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Original Research Article

Parental investment in child immunisation: the role of birth order and number of children

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ABSTRACT

Background: Immunisation of children remains an important public health challenge in India despite the implementation of the Universal Immunisation Programme. Understanding how household and child-specific factors affect children's immunisation is essential for improving immunisation coverage. In this paper, the effects of the number of children and birth order on children's immunisation in India have been examined. The number of children and birth order are two related but conceptually different aspects of families. Distinguishing between the two allows us to determine whether lower immunisation among children arises from larger families or from differences in a child's position within the sibling group, the birth order.
Methods: A cross-sectional analysis of nationally representative data from the fourth round of the National Family Health Survey, conducted in 2015-16, is used for the study. Logistic regression and household fixed-effects models have been employed to examine the impact of the number of children and birth order on children's immunisation.
Results: The findings reveal that immunisation increases with an increase in the number of children in a family, and this is consistent across both model specifications. In addition, a strong, negative effect of birth order on immunisation has been observed. Larger families are more likely, whereas a child of a higher birth order is less likely to achieve full immunisation.
Conclusions: The study highlights the importance of the number of children and birth order in explaining immunisation outcomes in India. The empirical findings show that the number of children has a positive effect and birth order has a negative effect on full immunisation.

Keywords: Fully immunised, Immunisation, Birth order, Number of children, National family and health survey

INTRODUCTION

The Universal Immunisation Programme is one of the largest and most cost-effective public health programmes in India.[1] Under this programme, vaccination is provided free of cost against diseases like tuberculosis, diphtheria, pertussis, tetanus, polio, and measles. A child is said to be fully immunised if he or she receives one dose of BCG, three doses of DPT, three doses of Polio vaccine and one dose of Measles vaccine by 12-23 months of age.[2] According to National Family and Health Survey (NFHS) data, the proportion of children fully immunised has increased from 35.4 per cent in NFHS-1 (1992-1993) to 44 per cent in NFHS-3 (2005-2006) and 62 per cent in NFHS-4 (2015-16), respectively.[3] This shows that the increase in coverage of fully immunised children has been substantial from 1992-93 to 2015-16. Although the immunisation programme has made considerable progress, it is still below its potential. A better understanding of how parents decide whether to immunise their children is important for improving immunisation coverage.

Parental decisions about investing in children have long-term effects on educational achievement, future earnings, and children's overall welfare. It not only varies with

differences in parental characteristics but also differs according to child-specific characteristics such as gender, birth order, initial endowment, and the number of children born in the family. This study explores whether parents' decision to immunise their children is influenced by the number of children in the family and the child's birth order.

The relationship between investments in children and the number of children is explained by Becker's "quantity-quality trade-off model".[4] According to this theory, parents make a trade-off between the number of children they have and the amount they invest in each child. As the number of children in the family increases, the total cost of investing in each child increases, which in turn reduces demand for children. Numerous empirical studies have tested the quantity-quality trade-off model in the context of human capital investment.[5-9] But the nature of the relationship between the number of children in a family and investment per child remains ambiguous. A study from India using a household-level sample found that an increase in the number of children reduces the educational attainment of all children in the household.[5] In contrast, evidence from China suggests that school enrolment of the firstborn child increases significantly with the number of children in the family.[6] They argued that the positive relationship between the number of children and school enrolment comes from economies of scale in raising the children. However, other studies from Norway, Israel, and South Korea found no effect of the number of children on educational outcomes.[7-9]

A second strand of literature focuses on the importance of birth order in children's outcomes. The studies show how the child's position within the siblings' birth sequence influences parental investment and later-life achievements.[7,10] The central argument is that earlier-born children receive more time, financial, and cognitive resources than later-born children, resulting in negative birth-order effects. However, if earlier-born children contribute to the development of later-born children by providing care, financial resources, and cognitive support, then we can observe positive birth-order effects.[11-13] There is extensive literature on the impact of birth order on investment in children, focusing on nutrition, education, preventive health care, parental time spent, and related areas. In developed countries, most empirical research has shown negative birth-order effects.[7,13,14] In developing countries, the evidence is mixed. A positive birth order effect is observed in Ecuador, and the Philippines, but a negative birth order effect is observed in China.[17] In India, however, most studies observe a negative birth order effect.[15,16,18-20]

The objective of this study is to investigate how the number of children and birth order are associated with full immunisation in children using nationally representative data from the NFHS-4 conducted during 2015-2016. Logistic regression and the household fixed-effects model of estimation are employed to examine the impact of these two variables, namely the number of children and birth order, on children's immunisation. There is very limited evidence on the roles of the number of children and birth order, and my study contributes to the existing work by providing empirical evidence on the effects of these factors on immunisation coverage using individual-level survey data in India. The number of children and birth order are two related but conceptually different aspects of families. While the number of children captures the effects of overall family size and resource dilution, birth order captures the differences in parental investment associated with a child's position within the sibling group.

Distinguishing between the two allows us to determine whether lower immunisation among children arises from larger families or from differences in a child's position within the sibling group.

METHODS

Data source and study design

For the empirical analysis, a cross-sectional study is used based on the fourth round of the National Family Health Survey of India, conducted in the year 2015-2016.[3] The NFHSs are nationally representative household sample surveys implemented by the Ministry of Health and Family Welfare, Government of India, in collaboration with the International Institute for Population Sciences, Mumbai. NFHS-4 covered 640 districts across all states and union territories in India, as per the Census 2011. Sample selection was done separately for rural and urban areas. NFHS-4 interviewed men aged 15-54 years and women aged 15-49 years in the sample households. This round surveyed a sample of 601,509 households with 699,686 women and 112,122 men.

NFHS-4 collects information on vaccination coverage, breastfeeding, nutrient and vitamin intake for all children born in the 5 years preceding the survey. In the survey, mothers were asked whether the child had received vaccinations against tuberculosis (BCG), DPT, polio, and measles by the age of 12 months. Children who received BCG, measles, and three doses each of DPT and polio (excluding Polio 0) are fully immunised. Along with vaccination coverage, this survey also collects information on the birth history of all children born to the eligible women aged 15-49 years in each household. The birth history provides information on the number of children born to the mother, their birth order, gender, and other characteristics.

Sample selection

To examine the effect of birth order and the number of children on full immunisation of children aged 0-59 months, the sample is restricted to mothers with at least one child. The final sample consists of 1,88,856 mothers and 2,57,321children.

Variable description

The outcome variable is fully immunised, which is defined as a dummy variable that takes the value 1 if the child received all basic vaccinations by the age of 12 months (basic vaccinations include one dose of BCG, three doses of DPT, three doses of Polio vaccine and one dose of Measles vaccine), and 0 otherwise.

The key explanatory variables are the number of children and the child's birth order. The number of children variable is measured using a set of dummy variables indicating the number of children born to the mother and alive: two-children, three-children, four-children and five-or-more-children. For example, two-children is a dummy variable that takes the value 1 if the mother has two children and 0 otherwise. In a similar manner, three-children, four-children and five-or-more-children are defined. Households with one child are treated as the reference category. The birth order variable is measured using a set of dummy variables indicating the child's birth order: second-born, third-born, fourth-born, fifth-born, and above. Where second-born is a dummy variable that takes the value 1 if the child is second-born, and 0 otherwise. In a similar manner, third-born, fourth-born and fifth-born-and-above are defined. The firstborn children are treated as the reference category.

The other explanatory variables included are gender of the child, measured by the dummy variable female (male is the reference category), mother's education, mother's age, currently working (dummy variable that takes value 1 if the mother is currently working, and 0 otherwise), household wealth index measured by dummy variables Poorer, Middle Income, Rich, Richest (Poorest is the reference category), urban (rural is the reference category), the caste and religion dummy variables, and the state dummy variables.

Ethical approval

This study uses the secondary data from NFHS-4, which is publicly available upon request from the Demographic and Health Surveys (DHS) Program. Ethical approval for the survey was obtained by the implementing agencies. No additional ethical approval was required for this secondary data analysis.

Statistical analysis

To investigate the association of full immunisation with the number of children and the birth order of the child, a logistic regression model is estimated using the following specification:

$$P(y_i = 1|\text{children}_i, \text{birth}_i, X_i) = G\,(\beta_0 + \beta_j \sum_{j=2}^{k} \text{Children}_{ij} + \gamma_i \sum_{j=2}^{k} \text{Birth}_{\text{Order}_{ij}} + X_i'\theta)$$

where y_i is a dummy variable indicating whether child i is fully immunised. The variable Children_i represents the number of children: Two-children, Three-children, Four-children and Five-or-more-children. The variable Birth_Order_i denotes a set of dummy variables representing the birth order of child i. The dummy variables correspond to Second-born, Third-born, Fourth-born and Fifth-born and above. X_i denotes a vector of other child and household characteristics that could affect the dependent variable. The variables in X are female, the mother's education, the mother's age, whether the mother is currently working, wealth index, whether the household is in urban areas, the caste and religion dummy variables, and the state dummy variables. The standard errors are clustered at the household level to correct for any unobserved correlation in the error term.

RESULTS

This section is divided into three subsections. The first subsection presents descriptive statistics for the variables used in the analysis and provides cross-tabulations to examine their associations. The second subsection reports and discusses the econometric model's results. The third subsection presents household fixed-effects estimates as robustness checks to assess the sensitivity of the main findings.

Descriptive analysis

Table 1 presents summary statistics of the variables used in the analysis. About 47 per cent of children aged 0-59 months in the sample are fully immunised; around 82 per cent have received at least one vaccine, while nearly 13 per cent have received none. Around 48 per cent of children are female, and the average age of children is 2 years. The average birth order is 2.3, and the mean number of children is 2.4. Mothers have an average of 6 years of education, and the average age of a mother is 27. About 3 per cent of mothers are currently working. The wealth distribution indicates that about 50 per cent of the households are poor. About 72 per cent of households are Hindu, 40 per cent of households belong to SC/ST, 39 per cent belong to OBC and 17 per cent to upper castes. About 24 per cent reside in the urban region.

Table 2 presents immunisation coverage across different vaccines by the number of children, gender and birth order. Overall, immunisation coverage is relatively high for initial vaccine doses but declines for later doses. The vaccination rate is highest at 2 children and declines thereafter as the number of children increases. Vaccination rates decline sharply with increasing birth order. These are consistently observed across all vaccines. There is almost no difference in immunisation observed between male and female children in the data.

Table 3 shows that 47% of children are fully immunized, 82 per cent receive some vaccinations, and 13% have not received any vaccinations. Consistent with Table 2,

children from two-child families show the highest rates of full immunisations and the lowest percentage of never-immunised children. However, immunisation rates (both fully and ever) decline as the number of children increases beyond two children. The vaccination rate declines sharply with increasing birth order. The 52% of the firstborns are fully immunized, whereas only 34 per cent of those born fifth and above are fully immunized. These descriptive patterns suggest that later-born children are considerably less likely to receive immunisation.

Econometric analysis

Table 4 presents the average marginal effects of the logistic regression specified in equation (1). Two model specifications are presented. Model (1) includes the number of children and other child-specific and household-specific covariates. Model (2) adds birth order dummy variables to study how the coefficients of number of children change after controlling for birth order. Model (2) yields full model specification given in equation (1).

Model (1) shows that children in families with two children are 4.5 percentage points more likely to be fully immunized than those in families with one child, and children in families with three children are 2 percentage points more likely to be fully immunized than those in families with one child. However, families with four children are 1 percentage point less likely to be fully immunized, and families with five or more children are 6.7 percentage points less likely to be fully immunized than families with one child. This shows the heterogeneous effect of the number of children on immunisation. Model (2) shows that, after controlling for birth order, large family size appears to increase children's full immunisation. Compared with children in families with one child, those in families with two children are 11 percentage points more likely to be immunised, and those in families with 5 or more children are 17 percentage points more likely to be immunised.

The coefficients for birth order are large and negative, suggesting negative birth-order effects. Compared with first-born children, second-born children are about 12 percentage points less likely to be fully iimmunized, while fifth-born children are nearly 29 percentage points less likely. This shows that later-born children are the most disadvantaged.

Moving to other covariates, coefficient for female children is statistically insignificant, suggesting that child's gender does not affect probability of full immunisation.

Mother's covariates are consistent across both Model (1) and Model (2). According to Model (2), an increase of 1 year of mother's education increases the likelihood of being fully immunized by 0.5 percentage points. An increase in the mother's age by 1 year increases the likelihood of being fully immunized by 0.9 percentage points. Compared to unemployed mothers, children of working mothers are 4.4 percentage points more likely to be fully immunized.

The household characteristics are also consistent across both models. According to Model (2), compared to the poorest household, poorer households are 6 percentage points more likely to be fully immunized, whereas the richest households are 13 percentage points more likely to be fully immunized. Compared to families belonging to the Hindu religion, families belonging to the Muslim community are 7 percentage points less likely to be fully immunized, and households belonging to a religion other than Hindu or Muslim are 2.3 percentage points less likely to be fully immunized. Among socioeconomic groups, children from the Other Backwards Classes are 1.43 percentage points less likely to be fully immunized than children from the Upper Caste. Children residing in urban areas are 1 percentage point less likely to be enrolled than those residing in rural areas. This result contradicts expectations.

Robustness checks

Here, a robustness check is conducted to validate the relationship between full immunisation, the number of children and birth order. The objective is to check whether the relationship among the variables is not spurious. A household fixed effects model is used to re-estimate equation (1) to account for observed and unobserved household characteristics that may affect child immunisation. Model (1) includes dummy variables for the number of children and other child- and household-specific covariates. Model (2) adds birth order dummy variables and gives the full model specification of equation (1). Table 5 presents the estimates from the household fixed-effect model. The estimates show that after controlling for birth order, a positive effect of the number of children and a negative effect of birth order is observed, consistent with our main findings. These results support the robustness of observed relationship between full immunisation, number of children, and birth order.

Table 1: Descriptive statistics.

Variables	Number of observations	Mean	SD
Fully immunized	257321	0.473	0.499
Never immunized	257321	0.128	0.334
Ever immunized	116129	0.816	0.387
Female	257321	0.48	0.5
Birth order	257321	2.287	1.492

Continued.

Variables	Number of observations	Mean	SD
Number of children	257321	2.402	1.362
Child age (in years)	247615	2.019	1.41
Mother's years of education	257321	6.152	5.13
Mother's age (in years)	257321	27.216	5.162
Mother currently working	257321	0.029	0.167
Poorest	257321	0.264	0.441
Poor	257321	0.236	0.425
Middle income	257321	0.199	0.4
Rich	257321	0.166	0.372
Richest	257321	0.134	0.341
Hindu	257321	0.722	0.448
Muslim	257321	0.158	0.365
Religion other than Hindu and Muslims	257321	0.12	0.325
SC/ST	257321	0.39	0.488
OBC	257321	0.392	0.488
Upper caste	257321	0.174	0.379
Urban	257321	0.237	0.425

Table 2: Mean number of children aged 12-23 months who received vaccines according to Number of children, gender, and birth order.

Variables	BCG	DPT1	Polio1	DPT2	Polio2	DPT3	Polio3	Measles
Total	0.847	0.799	0.814	0.745	0.751	0.666	0.612	0.651
	(0.360)	(0.400)	(0.389)	(0.436)	(0.433)	(0.472)	(0.487)	(0.477)
One child	0.862	0.808	0.815	0.749	0.748	0.672	0.622	0.616
	(0.345)	(0.394)	(0.388)	(0.434)	(0.434)	(0.470)	(0.485)	(0.486)
Two children	0.875	0.834	0.843	0.786	0.785	0.711	0.645	0.701
	(0.330)	(0.372)	(0.364)	(0.410)	(0.411)	(0.453)	(0.479)	(0.458)
Three children	0.840	0.795	0.811	0.742	0.747	0.657	0.599	0.664
	(0.367)	(0.404)	(0.392)	(0.438)	(0.435)	(0.475)	(0.490)	(0.472)
Four children	0.800	0.751	0.777	0.691	0.710	0.603	0.561	0.616
	(0.400)	(0.433)	(0.416)	(0.462)	(0.454)	(0.489)	(0.496)	(0.486)
Five and more children	0.723	0.666	0.715	0.606	0.645	0.515	0.506	0.540
	(0.447)	(0.472)	(0.451)	(0.489)	(0.478)	(0.500)	(0.500)	(0.498)
First born	0.884	0.839	0.845	0.788	0.785	0.715	0.650	0.690
	(0.320)	(0.367)	(0.362)	(0.409)	(0.411)	(0.451)	(0.477)	(0.462)
Second born	0.865	0.820	0.831	0.767	0.769	0.687	0.627	0.671
	(0.342)	(0.384)	(0.375)	(0.422)	(0.421)	(0.464)	(0.484)	(0.470)
Third born	0.827	0.777	0.794	0.721	0.728	0.635	0.584	0.629
	(0.378)	(0.416)	(0.405)	(0.449)	(0.445)	(0.481)	(0.493)	(0.483)
Fourth born	0.784	0.734	0.759	0.674	0.692	0.584	0.548	0.588
	(0.411)	(0.442)	(0.427)	(0.469)	(0.462)	(0.493)	(0.498)	(0.492)
Fifth and above born	0.711	0.654	0.702	0.591	0.631	0.503	0.500	0.515
	(0.453)	(0.476)	(0.458)	(0.492)	(0.483)	(0.500)	(0.500)	(0.500)
Male	0.847	0.801	0.814	0.747	0.751	0.667	0.612	0.652
	(0.360)	(0.400)	(0.389)	(0.435)	(0.432)	(0.471)	(0.487)	(0.476)
Female	0.846	0.798	0.813	0.744	0.750	0.664	0.611	0.651
	(0.361)	(0.401)	(0.390)	(0.436)	(0.433)	(0.472)	(0.487)	(0.477)

Table 3: Mean number of children who are immunised or not, according to no. of children, gender and birth order.

Variables	Fully immunized	Ever immunized	Never immunized
All	0.473	0.816	0.128
	(0.499)	(0.387)	(0.334)
One child	0.476	0.833	0.119
	(0.499)	(0.373)	(0.324)
Two children	0.515	0.844	0.104
	(0.500)	(0.363)	(0.305)
Three children	0.461	0.818	0.132

Continued.

Variables	Fully immunized	Ever immunized	Never immunized
	(0.498)	(0.386)	(0.338)
Four children	0.413	0.783	0.164
	(0.492)	(0.412)	(0.370)
Five and more children	0.352	0.726	0.224
	(0.478)	(0.446)	(0.417)
First-born	0.519	0.840	0.096
	(0.500)	(0.366)	(0.295)
Second-born	0.488	0.833	0.113
	(0.500)	(0.373)	(0.317)
Third-born	0.441	0.812	0.144
	(0.496)	(0.391)	(0.352)
Fourth-born	0.398	0.781	0.181
	(0.490)	(0.414)	(0.385)
Five and above born	0.343	0.737	0.239
	(0.475)	(0.440)	(0.427)
Male	0.473	0.819	0.128
	(0.499)	(0.385)	(0.334)
Female	0.473	0.813	0.128
	(0.499)	(0.390)	(0.334)

Table 4: Average marginal effects of family size as well as the birth order on the full immunisation among the children.

Variables	Model (1)	Model (2)
Two children	0.045***	0.111***
	(0.003)	(0.003)
Three children	0.020***	0.153***
	(0.003)	(0.004)
Four children	-0.010*	0.177***
	(0.005)	(0.006)
Five or more children	-0.067***	0.167***
	(0.005)	(0.008)
Second born		-0.116***
		(0.003)
Third born		-0.183***
		(0.004)
Fourth born		-0.233***
		(0.005)
Fifth or above born		-0.286***
		(0.007)
Female	0.002	-0.002
	(0.002)	(0.002)
Mother's years of education	0.006***	0.005***
	(0.000)	(0.000)
Mother's age (in years)	0.006***	0.009***
	(0.000)	(0.000)
Mother currently working	0.040***	0.044***
	(0.006)	(0.006)
Poorer	0.060***	0.060***
	(0.003)	(0.003)
Middle income	0.100***	0.098***
	(0.004)	(0.004)
Rich	0.115***	0.113***
	(0.004)	(0.004)
Richest	0.131***	0.128***
	(0.005)	(0.005)
Muslim	-0.068***	-0.068***

Continued.

Variables	Model (1)	Model (2)
	(0.003)	(0.003)
Religion other than Hindu and Muslim	-0.021***	-0.023***
	(0.005)	(0.005)
SC/ST	-0.003	-0.002
	(0.003)	(0.003)
OBC	0.013***	0.013***
	(0.003)	(0.003)
Urban	-0.010***	-0.010***
	(0.003)	(0.003)
Observations	257321	257321
Pseudo R^2	0.047	0.054

Standard errors in parentheses, *p<0.05, **p<0.01, ***p<0.001.

Table 5: Household fixed effects estimate of family size and birth order on full immunisation among children.

Variables	Model (1)	Model (2)
Two children	0.067*** (0.009)	0.153*** (0.010)
Three children	0.059*** (0.013)	0.232*** (0.014)
Four children	0.032 (0.021)	0.278*** (0.022)
Five or more children	0.007 (0.027)	0.307*** (0.028)
Second-born		-0.137*** (0.003)
Third-born		-0.227*** (0.005)
Fourth-born		-0.299*** (0.007)
Fifth-or-above		-0.378*** (0.010)
Female	0.019*** (0.003)	0.007* (0.003)
Mother's years of education	0.001 (0.001)	-0.000 (0.001)
Mother's age (in years)	0.007*** (0.001)	0.011*** (0.001)
Mother currently working	0.142*** (0.033)	0.145*** (0.033)
Constant	0.243*** (0.041)	0.167*** (0.041)
Observations	257321	257321
R^2 Overall	0.0026	0.012

Standard errors in parentheses * p<0.05, **p<0.01, ***p<0.001

DISCUSSION

The findings from the empirical analysis are summarised as follows. The logistic regression estimates indicate a positive association between the number of children and full immunisation, after controlling for the child's birth order. This suggests that negative effects observed in large families in descriptive analysis may partly reflect birth order rather than large-family effects. The positive effect of the number of children contradicts Becker's quantity-quality trade-off theory, which predicts that an increase in the number of children reduces investment in children.[4] It is also inconsistent with previous studies in India that document the negative effects of the number of children on educational outcomes.[5] One possible explanation is that children's immunisation in India is largely provided free of cost by public health programmes. The main constraints associated with immunisation include transport costs, awareness and familiarity with immunisation and other public health services. These costs may decline as parents gain experience with successive children, resulting in a positive effect of the number of children.

Another key finding of the study is the strong negative association between birth order and full immunisation. Firstborn children are consistently more likely to receive full immunisation than later-born children, and the magnitude of the negative effect increases with higher birth order. The negative effects of birth order on full immunisation are consistent with the findings of the previous study in India.[18-20] The robustness checks based on the household fixed-effects model support the main findings of the logistic regression model. This suggests that the results are unlikely to be driven by unobserved household-level factors.

Among other variables, mothers' years of education are associated with higher immunisation coverage, indicating the importance of mothers' education in achieving it. Mother's age is positively associated with full immunisation, suggesting that older mothers are more likely to ensure their children are fully immunised, possibly due to greater experience and maturity. Children of working mothers are more likely to be fully iimmunized. This may reflect that greater maternal financial independence improves full immunisation.

The analysis, however, is not without limitations. First, since NFHS collects immunisation information only for births in the five years preceding the survey, immunisation information for all children born to the mother is not available. Therefore, the findings may not reflect immunisation for all children born to the mother, potentially leading to sample selection bias. Second, although the analysis controls for a wide range of covariates, including child, maternal, and household characteristics, attitudes towards vaccination and accessibility of public healthcare services may still influence the results.

CONCLUSION

In conclusion, this study highlights the importance of the number of children and birth order in explaining child immunisation outcomes in India. The empirical findings reveal positive effects of the number of children and negative effects of birth order on full immunisation. The magnitude of the negative birth order effects increases with higher birth order, suggesting that later-born children are at a disadvantage in immunisation. Along with the key explanatory variables, maternal age, education and employment status positively affect children's immunisation. This may reflect the importance of mothers' education, experience and financial independence in child immunisation coverage. These findings have important policy implications and suggest the need for public health policies that focus on the vulnerable families and the most vulnerable children within families, particularly later-born children, to ensure equitable access to immunisation services in India.

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