008)
Daughter/total children	-0.003	(0.006)	0.006	(0.010)	-0.001	(0.011)
Wealth: poor	0.006	(0.005)	-0.020***	(0.007)	0.017*	(0.010)
Wealth: middle	0.005	(0.005)	-0.026***	(0.009)	0.025**	(0.010)
Wealth: rich	0.010	(0.006)	-0.042***	(0.009)	0.037***	(0.010)
Wealth: richest	-0.0003	(0.007)	-0.062***	(0.010)	0.067***	(0.013)
Father ever attended school	-0.004	(0.004)	-0.009	(0.008)	0.015	(0.009)
Mother ever attended school	-0.011***	(0.004)	-0.032***	(0.007)	0.053***	(0.009)
Mother's age at birth	0.001	(0.002)	-0.018***	(0.005)	0.018***	(0.005)
Mother's age at birth: square	-0.000	(0.000)	0.0002***	(0.0001)	-0.0003***	(0.0001)
Birth order 2	0.001	(0.004)	0.022***	(0.007)	-0.023***	(0.008)
Birth order 3	0.005	(0.005)	0.055***	(0.010)	-0.063***	(0.012)
Birth order 4	-0.001	(0.006)	0.052***	(0.014)	-0.043***	(0.016)
Birth order 5 and above	0.003	(0.006)	0.073***	(0.016)	-0.069***	(0.017)
Village has electricity	0.002	(0.004)	-0.024***	(0.009)	0.024**	(0.010)
Village has Anganwadi	-0.002	(0.006)	0.013	(0.012)	-0.015	(0.013)
Hh is JSY participant	-0.004	(0.004)	-0.014	(0.009)	0.020*	(0.010)
Dist. to DH	-0.0001	(0.0001)	0.000	(0.0002)	-0.0001	(0.0002)
Dist. to CHC	0.0001	(0.0001)	0.0002	(0.0002)	-0.0003	(0.0003)
Dist. to PHC	0.0001	(0.0002)	0.0002	(0.0004)	-0.000	(0.001)
Dist. to SC	-0.0003	(0.0004)	0.001	(0.001)	-0.000	(0.001)
Dist. to pvt. clinic/hospital	0.000	(0.0001)	0.0001	(0.0003)	-0.0001	(0.0003)
Jammu and Kashmir	-0.001	(0.009)	-0.122***	(0.008)	0.141***	(0.017)
Himachal Pradesh	-0.008	(0.008)	-0.102***	(0.010)	0.131***	(0.012)
Punjab	-0.020**	(0.008)	-0.117***	(0.009)	0.164***	(0.013)
Uttar Khand	0.006	(0.008)	-0.098***	(0.013)	0.112***	(0.019)
Haryana	-0.017***	(0.006)	-0.092***	(0.012)	0.135***	(0.015)
Rajasthan	0.012	(0.013)	-0.113***	(0.011)	0.131***	(0.021)

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: (Continued)

	Probability of being vaccinated prematurely before 7 months		Probability of being vaccinated above 12 months		Probability of being vaccinated between 7–12 months	
	ME	SE	me	se	me	se
Bihar	0.015**	(0.007)	-0.010	(0.012)	-0.010	(0.016)
Assam	0.019**	(0.008)	-0.070***	(0.010)	0.059***	(0.013)
West Bengal	-0.030***	(0.004)	-0.118***	(0.008)	0.169***	(0.011)
Jharkhand	0.013	(0.009)	-0.067***	(0.024)	0.069**	(0.028)
Orissa	0.020	(0.013)	-0.102***	(0.011)	0.115***	(0.018)
Chhattisgarh	-0.013	(0.008)	-0.095***	(0.011)	0.127***	(0.015)
Madhya Pradesh	0.015	(0.010)	-0.071***	(0.012)	0.070***	(0.018)
Gujarat	0.034**	(0.014)	-0.072***	(0.012)	0.057***	(0.017)
Maharashtra	0.006	(0.009)	-0.108***	(0.008)	0.134***	(0.011)
Andhra Pradesh	0.001	(0.013)	-0.117***	(0.009)	0.143***	(0.012)
Karnataka	-0.013	(0.008)	-0.124***	(0.007)	0.169***	(0.011)
Goa			-0.123***	(0.037)	0.166***	(0.039)
Kerala			-0.090***	(0.032)	0.154***	(0.034)
Tamil Nadu	-0.012	(0.010)	-0.123***	(0.008)	0.161***	(0.013)
	17,915		17,915		17,915	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Logit with household fixed effect (sample of two children, one boy and one girl)

	Right timing (9>t>12)		Premature (t<7)		Late (t>12)	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
Female	0.076	0.112	-0.277	0.265	0.323**	0.150
Observations	632		632		632	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1