Mother's Education, Learning-by-Doing, and Child Health Care in Rural India

By

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ABSTRACT

This study analyzes the determinants of the use of prenatal care and child immunization in rural India relying primarily on the 1993/94 National Family Health Survey. The key question addressed is whether learning-by-doing is an important feature of the health care system. More specifically, are women who use prenatal care *as a result* more likely to immunize their children? We conclude that important unobserved traits influence the utilization of both prenatal and immunization services. Once these are controlled, learning-by-doing is important for educated women, but not for uneducated women. There are two possible interpretations of this finding. One is that a lack of education limits the ability of women to effectively learn from the prenatal experience. The other is failings of the health care system limits its effectiveness with uneducated women. We also find strong evidence of gender bias in the demand for immunization services particularly among uneducated women. In addition, the analysis provides estimates of the effects on prenatal care and immunization of formal education, media exposure, economic status, family composition, access to services, and other variables.

Key words: mother's education, learning-by-doing, child health-care

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1. Introduction

Research on health in many contexts demonstrates that education improves both health-seeking behavior and health outcomes (Caldwell, 1979; Rosenzweig and Schultz, 1982; Streatfield et. al.; 1990; Barrera, 1990; Pebley et. al, 1996; Gokhale et. al.; 2002). An important benefit of raising literacy and school enrollment, particularly for girls, is the subsequent spillover to the health of their children. General education is important because it often enhances the ability to process and evaluate information – to engage in critical thinking. Health-seeking behavior may also be influenced by more targeted education. Governments and NGOs undertake media campaigns to influence or to educate the public about the benefits of a particular course of action. A third form of education, one that is emphasized in this research, is learning-by-doing. Participation in a program or a system yields information to the participant that influences subsequent assessments about the benefits and costs of further participation. The power of learning-by-doing is evident to anyone who has experienced rude service at a restaurant or a semester of boring lectures.

Learning-by-doing is important because health care systems are complex and provide a service that is not easily evaluated by the consumer. The importance is compounded in poor, rural areas of developing countries where adults have limited exposure to health care systems. Moreover, if health care consumers in rich industrial countries are dis-satisfied with one provider, other providers are available. But in poor rural areas, the options may be limited to a single rural health center, a traditional healer, or foregoing treatment altogether. Thus, subsequent participation in the system may be greatly influenced by the earlier experience. There are a variety of aspects of the learning-by-doing. Participants may learn about the value of modern health services, in general, or about the value of specific services, e.g., child immunization. They may learn about how the health system operates, thereby reducing the costs of accessing the system. They may learn – for better or for worse – about the quality of services.

It is important to understand learning-by-doing. If early participation has a large effect on subsequent participation, “recruitment” strategies would be quite different than if utilization is independent from one period to the next. If the spillover effects are large, encouraging earlier participation by using policy levers, e.g., subsidies, will lead to a more efficient resource allocation. If utilization appears to be independent from one period to the next or if subsequent utilization is adversely affected by earlier participation, then identifying barriers or failures in the system is important to achieving a more effective and efficient health care system.

The health-seeking behavior considered in this paper is the demand for prenatal and postnatal care. More specifically, we investigate the effect of prenatal care on the subsequent demand for immunization services. Women who seek prenatal care are much more likely to immunize their children. By itself, however, this does not confirm the importance of learning-by-doing. One reason is that a variety of other factors influence both the likelihood that women will seek prenatal care and that they will immunize her children. The analysis presented below shows that a variety of factors – education, media exposure, income, wealth, access to care, family composition, religion and caste – influence both the use of prenatal care and immunization services.

A more difficult issue to address, however, is the influence of unobserved traits of women – tastes, attitudes, other unmeasured factors – that pre-condition their use of health services. If we fail to account for this possibility, the “effect” of prenatal care on immunization confounds learning-by-doing and tastes. The model and estimation techniques adopted in this paper accounts for the underlying selection which would otherwise bias the results. The analysis and methodology builds on earlier research that has investigated mother's selection in seeking her prenatal health care behavior (Panis and Lillard, 1994; Rosenzweig and Schultz, 1991; Rosenzweig and Wolpin, 1988), but the learning-by-doing effect of prenatal care has not been examined as far as we know.

A mother's choice to immunize her child may also be conditioned by birth outcomes, e.g., the sex or the health of the newborn child. Son preference is strong in some subpopulations in the world which may lead to different treatment of sons and daughters. A child's sex, however, does not play a role in demand for prenatal care as measured in this study. Prenatal care is measured as a single prenatal visit. Thus, the child's sex is unknown to the mother at this point in the health care decision process. Testing behavioral change before and after the first prenatal visit provides natural experiment to test the gender discrimination hypothesis.

In similar fashion, we can test whether health complications for the child lead to compensatory behavior by mothers (more immunization for children with complications) or leads mothers to reduce investment in children who face higher mortality risks.

This study uses the 1992-93 National Family Health Survey (NFHS) in rural India. In India, the immunization of children against six fatal but preventable diseases (tuberculosis, diphtheria, whooping cough (pertussis), tetanus, polio, and measles) has been an important cornerstone of the child health-care system since it was first introduction to the country in 1978 (WHO, 1986).[1] The 1992-93 survey data contains detailed histories of a child's immunization

[1] As part of the National Health Policy, the Expanded Programme on Immunization (EPI) was introduced in 1978 with the objective of providing free vaccination services to all eligible children and expectant mothers. In order to step up the pace of immunization, the Universal Immunization Programme (UIP) was introduced in 1985-86 and is

as well as considerable information on socioeconomic, demographic and community measures. This study uses this information to estimate a child's health demand function focusing on children born in the period 12-48 months before the survey. In order to construct a variable measuring household expenditure, the 1993 (50^{th} round) National Sample Survey (NSS) in India is also used. The log of per capita household expenditure is projected based on household head's occupation, education, age, and residence using the NSS and merged into the NFHS.

The analysis supports the following conclusions. First, important unobserved traits influence the utilization of prenatal and immunization services. Failing to account for these traits leads to erroneous conclusions about the causal connection between prenatal care and immunization. Second, learning-by-doing is important for educated women. Those who sought prenatal care were much more likely to immunize their children after controlling for both their observed and unobserved characteristics. Third, we find no compelling evidence for learning-by-doing among uneducated women. There are two possible interpretations of this finding. One is that their lack of education limits their ability to effectively learn from the prenatal experience. The other is that there are features of the health care system that limits its effectiveness with uneducated women. These explanations are not mutually exclusive. Fourth, we find strong evidence of gender bias in the demand for immunization services particularly among uneducated women. In addition, the analysis provides estimates of the effects on prenatal care and immunization of formal education, media exposure, economic status, family composition, access to services, and other variables.

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being implemented through the existing network of the primary health-care system, including Primary Health Centres (PHCs), sub-centres and referral centres called Community Health Centres. See WHO (1986) for details.

The paper is organized as follows. In the next section, a household healthcare demand model is presented. Data and variable selection are discussed in section 3. Section 4 reports estimated results. Section 5 summarizes the study.

2. Model

The model considers two forms of health-seeking behavior of mothers: prenatal care and postnatal care. The outcomes are viewed as inputs into the production of child health following in the tradition of the Becker (1965) model. The household demand functions for inputs T^1 and T_k^2 can be written as

$$T^1 = \Psi^1(p, M, z, \eta^1, \nu)$$

$$T_k^2 = \Psi^2(p, M, T^1, z, \varepsilon_k, \eta^2, \xi) \qquad k = 0, 1, \ldots\ldots, \text{t}.$$

where T^1 represents prenatal care, T_k^2 is a vector of postnatal care over the child's history from birth (k=0) to current age (k=t), p is a vector of prices, M is household income, z represents other household and community characteristics that affect the demand for inputs including the education of the mother, $\eta^1$and η^2 represent unobserved characteristics of the mother, and ν and ξ are disturbance terms. The term ε_k represents a history of shocks – a vector of stochastic components of the child's health. Of particular importance in the analysis presented below are shocks at birth or during a prenatal visit (ε_0). The confounding relationships between the demand for pre-natal and the demand for post-natal care can be summarized as $Cov(\eta^1, \varepsilon_k) = 0$, $Cov(\eta^2, \eta^1) \neq 0$, and $Cov(\eta^2, \varepsilon_k) \neq 0$. Each relationship is discussed in turn.

By definition the vector of postnatal ε is unforeseen by mothers at the time of birth or during a prenatal visit. Hence, it follows that $Cov(\eta^1, \varepsilon_k) = 0$.

Second, mothers may have unobserved characteristics that pre-dispose them to seeking health care for their children ($Cov(\eta^2, \eta^1) \neq 0$). Several medical studies have shown that attitudes and beliefs influence the demand for immunization, for example.[2] Thus, mothers who seek prenatal care will be more likely to seek postnatal care, in part, because the use of prenatal care captures unmeasured characteristics of the mother. Analysis that fails to incorporate this confounding effect will bias estimates of the causal effect of prenatal on postnatal care.

Third, mother's choice of postnatal care, e.g., child immunization, may be conditioned on birth outcomes (ε_0) and other shocks experienced by her child (ε_1,..,ε_t), i.e. $Cov(\eta^2, \varepsilon_k) \neq 0$. These shocks may lead mothers to reassess the value they place on the child, thereby, influencing investments in the child's health. If the child experiences health shocks mothers may make compensating investments in the child's health. For example, mothers may choose to immunize children whose health status places them at greater risk. Ignoring this selection might overstate the role of prenatal care in increasing access to vaccination.

This study employs the following estimation strategy. Two demand equations are estimated: the demand for prenatal care and the demand for postnatal care. The demand for prenatal care is modeled as a binary choice model, only distinguishing children who have received any prenatal care from those who received no prenatal care.

The demand for prenatal care is described as

$$T^1 = Z_1\delta_1 + \eta^1 + \nu$$

where Z_1 is a set of variables which include M and z , but not ε_k. The likelihood for each child is then:

[2] See Strobino et. al. (1996) for a review.

$$L^1(\eta^1) = \begin{cases} \Phi(\delta_1 Z_1 + \eta^1) & \text{if prenatal care was ever used} \\ 1 - \Phi(\delta_1 Z_1 + \eta^1) & \text{if prenatal care was not used} \end{cases}$$

where $\Phi(.)$ is cumulative normal density function.

Postnatal care is measured by the child's immunization status, distinguishing children who are fully immunized, partially immunized, or not immunized at all. Children who have received BCG vaccine, measles vaccine, three doses of DPT vaccine, and three doses of polio vaccine (not counting polio 0) are considered *fully immunized*. Children who have had one or more vaccinations but are not fully immunized are defined as *partially immunized*. We limit the sample to children aged 12-48 months because full immunization is recommended for all children by age one and data are collected for all children born in the 12-48 month period preceding the survey.[3,4]

Let the underlying response model be described as

$$T_k^2 = \gamma_1 T^1 + Z_2 \delta_2 + \eta^2 + \xi$$

where Z_2 includes *M*, *z*, and ε_k . The immunization choice is conditioned on the choice of prenatal care, capturing any "learning by doing" effect. T_k^2 equals zero if the child is not immunized at all, one if the child is partially immunized, and two if the child is fully immunized. It belongs to the *j*th category if:

$$\mu_{m-1} < T_k^2 < \mu_m \quad (m = 1, 2)$$

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[3] According to the WHO guidelines, the recommended immunization schedule is: BCG (against tuberculosis) at birth; three doses of DPT (diphtheria, pertussis, tetanus) vaccine and three doses of oral polio vaccine at 6, 10, and 14 weeks; and measles immunization at 9 months. The NFHS shows that almost every children who are vaccinated met this criteria.

[4] The usual truncation problem arises whenever the input is defined to depend on the duration of life or it is dependent on the achievement of a given age. For example, immunizations given after some age is reached would be truncated by death prior to the immunization age thus be spuriously related to life expectancy. However, this is unlikely a problem here since the data is restricted to the children born in the period 12-48 months before the survey, and almost every child vaccinated met the criteria by WHO.

where μs are unknown parameters to be estimated. Because T_k^2 is ordinal, we can normalize the transitory residual, $\xi \sim N(0,1)$, and assume that $\eta^2 \sim N(0,\sigma^2_{\eta^2})$. The likelihood for each child is:

$$L^2(\eta^2) = \begin{cases} \Phi(\mu_1 - \gamma_1 T^1 - Z_2\delta_2 - \eta^2) & \text{if not immunized at all,} \\ \Phi(\mu_2 - \gamma_1 T^1 - Z_2\delta_2 - \eta^2) - \Phi(\mu_1 - \gamma_1 T^1 - Z_2\delta_2 - \eta^2) & \text{if partially immunized,} \\ 1 - \Phi(\mu_2 - \gamma_1 T^1 - Z_2\delta_2 - \eta^2) & \text{if fully immunized.} \end{cases}$$

There is an issue of how Z_2 incorporates ε_k because our theory suggests that mother's demand for immunization is likely to be correlated with birth outcomes. Of particular interest is the child's sex because of the extensive evidence of the effects of gender on abortion, health care, and infant and child mortality (Arnold et. al.1998, 2002; Retherford and Roy, 2003; Pande, 2003; Sudha and Rajan, 1999). When the gender outcome is revealed, at birth or during a prenatal visit, parents may differ in their treatment of sons and daughters. We handle the issue by estimating separate regressions for boys and girls. The theory also suggests that mother's demand for immunization is likely to be correlated with heterogeneity in the other inherent qualities of children born within a family. Although this is potentially an important issue, little evidence exists with regard to how health inputs are allocated across family members as a function of their endowments. Rosenzweight and Wolpin explore this issue for prenatal inputs for prior-born children as instruments for the difference in prenatal inputs between the later- and prior-born children (Rosenzweig and Wolpin, 1988). However, this lagged instrument method may not be suited to the analysis of immunizations, because, unlike prenatal input, qualities of children are known by parents when family decisions about postnatal inputs are made. Furthermore, instrumental variable estimators can be fragile and perform poorly in practice. Therefore, we use a proxy variable, indicator for difficulties in delivery, to capture the effect of children's different health quality on the demand for immunization. We estimate our model first without the variable and then with it to test the robustness of our results. This variable is treated as exogenous in our analysis in order to avoid additional complications to the model.

The two equations, prenatal care and immunization, are estimated simultaneously. The joint marginal likelihood is given by:

$$\int_{\eta^1}\int_{\eta^2} f(\eta^1,\eta^2)\prod L^1(\eta^1)\prod L^2(\eta^2)\,d\eta^1 d\eta^2$$

where $f(\eta^1,\eta^2)$ denotes the two dimensional normal density function. In order to exploit efficiencies, both specification models are estimated jointly based on a Full Information Maximum Likelihood (FIML) method.[5]

3. Data and Variables

The 1992-1993 National Family Health Survey (NFHS) of India gathered information on a representative sample of 89,777 ever-married women aged 13-49 residing in 88,562 households. The survey also collected information on children born to interviewed women in the four years preceding the survey. An advantage of the NFHS is that the data set includes health information for children who died. Several researches have examined the determinants of immunization coverage using surviving children because no immunization information was obtained for children who died (e.g. Pebley et. al., 1996). The restriction of immunization

[5] FIML estimates will be inconsistent if any equation in the model is misspecified. Nonetheless, it is occasionally useful to obtain maximum likelihood estimates directly because, with normally distributed disturbance, FIML is efficient among all estimators. Since asymptotic comparisons are unambiguous, the remaining considerations are based primarily on small-sample behavior. Unfortunately, there are few usable general results. In practice, 2SLS and 3SLS are used more often than FIML because of their simplicity. See Greene (2002 pp.407-411) about this issue.

estimates to living children probably has resulted in overestimates of immunization coverage, which is not a problem of using the NFHS data set. The analysis focuses on children in rural India born 12-48 months preceding the survey. The total number of children belonging to this group is 24,033, among whom 505 died. The maximum number of children from the same mother is three.

Three types of questionnaires were used in the NFHS–one for ever-married women living in households, one for households, and one for villages. For our analysis, selected variables from the household questionnaire and the village questionnaire were merged into the individual data file for women of childbearing age. The child data file used in this paper was then created from the augmented individual women data file. Thus, the record for each child includes selected characteristics of the child, the child's mother, the child's father, the mother's household, and the mother's village. The sample design for some states is self-weighting, but in other states certain sectors of the population are over-sampled. It is therefore necessary to use weights to restore the correct proportions. All estimates in this paper make use of national level weights. Details of the sample design are described in the report for the NFHS of India (IIPS, 1995).

Table 1 lists the variables, their definitions and their mean. The information on immunization coverage is derived both from vaccination cards, when the mother has one, and from the mother's memory, when she cannot show a card.[6] Each mother was asked whether she had a vaccination card for each child born since January 1988. If a card was available, the

[6] The information based on mother's memory does not provide the date of vaccination and it might have higher percentage of children who did not meet the criteria recommended by WHO. However, Goldman and Pebley (1994) demonstrate that inclusion of maternal recall data improves the accuracy of estimates of immunization coverage even though it is subject to recall error.

interviewer copied the date for each vaccination. If the mother could not produce a vaccination card, she was asked whether the child had received any vaccinations. If any vaccination had been received, the mother was then asked whether the child had received one or more vaccinations against each of the six fatal diseases. For DPT and polio, information was obtained on the number of injections or oral doses given.

<Table 1 about here>

Prenatal care is measured by whether a mother received a prenatal check-up from a doctor or a health care worker in a health facility. We use mother's prenatal check-up at any time during her pregnancy as our measure. This variable is used as a dependent variable in the model for prenatal care. Then, it is used as an explanatory variable in the immunization coverage model.

Three forms of education are distinguished. The first is learning-by-doing. Children who received prenatal care have mothers who, in most cases, have been exposed to the particular health care system which also provides postnatal care including immunizations. The second form of education consists of public efforts or media campaigns which provide specific information about the importance of immunization programs and the availability of services. The effect of this form of education is captured by including a dummy variable that is equal to one if a child's mother reports that she watches television or listens to the radio at least once a week or visits a cinema at least once a month. The third form of education is general education, which may provide mothers increased specific knowledge about health issues and may also provide them with the ability to access and to use information that is available. This form of education is measured by two dummy variables (literate but less than middle school complete, middle school complete or higher).

The NFHS data set does not contain information on household income. This study uses the 1993 (50th round) National Sample Survey (NSS) of India to predict per capita household expenditure for NFHS respondents based on state of residence (24 State dummy variables) and characteristics of the father: his occupation (7 categories), his education (8 categories), his age, and his age squared.[7] Only father's characteristics are included in the estimation, because the mother's labor is assumed to be endogenous in child health investment decisions. Per capita expenditure is used as a measure of long-run income because it is a good proxy for permanent income.[8] In addition to per capita expenditure, three other dummy variables (living in a good quality house, using electricity as the main source of lighting, and the availability of safe drinking water) are included as controls to proxy for the household standard of living.

Health care costs are difficult to measure and often do not vary markedly across mothers in most of the environments from which survey data are derived. Reduced-form estimates of the effects of variation in prices on measures of human capital investments are thus absent from most previous literature. To proxy for the cost of access to general health-care facilities, availability of a health-care facility in the village as well as an all-weather road connecting the village to the outside are included in all reduced form demand equations. There are several types of health-care facilities in India. We include a measure of the availability of the following kinds of facilities in the mother's village: Primary Health Centre, sub-centre, government hospital, private hospital, dispensary/clinic, or NGO family planning/health clinic.

[7] See Department of Statistics (1993) for detailed information on the NSS.

[8] The NSS does not contain reliable information on income. See Strauss and Thomas (1995) for pros and cons of using different measures of income. Also see Deaton (1997) for the difficulties of measuring income as well as consumption in developing countries. Because we are predicting the per capita expenditure using a different data set, the estimated coefficients of per capita expenditure may not be efficient.

Two measures of the child's sibling composition – the number of older brothers and the number of older sisters – are included. Health investments by parents may be influenced because siblings compete for resources and because they influence the value attached to new born children. Outcomes may depend on both the number and gender of older siblings as previous studies imply (Vinod et. al. 2004; Pande, 2003). Other variables such as religion of household head (Muslim or others) and caste/tribe of household head (scheduled caste/tribe[9] or others) are also included to control for cultural variation in prenatal and postnatal health-seeking behavior.

Immunization coverage is much higher for children of mothers who have received prenatal care (Table 2). Forty-eight percent of children whose mothers received prenatal care are fully vaccinated, compared with 19 percent of children whose mothers did not receive prenatal care. The proportion of children who are fully vaccinated increases from one-fourth for children of illiterate mothers to two-thirds for children of mothers with at least a middle school education. Children of higher birth order tend to have lower vaccination rates. Coverage is also higher for boys than for girls. Thirty-two percent of boys are fully vaccinated, compared with 29 percent of girls. Hindu children are more likely to be vaccinated than are Muslim children.

<Table 2 about here>

4. Estimation Results

Discussion of the empirical results is organized as follows. First the effects of controlling for selectivity in estimating the immunization model are addressed. Second, the immunization

[9] Scheduled castes and tribes are those castes and tribes identified by the Government of India as socially and

results with education groups pooled are presented and discussed. As will be seen, additional insights about the role of formal education emerge when the immunization model is estimated separately for mothers who are educated and those who are not. In the final section, the estimates of the demand for prenatal care are briefly discussed.

From Table 2 we know that women who seek prenatal care for their children are also much more likely to immunize them. In part, this statistical association may reflect observed differences between women or their children that can be readily controlled. For example, educated women are both more likely to seek prenatal care and to immunize their children. In part, women who are exposed to prenatal care may learn about the importance of immunization to the health of their child. They may develop a trusting relationship with health care providers. They may acquire more general knowledge about the health care system. We group these effects into "learning-by-doing" and they are emphasized because of their policy significance. If the learning-by-doing effect is large and positive it indicates that prenatal care has important subsidiary benefits because it draws women into the health care system to the benefit of their children. Of course, the learning-by-doing effect is not always positive. An experience can be negative and exposure to a low-quality health care system may lead women to avoid it in the future.

Estimating the learning-by-doing effect is difficult, because of the presence of unobserved characteristics of women that influence both the likelihood that they will seek prenatal care and the likelihood that they will immunize their children. There are countless examples. Women may have previous experiences which make them favorable to or leery of the health care system. They may have attitudes that were passed on by their parents or their

economically disadvantaged and in need of protection from social justice and exploitation.

husbands. If these unobserved factors account for the observed correlation between prenatal care and immunization, then increased access to prenatal care would not lead to increased immunization of children.

In statistical terms, failing to control for the selectivity effects will lead to biased estimates of the learning by doing effect (γ_1). The sign and magnitude of the bias are, in general, indeterminate without knowledge of how all variables respond to these unobservable traits. However, if we consider a simple model in which only prenatal care influences immunization, the probability limit of the estimated coefficient of prenatal care obtained when selectivity is not controlled is:

$$p\lim(\hat{\gamma}_1) = \gamma_1 + \frac{Cov(\eta^1, \eta^2)}{Var(T^1)}$$

Thus ignoring the selectivity leads to an overestimate of the true learning-by-doing effect if the covariance between the unobserved predispositions towards prenatal care and immunization is positive.

Table 3 presents estimates of the selection structure which are correlation coefficients for the unobserved characteristics of the mother for prenatal care and immunization. The models are estimated separately for boys and girls. The first row presents results for the analysis that pools women at all educational levels, while the second and third rows are results obtained by estimating separate models for educated and uneducated women.

<Table 3 about here>

The pooled estimates in the first row show strong evidence of positive selection. Apparently, women who are predisposed toward prenatal care are predisposed to immunize their children. The effect is much stronger for daughters (0.4358) than for sons (0.1182).

When we estimate the models separately for educated and uneducated mothers, however, it is quite clear that the effect of unobservable traits is confined entirely to uneducated mothers. For educated mothers the correlation coefficient is quite small for both sons (-0.0979) and daughters (0.0499) and it is only significant for boys. However, even the sign and significance for sons is not robust at all. A slight modification of specification, such as dropping a measure of household economic status, changes the sign and makes the estimated coefficient insignificant.

For uneducated mothers, however, the effects of unobserved traits are quite strong particularly as they influence health care for daughters. The correlation coefficient for sons is 0.3630 and for daughters is 0.5684 and they are significant.

The importance of estimating and controlling for unobserved traits is apparent when we examine the immunization estimates and compare them to single equation estimates using the pooled sample (Table 4). Neglecting unobserved traits that predispose women to prenatal and immunization services leads to the erroneous conclusion that in all cases increased use of prenatal services leads to increased use of immunization. The single equation estimated effects are strong and statistically significant. By accounting for selection, we find that the learning-by-doing effect associated with prenatal care is indeed quite strong for sons. For daughters, however, we find no learning-by-doing effect. All of the statistical association between prenatal care and immunization for daughters is explained by other observed and unobserved correlates.

<Table 4 about here>

Failing to control for selectivity also influences the estimates of other coefficients in the immunization model. With few exceptions estimates from the single equation model are biased towards zero, i.e., the importance of other variables are underestimated and often by substantial amounts.

Simultaneous equation estimates support the important and fundamental role played by formal education in determining immunization use. The effects of formal education are very strong for both sons and daughters. Exposure to media also has a strong effect for both sons and daughters. A mother who watches television or listens to radio at least once a week is more likely to have her child vaccinated. Perhaps this measures economic status to the extent that it depends on access to the media, but it may also measure the effect of efforts to raise awareness and knowledge about health care, in general, and immunization, in particular.

More direct measures of economic status have significant effects on immunization coverage. Children from households with higher per capita expenditure are much more likely to be immunized as are children who are living in a good quality house. The effect of using electricity as a main source of lighting has also significant effects on immunization coverage.

As expected, the availability of clinics in local areas has a positive and significant effect on child's immunization, suggesting that accessibility of healthcare facilities may be effective in promoting vaccinations. Note, however, the estimates presented here assume that no correlation exists between the community variables and unobserved component in the outcome. Because immunization programs may be placed using criteria that are related to the outcomes being studied (i.e., non-random program placement) this condition is often violated. As a crude test, we estimate whether the distance to clinics is negatively related to the immunization rate by regressing the availability of clinic variable on the full immunization rate of the village. No statistical evidence of non-random program placement was found. A more carefully designed test of this potential problem is not pursued here.

The effect of gender on immunization is emphasized by our approach to the analysis. As already noted, the learning-by-doing effect depends on the sex of the child. The effects of other variables also vary depending on whether the child is a son or a daughter. Increase in mother's education leads to more equal treatment as does access to care. Economic status has a mixed effect with a higher quality house leading to more favorable treatment for daughters but higher per capita expenditure and clean water availability favoring sons. The differences between the effects for sons and daughters are modest as compared with the difference for prenatal care.

Analysis of household composition identifies another important way in which gender operates. Girls who have more brothers or sisters are less likely to be immunized. It does not appear to matter whether the older siblings are sisters or brothers. This effect is consistent with resource competition among siblings or perhaps a diminishing value of additional children born into high parity families (Pande 2003, Vinod et. al. 2004). Boys who have more (older) brothers are also less likely to be immunized. Having sisters, however, has no effect on whether boys are immunized. This suggests that boys do not compete with their sisters for resources. This result also supports the general notion of favored treatment for first-born children, especially first-born sons.

Several other variables are included in the model. Muslims and members of scheduled castes are less likely to be immunized. Age of mother at birth does not have an important effect on immunization.

Table 5 presents estimates of the immunization model separately for educated and uneducated women as measured by literacy. For the most part the effects of media exposure, economic status, accessibility to health care, and household composition are similar to those found in the pooled sample. However, the effect of prenatal care, i.e., learning-by-doing, is much greater for educated mothers than uneducated mothers. For educated mothers, the effect of prenatal care on immunization is somewhat larger for sons than for daughters, but irrespective of gender the effect is substantial. For illiterate mothers who bear a son, prenatal care does have a statistically significant positive effect. But for illiterate mothers who bear a daughter, the effect is significantly less than zero. This is consistent with the general notion that education provides a mother with skills in acquiring and decoding new information, and thus effectively lowers the cost of using more information about new health techniques. Thus the learning-by-doing effect is much greater for the educated mother because she is more likely to acquire information on how to produce good health for her children more efficiently. In contrast, the result shows that prenatal care is a much less effective tool for uneducated mothers. Thus, formal education and learning-by-doing are complementary and reinforcing in their effects on immunization.

<Table 5 about here>

Child characteristics other than their gender may also influence immunization. According to our model, a mother may make compensating investments in the child's health if the child experiences health shocks. Analysis here is confined to difficulties at delivery, treated as an exogenous variable. The coefficients are positive and statistically significant in the sample for all mothers (Table 6). When we estimate the models separately for educated and uneducated mothers, however, it is clear that the effect of selection is again confined to uneducated mothers. Uneducated mothers appear to engage in compensatory behavior seeking additional health care in the form of immunization for children exposed to adverse health shocks. Ignoring this selection overstates the effect of prenatal care in increasing access to vaccination.

<Table 6 about here>

Another interesting question that we have pursued with mixed success is whether these results vary across India's regions. India is a very diverse country and several previous studies conclude that the extent of gender discrimination in the provision of child healthcare varies by region. Vinod, Roy, and Retherford (2004), for example, found gender discrimination in immunization coverage only in the North. Our sample size proved to be insufficient to support further disaggregation. The FIML did not converge well for the South sample, although it did converge well for the North sample. In the North (results not shown in any table) the pivotal connection between formal education and learning-by-doing persists. The learning-by-doing effect is substantial and statistically significant for both the sons and daughters of educated mothers. For uneducated mothers, however, the learning-by-doing effect is statistically insignificant for sons and daughters. It is mother's education that triggers the learning-by-doing effect.

Regression results for prenatal care are reported in the Appendix. The results are similar to those found for immunization. Formal education, media exposure, economic status, and access to health care all have favorable effects on the use of prenatal services. There are two main differences from the immunization results, though. First, the number of older sisters does have a significant, negative effect on prenatal care for boys, as well as, girls. That the gender of

the child receiving care has no bearing reflects the dynamics of the behaviors in question. The sex of the child is unknown at the time of the first prenatal visit and, hence, can have no bearing on treatment at that point. The coefficient for older brothers is bigger (more negative) than the coefficient for older sisters suggesting that older brothers make greater demands on limited family resources or that a child of unknown sex is less valued by mothers who already have one or more surviving sons. Second, the effects of religion on prenatal care are different. Being Muslim has an insignificant or a positive effect on the likelihood of receiving prenatal care. That leads us to wonder whether selection and the learning-by-doing effect differ across religion. Although this is an interesting question, it is not pursued here.

5. Conclusion

Child immunization is widely believed to be “the most cost-effective route to child’s better health” (WHO, 1998) and, thus, child immunization has become the major focus of child survival programs over the last two decades. Unfortunately, immunization coverage is still very low in many developing countries, a matter of considerable concern to their Government.

The ultimate objective of social science research on immunization is to identify barriers that limit the spread of immunization and policy levers that can be used to achieve near-universal coverage for children. Two important barriers stand out in our analysis of rural India. The first is education and the second is gender bias. These operate independency, but they also interact. Uneducated women are less likely to immunize their children and girls are less likely to be immunized than boys. Importantly it is less educated women, in particular, who are less likely to immunize their daughters. Thus, expanding educational opportunities for women appears to be an important means by which the health of children in India can be enhanced.

That improvements in education enhances health is widely known and has been demonstrated in many previous studies. The original contribution of this paper is to consider in some depth whether there are important spillovers, what we call learning-by-doing effects, from prenatal care to immunization programs. Women who participate in prenatal health care programs may receive counseling about the importance of immunization programs. They may develop confidence, in general, about the value of modern medicine. They may develop a familiarity with health care systems that increases the likelihood that they will rely on them again to the benefit of their children.

In order to address these issues, a household dynamic health demand model is estimated in which prenatal care enters as a variable affecting postnatal input. Careful attention is paid to the potential correlation between immunization status and prenatal care that arises because of tastes or because some women are just more predisposed to rely on health care systems than others. This is a critical issue in assessing whether successful efforts to expand prenatal care would yield additional dividends in the form of improved immunization coverage. Indeed the analysis shows that once we control for other determinants of immunization and once we control for unobserved traits of mothers, learning-by-doing is clearly important only for educated women. For illiterate women we find no evidence that expanding prenatal care would lead to higher rates of immunization for daughters. For sons we find a substantially diminished effect in the national analysis and no significant effect in Northern India.

These results reinforce and strengthen the conclusion that education programs are vital to improving prenatal care, immunization coverage, and ultimately child health. Traditional education programs are unfortunately a long-term solution. There are long lags between the time that girls enroll in primary school and begin to bear children. One intermediate solution is to focus on literacy training for older women as many countries have done. Another possible solution that deserves attention may be to improve the ways health care systems interact with illiterate women. The failure of illiterate women to learn about the importance of immunization for their children may be a correctible failure of the health care system.

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Table 1. Definitions and mean values of variables

	Definition (In case of dummy variable value 1 if the specified condition is met, 0 otherwise)	Mean (s.e.)
Full immunization	Child has received BCG, measles, and three doses of DPT and polio vaccines	0.306
Partial immunization	Child has had one or more of vaccines, but not fully immunized	0.326
Prenatal care	Mother received prenatal care regardless of the timing of trimester	0.417
Mother's education		
Literate, < middle	Mother is literate with less than middle school	0.155
≥ Middle complete	Mother is literate with middle school complete or higher education	0.109
Media exposure	Mother watches television or listens to radio at least once a week or visits a cinema at least once a month	0.384
Log of per capita household expenditure	Predicted based on husband's age, age squared, education (8), occupation (7), and residence (24) by using 1993 National Sample Survey of India	5.87 (0.245)
Type of house	Type of house is *pucca*, or *semi-pucca* (quality house)	0.381
Electricity	Child lives in a household that uses electricity as main source of lighting	0.376
Safe drinking water	Child lives in a household that uses piped/tap water, hand pump, tanker truck, or bottled water as the main source of drinking water	0.354
Health-care facility	Child lives in a village that has a Primary Health Centre, sub-centre, government hospital, private hospital, dispensary/clinic, or Non-Government Organization family planning/health clinic	0.661
All-weather road	Child lives in a village that is connected by an all-weather road	0.481
Sibling composition		
Number of old boys	Number of old male siblings	0.992
Number of old girls	Number of old female siblings	1.077
Muslim	Child lives in a household whose head is Muslim	0.131
Scheduled Caste/Tribe	Household head is scheduled Caste/tribe	0.256
Mother's age	Mother's age at childbirth and its squared	23.6 (5.74)
Complication at birth	Mother experienced complication at birth	0.102
Number of observation	Number of children age 12-48 months	24,033

Based on the weighted sample. The number of observation is not weighted.
Standard errors are in parentheses.

Table 2. Percentage of children vaccinated by vaccination type

Selected Variables	Percentage vaccinated					
	BCG	Polio 3	DPT 3	Measles	All[a]	None[b]
Total (percentage)	54.8	47.0	45.0	38.1	30.6	36.8
Prenatal care						
Yes	74.8	67.7	65.9	56.4	47.5	19.4
No	40.6	32.2	30.3	24.9	18.6	54.7
Mother's education						
Illiterate	46.9	38.4	36.4	30.1	23.0	44.4
Literate < Middle school complete	70.2	63.7	62.3	52.3	44.4	20.8
Middle school/above	86.1	81.0	79.3	71.3	62.4	7.9
Media exposure						
Yes	71.0	63.7	62.0	53.7	45.4	23.9
No	44.6	36.5	34.5	28.2	21.4	50.2
Heath-care facilities						
Yes	59.1	51.4	49.8	41.9	34.2	32.2
No	46.3	38.3	35.8	30.5	23.5	45.8
Child's sibling composition						
Have old male siblings	49.5	41.3	39.4	32.4	25.5	42.0
Have old female siblings	49.9	41.8	40.0	33.3	26.4	41.6
No older siblings	63.1	56.3	54.3	47.1	38.7	28.4
Child's sex						
Boy	57.1	49.0	47.0	39.9	31.9	33.9
Girl	52.3	44.9	43.0	36.1	29.3	39.8
Religion						
Hindu	56.9	49.0	47.2	39.9	32.2	34.8
Muslim	40.5	33.6	31.0	26.0	19.7	50.3
Scheduled Caste/Tribe						
Yes	49.1	39.3	38.0	32.6	25.0	42.5
No	56.7	49.0	47.5	39.9	32.5	34.8
Source of information						
Vaccination card	87.5	82.9	82.5	65.3	58.2	..
Mother's report	46.8	38.2	35.9	31.4	23.8	45.8

Based on the weighted sample.

a. Fully vaccinated.

b. No vaccination.

Table 3. Correlation coefficient between two selection terms

	Boys	Girls
1. All education level	0.1182 *** (0.0456)	0.4358 *** (0.0448)
2. Educated mothers	-0.0979 ** (0.0424)	0.0499 (0.0422)
3. Illiterate mothers	0.3630 *** (0.0574)	0.5684 *** (0.0490)

Standard errors are in parentheses
, * indicate significance from zero at 5 percent and 1 percent, respectively.

Table 4. Estimates of child immunization coverage model (all mothers)

	Boy		Girl	
	Single Equation	Selection Correction	Single Equation	Selection Correction
Prenatal Care	0.5954 ***	0.7544 ***	0.5550 ***	0.0298
	(0.0235)	(0.0998)	(0.0238)	(0.0962)
Literate	0.2293 ***	0.4414 ***	0.2519 ***	0.5742 ***
	(0.0308)	(0.0590)	(0.0311)	(0.0590)
≥ Middle	0.3808 ***	0.7144 ***	0.3914 ***	0.9111 ***
	(0.0415)	(0.0806)	(0.0433)	(0.0835)
Media Exposure	0.1897 ***	0.3479 ***	0.3079 ***	0.6012 ***
	(0.0237)	(0.0453)	(0.0238)	(0.0466)
Log(PCE)	0.2971 ***	0.5093 ***	0.2098 ***	0.4624 ***
	(0.0494)	(0.0904)	(0.0507)	(0.0911)
Good house	0.0659 ***	0.1405 ***	0.1188 ***	0.2479 ***
	(0.0238)	(0.0423)	(0.0241)	(0.0431)
Electricity	0.3811 ***	0.6672 ***	0.2876 ***	0.5380 ***
	(0.0241)	(0.0481)	(0.0243)	(0.0461)
Water	0.0914 ***	0.1368 ***	0.0069	0.0156
	(0.0225)	(0.0399)	(0.0234)	(0.0406)
Clinics	0.1625 ***	0.2872 ***	0.2349 ***	0.4744 ***
	(0.0229)	(0.0415)	(0.0240)	(0.0448)
Road	0.0160	0.0367	0.0419 *	0.1070 ***
	(0.0219)	(0.0392)	(0.0225)	(0.0400)
Old boys	-0.0838 ***	-0.1398 ***	-0.0561 ***	-0.1270 ***
	(0.0109)	(0.0195)	(0.0112)	(0.0202)
Old girls	-0.0134	-0.0235	-0.0607 ***	-0.1247 ***
	(0.0102)	(0.0179)	(0.0104)	(0.0183)
Muslim	-0.4197 ***	-0.7004 ***	-0.3748 ***	-0.6490 ***
	(0.0317)	(0.0594)	(0.0335)	(0.0611)
Scheduled Caste/tribe	-0.0702 ***	-0.1258 ***	-0.0403	-0.1173 ***
	(0.0241)	(0.0431)	(0.0250)	(0.0439)
Mother’s age				
At birth	-0.0049	-0.0096	0.0248 **	0.0321
	(0.0120)	(0.0207)	(0.0124)	(0.0216)
Squared	0.0002	0.0002	-0.0004 *	-0.0005
	(0.0002)	(0.0004)	(0.0002)	(0.0004)
Number of Observation	12,260		11,773	
ln-L	-18481.98	-18208.02	-17694.79	-17425.28

Standard errors in parentheses.
*, **, *** indicate significance from zero at 10 percent, 5 percent and 1 percent, respectively.
Other variables include two cut-off points all of which are significant at 1 percent level.

Table 5. Estimates of immunization coverage model by mother's level of education

	Boy		Girl	
Mother	Educated	Illiterate	Educated	Illiterate
Prenatal Care	1.4417 ***	0.2784 **	0.7603 ***	-0.2297 **
	(0.1589)	(0.1173)	(0.1309)	(0.1093)
Media Exposure	0.2674 ***	0.4222 ***	0.6135 ***	0.6189 ***
	(0.0889)	(0.0526)	(0.0877)	(0.0558)
Log(PCE)	0.4998 ***	0.6002 ***	0.2305	0.6176 ***
	(0.1773)	(0.1040)	(0.1667)	(0.1114)
Good house	0.1781 *	0.1540 ***	0.2368 ***	0.2601 ***
	(0.0926)	(0.0477)	(0.0877)	(0.0510)
Electricity	0.7769 ***	0.6583 ***	0.5577 ***	0.5463 ***
	(0.1025)	(0.0549)	(0.0930)	(0.0546)
Water	0.1508 *	0.1222 ***	0.0813	0.0134
	(0.0810)	(0.0460)	(0.0765)	(0.0495)
Clinics	0.2797 ***	0.3017 ***	0.3367 ***	0.5180 ***
	(0.0942)	(0.0461)	(0.0944)	(0.0524)
Road	-0.0508	0.0975 **	0.1931 **	0.0829 *
	(0.0858)	(0.0441)	(0.0817)	(0.0471)
Old boys	-0.1809 ***	-0.1393 ***	-0.2745 ***	-0.0961 ***
	(0.0524)	(0.0212)	(0.0495)	(0.0228)
Old girls	-0.0151	-0.0247	-0.2323 ***	-0.1023 ***
	(0.0448)	(0.0193)	(0.0420)	(0.0209)
Muslim	-1.0045 ***	-0.6120 ***	-0.8128 ***	-0.5730 ***
	(0.1318)	(0.0676)	(0.1149)	(0.0725)
Scheduled Caste/tribe	-0.2242 *	-0.0907 *	-0.2911 ***	-0.0785
	(0.1157)	(0.0465)	(0.1086)	(0.0498)
Mother's age				
At birth	-0.0693	-0.0097	0.0663	0.0176
	(0.0618)	(0.0224)	(0.0498)	(0.0247)
Squared	0.0017	0.0002	-0.0007	-0.0004
	(0.0012)	(0.0004)	(0.0010)	(0.0005)
Number of Observation	3,744	8,516	3,621	8,152
ln-L	-5144.32	-12951.39	-5199.66	-12152.24

Standard errors in parentheses.
*, **, *** indicate significance from zero at 10 percent, 5 percent and 1 percent, respectively.
Other variables include two cut-off points.

Table 6. Estimates of immunization coverage model including complication at delivery

	Boy		Girl	
	Single Equation	Selection Correction	Single Equation	Selection Correction
Prenatal	0.5924 ***	0.7520 ***	0.5525 ***	0.0277
Care	(0.0235)	(0.0998)	(0.0239)	(0.0961)
Complication	0.0820 **	0.1315 **	0.0440	0.0977 *
At delivery	(0.0365)	(0.0615)	(0.0365)	(0.0587)
	Educated	Illiterate	Educated	Illiterate
Prenatal	1.4302 ***	0.2768 **	0.7618 ***	-0.2595 **
Care	(0.1586)	(0.1166)	(0.1315)	(0.1074)
Complication	0.1555	0.1329 *	0.0636	0.1258 *
At delivery	(0.1084)	(0.0743)	(0.1074)	(0.0718)

Standard errors in parentheses.
*, **, *** indicate significance from zero at 10 percent, 5 percent and 1 percent, respectively.

Appendix. Estimates of demand for prenatal care model

A. All mother

	Boy		Girl	
	Single Equation	Selection Correction	Single Equation	Selection Correction
Literate	0.4947 ***	1.1999 ***	0.5116 ***	1.1828 ***
	(0.0345)	(0.1160)	(0.0343)	(0.1136)
>=Middle	0.7706 ***	1.7020 ***	0.7250 ***	1.7181 ***
	(0.0481)	(0.1394)	(0.0480)	(0.1555)
Media Exposure	0.4070 ***	0.8931 ***	0.2954 ***	0.6755 ***
	(0.0265)	(0.0794)	(0.0270)	(0.0766)
Log(PCE)	0.5681 ***	1.4003 ***	0.4612 ***	1.0659 ***
	(0.0576)	(0.1435)	(0.0582)	(0.1479)
Good house	0.1547 ***	0.3341 ***	0.1618 ***	0.3361 ***
	(0.0271)	(0.0634)	(0.0274)	(0.0679)
Electricity	0.1984 ***	0.4014 ***	0.1925 ***	0.4501 ***
	(0.0276)	(0.0661)	(0.0280)	(0.0720)
Water	-0.0381	-0.1027 *	0.0063	0.0120
	(0.0259)	(0.0571)	(0.0262)	(0.0616)
Clinics	0.1505 ***	0.3449 ***	0.2696 ***	0.6203 ***
	(0.0268)	(0.0592)	(0.0278)	(0.0728)
Road	0.2172 ***	0.4550 ***	0.2032 ***	0.4032 ***
	(0.0252)	(0.0580)	(0.0253)	(0.0638)
Old boys	-0.1186 ***	-0.2416 ***	-0.1415 ***	-0.3154 ***
	(0.0127)	(0.0286)	(0.0133)	(0.0351)
Old girls	-0.0833 ***	-0.1651 ***	-0.1079 ***	-0.2384 ***
	(0.0121)	(0.0262)	(0.0124)	(0.0311)
Muslim	0.1119 ***	0.2375 ***	-0.0092	-0.0233
	(0.0369)	(0.0818)	(0.0374)	(0.0894)
Scheduled Caste/tribe	-0.0931 ***	-0.1862 ***	-0.1274 ***	-0.2965 ***
	(0.0286)	(0.0620)	(0.0291)	(0.0704)
Mother's age				
At birth	-0.0123	-0.0208	0.0106	0.0121
	(0.0146)	(0.0308)	(0.0157)	(0.0353)
Squared	0.0002	0.0003	0.0000	0.0002
	(0.0003)	(0.0006)	(0.0003)	(0.0007)

Standard errors in parentheses.
*, **, *** indicate significance from zero at 10 percent, 5 percent and 1 percent, respectively.

B. By mother's education level

	Boy		Girl	
Mother	Educated	Illiterate	Educated	Illiterate
Media	1.2352 ***	0.9575 ***	0.9449 ***	0.6856 ***
	(0.1564)	(0.1070)	(0.1430)	(0.0929)
Log(PCE)	1.9302 ***	1.4302 ***	1.2598 ***	1.0898 ***
	(0.2752)	(0.1921)	(0.2568)	(0.1830)
Good house	0.4037 ***	0.3562 ***	0.4574 ***	0.3379 ***
	(0.1277)	(0.0826)	(0.1292)	(0.0829)
Electricity	0.4409 ***	0.4227 ***	0.4315 ***	0.4363 ***
	(0.1294)	(0.0869)	(0.1281)	(0.0879)
Water	-0.4442 ***	0.0173	-0.3010 **	0.1323 *
	(0.1227)	(0.0744)	(0.1199)	(0.0771)
Clinics	0.4859 ***	0.3718 ***	0.2960 **	0.6873 ***
	(0.1402)	(0.0767)	(0.1338)	(0.0903)
Road	0.7329 ***	0.4167 ***	0.6546 ***	0.3565 ***
	(0.1291)	(0.0757)	(0.1270)	(0.0770)
Old boys	-0.6293 ***	-0.1899 ***	-0.7287 ***	-0.2659 ***
	(0.0771)	(0.0351)	(0.0946)	(0.0404)
Old girls	-0.5453 ***	-0.0984 ***	-0.5325 ***	-0.2108 ***
	(0.0738)	(0.0326)	(0.0771)	(0.0370)
Muslim	0.3681 *	0.1754 *	0.1739	-0.0859
	(0.1881)	(0.1015)	(0.1797)	(0.1093)
Scheduled	-0.2790 *	-0.1626 **	-0.5337 ***	-0.2549 ***
Caste/tribe	(0.1622)	(0.0768)	(0.1748)	(0.0825)
Mother's age				
At birth	0.1608 *	-0.0536	0.2433 ***	-0.0281
	(0.0887)	(0.0379)	(0.0892)	(0.0421)
Squared	-0.0020	0.0007	-0.0034 *	0.0008
	(0.0018)	(0.0007)	(0.0018)	(0.0008)

Standard errors in parentheses.
*, **, *** indicate significance from zero at 10 percent, 5 percent and 1 percent, respectively.