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Determinants of the Uptake of the Full Dose of Diphtheria–Pertussis–Tetanus Vaccines (DPT3) in Northern Nigeria: A Multilevel Analysis

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Abstract *Objectives* Health behaviors are influenced by an array of factors at the individual, household, community and societal levels. This paper examines the relative contribution of child's characteristics, mother's attributes, household profiles and community factors on the probability that a child will receive the full series of diphtheria–pertussis–tetanus vaccines (DPT3) as a proxy for full immunization. *Methods* We used data from a 2004 household survey conducted in three northern Nigeria states: Borno, Kano and Yobe. We estimated multilevel models with fixed effects specified at the individual, household and community levels, and random effects at the community level. *Results* Overall, only 16.0% of the children aged 12–35 months had received DPT3. The data show that a significant amount of the variation in DPT3 uptake occurs at the community level. The most significant predictors of the uptake of DPT3 are found at multiple levels and include child's place of birth, presence of an immunization card, mother's ideation, mother's decision-making power and perceived social approval of immunization. The data further show that significant community-level variations in immunization uptake remain even after individual and household factors have been considered. *Conclusions* The data reveal that childhood immunization is influenced by norms and unmeasured factors at the community level in addition to factors operating at the level of the individual child and the household. Strategies for improving the uptake of immunization should include culturally appropriate interventions that target multiple levels of influences. Improving parental attitudes towards immunization without addressing the issue of community norms is not likely to yield significant results.

Keywords Immunization · Northern Nigeria · Multilevel analysis · Demand

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Introduction

With an under-five mortality rate of 194 per thousand, Nigeria ranks very low in terms of child survival and the overall well-being of children. Significantly contributing to the poor health outcomes among Nigerian children is low uptake of immunization. Childhood immunization coverage in Nigeria is among the lowest in the world. In 2005, an estimated 25% of one-year-old children had received the third dose of DPT [1]. This national average hides considerable regional disparities within the country. The results of the 2003 Demographic and Health survey (NDHS) show that immunization coverage is considerably lower in the northern states than in the south [2]. For example, whereas DPT3 coverage was 67.8% in the south-west and 58.5% in the south-east, it was 5.8% in the north-west and 9.1% in the north-east. Similarly, the percent of children who have completed their immunization schedule was 44.6 and 32.5% respectively in the south-west and the south-east compared to only 6.0 and 3.7% in the north-east and the north-west, respectively.

The Nigerian government continues to demonstrate a high level of political will to address the problems associated with low level of immunization uptake in the country. Local NGOs and international donor agencies have made considerable contribution to support governmental efforts to boost immunization uptake. Yet, childhood immunization situation remains critical in Nigeria and thousands of children die unnecessarily every year.

The barriers to effective uptake of childhood immunization in Nigeria are multiple and include both supply and demand elements. The demand side factors include a generally low level of health service utilization, high transportation cost to services and a lack of community ownership of immunization programs fostered by a poor understanding of immunization, suspicions, myths, and rumors [3]. On the supply side, immunization programs are fraught with insufficient number of immunization facilities, poor road networks, poor health infrastructure, inadequacies in vaccine supply and distribution, poor provider skills, and inadequate funding. Traditionally, efforts to boost immunization uptake in Nigeria and elsewhere in Africa have tended to privilege the supply side while paying only marginal attention to demand side factors [4]. Experience has shown that supply side improvements alone are not enough to bring about dramatic changes in the level of immunization coverage. Service availability does not necessarily translate into higher coverage [5].

A relatively large body of literature has looked at the factors associated with the demand for childhood immunization in developing countries. Most studies relied on household surveys and looked at how mother and household characteristics affect child immunization. Most of these studies have looked at fixed effects at the individual and household levels although a few studies also examined community fixed effects [6]. Probably due to the complex data requirements, rare are the studies that look at random effects, particularly at the community level. Moreover, at the individual level, most studies merely looked at socio-demographic characteristics. Very few studies examined the role of psychosocial characteristics, an important lapse considering abundance of theoretical support for, and the wealth of empirical evidence documenting the importance of cognitive, emotional and social interaction variables for health behaviors [7–11].

Almost invariably, previous studies have found a strong positive correlation between maternal education and child immunization although the studies differ in their findings regarding the substantive nature of the correlation [12–16]. Gage et al. found that in both urban and rural areas of Nigeria and Niger, maternal education significantly increases the likelihood of full immunization [17]. In addition, the authors found that maternal education tended to mediate the relationship between household structure (e.g., nuclear as opposed to extended family structure) and immunization. In their study on Gambia, Cassell et al. found that higher maternal education was associated with lower incidence of immunization defaulting [4]. While most studies found that the odds of child immunization increase consistently with maternal education, others have demonstrated that the relationship is not so clear-cut. For example, Streatfield et al. documented a U-shaped relationship between maternal education and immunization in Indonesia with children born to mothers with primary education being less likely to be immunized than those whose mothers have post-primary education or are illiterates [18]. Others have found that the strong relationship between maternal education and child immunization tends to disappear when other variables paternal education or other variables are accounted for [19].

A few studies have focused on maternal employment status and found a strong link with child immunization. The evidence in this respect generally indicates the positive effects of mother's working status on the completion of the immunization schedule [12]. Other studies however found that children of women who work outside the home tend to complete their immunization schedule later than those whose mothers work at home [20].

Other individual-level variables that have been found to be correlated with child immunization include parental characteristics such as paternal education, paternal occupation, mother's age, and place of residence. For example, Luman et al. found that children born to younger mothers were less likely to be immunized than those born to older mothers [15].

A few studies have included some characteristics of the child, including age, gender, place of birth and presence of an immunization card. In general, evidence from these studies suggests that children born in a health facility and those who have an immunization card are more likely than others to have completed the immunization schedule [16, 21–23]. Regarding the gender of the child, much of the evidence suggests that in places where there is strong son preference, female children are comparatively less likely to be immunized [23–25] although a few studies have found a comparatively lower level of immunization for male children [26].

Two household characteristics often found in the literature to be correlated with child immunization are household structure and socio-economic status. Existing literature suggests that children from poor households are less likely to be immunized than their peers from wealthier households [17, 27, 28]. The limited findings relating household structure to immunization indicate that nuclear families are worse off in terms of child immunization [17].

Probably due to the complexity of data required for assessing the role of community factors in child immunization uptake, relatively few studies have analyzed the predictive value of community variables. The community variables examined in most of these studies relate to physical characteristics (such as level of urbanization or proximity of a health facility) or the socio-economic environment [25, 29]. Other studies did not explicitly include any community-level variables but simply treated community as a source of random variation in immunization uptake

thereby examining the role of community heterogeneity in child immunization status [19].

This study draws on existing literature to identify the predictors to include in our models. We conduct a multilevel analysis using multi-state survey data collected in 2004 to determine the role of measured individual and household characteristics (fixed effects) and unmeasured factors (random effects) at the local government area (LGA). In line with previous studies, we assess the role of individual socio-demographic characteristics and household factors in immunization uptake. In addition, we examine cross-community variations in the relationship between selected child characteristics and immunization uptake. In this way, we expect to make a significant contribution to the literature.

Methods

In this paper, we analyze data from a 2004 household survey on the factors affecting immunization uptake in Nigeria. Although the survey covered six states (two in the south and four in the north), we only focused on the northern states. Nonetheless, we excluded one northern state (Jigawa) because the level of DPT3 uptake was less than 1%. The data analyzed in this paper therefore covered three states in northern Nigeria: Borno, Kano, and Yobe. During the survey, we collected data from a representative sample of men and women of reproductive age who have children under the age of five years. The sample was selected using a multi-stage sampling approach that involves successively selecting the study states, LGAs, and households. In each of the selected households, we selected one female respondent and (in half of the sampled household) the male head of household. The survey tool included questions that allow female respondents to provide details about the immunization status of the under-5 children.

The interviews followed standard ethical procedures. Verbal consent was obtained from the respondents prior to interviewing them. Respondent's privacy was protected through private face-to-face interview with no third party present, use of experienced and trained interviewers, no identifiers in the questionnaire and limited access to completed questionnaires.

The unit of analysis in this paper is the child aged 12–35 months. We decided to focus on this age range as opposed to the more conventional 12–23 months because most children in northern Nigeria start and complete their immunization schedule late. Some women have more than one child in this age range. However, in order to minimize over-representation of women with more than one young child and minimize bias due to woman's individual fixed effects, we limit the analyses here to one child per woman. When a woman has more than one child in the 12–35 months age range, we randomly select one child for inclusion in the analyses. A total of 1,472 children aged 12–35 months were included in the analyses.

The dependent variable that we examine in this paper is the receipt of the full series of diphtheria–pertussis–tetanus vaccines (DPT3). DPT3 is often used as an indicator of full immunization coverage [1, 30, 31]. In this paper we define the dependent variable as a binary variable that takes the value of 1 if the child has received DPT3 and 0, otherwise. Much of the information on DPT3 immunization in this study derives from verbal reports: whereas 31.7% of the children aged 12–35 months reportedly have an immunization card, interviewers were able to sight the card for only 2.4% of the children. Although it is easy to argue that verbal reports are biased by memory lapse, many scholars have argued that caregivers' reports are acceptably accurate and warned that failure to take verbal reports into account may result in significant sample attrition and lead to overestimation of immunization rates [14, 32].

The independent variables included in the estimated model are as follows:

Child's characteristics: Place of birth (modern health facility versus non-health facility), age of the child in months; and, whether or not the child reportedly has an immunization card.

Mother's socio-demographic characteristics and psychosocial profiles: current age, education and religion (Moslem versus Christian). The mother's psychosocial profiles that we included in the estimated models are the following:

- A measure of childhood immunization *ideation* (defined as ways of thinking; [33]) derived from knowledge about immunization, perceived social approval of immunization, perceived self-efficacy to overcome opposition from spouse to child immunization, perceived self-efficacy to overcome transportation-related obstacles to child immunization, perceived response efficacy of specific childhood vaccines, personal advocacy in favor of polio immunization, discussion about child immunization with significant others, and the perception that one's religion supports child immunization. These psychosocial variables cohere (Cronbach's alpha = 0.73) indicating that they collectively measure the same underlying disposition towards immunization;
- Indicator of the mother's conjugal power measured as an index for contribution to household decision-making (mean: 2.6; range: 0–12); and,
- Perception that most people in one's community favor child immunization.

Household characteristics: Gender of the head of household and household socio-economic status are the

two household level variables included in the analyses. Socio-economic status is measured through household living conditions and ownership of specific goods, including type of floor of dwelling unit (finished versus rudimentary), type of toilet facility, and whether or not household has the following: electricity, a refrigerator, radio, television, cellular phone, motorcycle and car. The items have a Cronbach's alpha of 0.765. In the estimated models, we split the indicator of socio-economic status into five quintiles to denote very poor, poor, medium, rich and very rich, respectively (Table 1).

Community random effects: In this paper, the community is defined as the local government area (LGA). In Nigeria, the LGA is the third tier of government after the state and the federal governments. The provision of primary health care, including immunization services, devolves on the LGA. Moreover, the residents of an LGA have many things in common, including social services (health facility, schools, markets, etc.), language, cultural practices, values, and norms. Therefore treating the LGA as a community is justified. We did not explicitly include any community level variables in the estimated models but model community effects as random, that is, representative of the general community context. Treating community effects as random enables us to assess the extent to which DPT3 uptake cluster by community.

Evidently, data on child immunization implicitly reflect a multilevel structure with children being nested in households and households in communities. It therefore is intuitively logical to analyze the data within a multilevel framework that assesses the fixed effects of the predictors at all levels, as well as the random effects due to the community of residence. Sociological and econometric literature abounds with discussion about the importance of using multilevel models for nested data such as those analyzed in this paper [34]. Traditional linear regression models assume independence among the respondents within each cluster and equal variance among the various clusters in a dataset. However, when a dataset has a nested structure, the units within the same cluster are very likely to be similar, and different clusters cannot be assumed to have equal variance [35]. Failure to take the multilevel structure of the data into consideration might result in biases in estimation of the regression parameters and their standard errors [34].

The estimated multilevel models have the following general specifications:

$$\text{logit}(\pi_{ijk}) = \beta_o + \beta_1 \mathbf{X}_{ijk} + \beta_2 \mathbf{Q}_{2k} + \varepsilon_{ijk} + \varepsilon_k$$

The fixed part of the model is given by $\beta_o + \beta_1 \mathbf{X}_{ik} + \beta_2 \mathbf{Q}_{2k}$, where β_o is overall intercept of the model, $\beta_1 \mathbf{X}_{ijk}$ is the vector of coefficients (β_1) and predictors ($\mathbf{X}$) at level 1 (individual children), $\beta_2 \mathbf{Q}_{2k}$ is the vector of coefficients (β_2) and predictors ($\mathbf{Q_2}$) at level 2 (parental/household). The random component of the model is given by $\varepsilon_{ik} + \varepsilon_k$, where ε_{ik} is the random variation of DPT3 immunization across individual children and ε_k is the random variation across communities.

To justify the investment of time and energy in a multilevel model, we start by doing an ANOVA-type multilevel model that includes no predictors (an empty model) to see if there is significant random variation in DPT3 immunization at the community level. If the results of this baseline model show an insignificant random variation at the community level, the use of multilevel modeling is not justified and a simple logistic regression model could be used. In addition to this baseline model, we estimated three explanatory models. Model 1 included only the child's characteristics while model 2 contains mother's socio-demographic and psychosocial profiles in addition to the child's characteristics. In model 3, we included household characteristics in addition to the variables included in model 2. The models were estimated using the *gllamm* command in STATA [36].

Testing the hypothesis that the variance of the random effects equals zero was not based on Wald tests since the null value is on the border of the parameter space [37]. Instead, we computed a log-likelihood ratio chi-square statistic that compares a particular model with a similar one in which the random effects have been constrained to be zero and evaluated the significant of the test statistic using one-sided *P*-values (Table 3).

Results

Overall, only 16.0% of the children aged between 12 and 35 months had received DPT3. There are considerable variations by state: from 10.9% in Yobe to 21.5% in Kano State. DPT3 uptake also varies considerably by the child's characteristics, the mother's profiles, and household characteristics, as Table 2 shows.

The results of the empty model are presented in Table 3. As indicated by the magnitude and the significance of the variance, there is considerable unobserved variability in DPT3 uptake across LGAs. The intra-class correlation coefficient derived from this empty model further show that a significant proportion of the total variance in DPT3 is accounted for by the LGA in which individuals reside. In other words, there is a high level of clustering in DPT uptake within LGAs.

We now turn to the results of the explanatory models. The model containing only the child's characteristics (Model 1) explains about 8.7% of the variance in DPT3 uptake. The results show that children born in a health facility are more than three times as likely as those born at home or in a non-health facility to obtain DPT3. Children

Table 1 Selected characteristics children aged 12–35 months

Explanatory variables	Percent/ value
Child's characteristics	
Percent distribution by place of birth	
Health facility	29.55
Home/Other	70.45
Percent distribution by reported ownership of immunization card	
Yes	31.73
No	68.27
Average age of child in months (range: 12–35)	25.5
Mother's socio-demographic and ideational characteristics	
Age group	
<20 years (RC)	10.33
20–29	52.24
30–39	27.04
40+	10.39
Education	
None (RC)	78.46
Primary	8.97
Post-primary	12.57
Religion	
Christian (RC)	6.73
Moslem	93.27
Average score on immunization ideation (range: 0–31)	11.12
Percent that perceived that most people in community favor immunization	
Yes	22.55
No	77.45
Average score for conjugal decision-making power (range: 0–12)	2.72
Household characteristics	
Household socio-economic status	
Very poor	30.37
Poor	16.03
Medium	17.46
Rich	23.44
Very rich	12.70
Gender of head of household	
Male (RC)	94.09
Female	5.91
Number of observations	1472

Source: DFID/PATHS Survey on the Factors Influencing the Uptake of Immunization in Nigeria, Nov/Dec 2004

with immunization cards are two and a half times as likely to be immunized as those without an immunization card. In contrast, the child's age is an insignificant predictor. This model shows that community level random effects are significantly different from zero.

With maternal socio-demographic and psychosocial characteristics introduced in Model 2, the community level

Table 2 Percent of children aged 12–35 months that received DPT3 by selected individual, maternal and household characteristics

Characteristics	Percent that received DPT3	Pearson X^2/ *P*
Child' place of birth		
Health facility	31.95	116.27/ 0.001
Home and others	9.35	
Child's age		
12–23 months	15.58	0.852/0.356
24–35 months	17.78	
Immunization card		
Child has a card	27.19	63.30/0.001
Child does not have a card	10.84	
Mother's age group		
<20 years	5.92	15.82/0.001
20–29 years	15.73	
30–39 years	19.09	
40+	19.61	
Mother's education		
None	13.33	48.32/0.001
Primary	15.15	
Secondary+	33.51	
Mother's decision-making power		
Low	13.74	59.17/0.001
Medium	29.09	
High	8.05	
Mother's religion		
Moslem	14.20	50.79/0.001
Christian	41.41	
Mother perceived that immunization is the norm in the community		
Yes	30.66	8.52/0.001
No	11.49	
State of residence		
Borno	15.25	21.26/0.001
Kano	21.55	
Yobe	10.93	
Household socio-economic status		
Very poor	5.81	76.70/0.001
Poor	17.37	
Medium	15.56	
Rich	19.71	
Very rich	32.62	
Gender of head of household		
Male	16.82	10.88/0.001
Female	3.45	
Number of observations	1472	–

Source: DFID/PATHS Survey on the Factors Influencing the Uptake of Immunization in Nigeria, Nov/Dec 2004

Table 3 Parameter estimates[a] (odds ratio) for the multilevel model for the uptake of DPT3 immunization—Children aged 12–35 months

Explanatory variables	Model 0[b]	Model 1[c]	Model 2[d]	Model 3[e]
Fixed effects				
Child's characteristics				
Child's place of birth				
Home/other (RC)		1.00	1.00	1.00
Health facility		3.41***	2.45***	2.54***
Child's age in months		0.98	0.98	0.98
Child has immunization card				
No (RC)		1.00	1.00	1.00
Yes		2.51***	2.25***	2.10***
Mother's socio-demographic and ideational characteristics				
Age group				
<20 years (RC)			1.00	1.00
20–29			2.38*	2.42*
30–39			2.88**	2.83*
40+			2.81*	2.69*
Education				
None (RC)			1.00	1.00
Primary			0.58‡	0.55*
Post-primary			1.11	0.92
Religion				
Christian (RC)			1.00	1.00
Moslem			0.62‡	0.56*
Immunization ideation				
Low (RC)			1.00	1.00
High			6.21***	6.04***
Score for conjugal decision-making power (range: 0–12)			1.28***	1.22**
Square of score for conjugal decision-making power			0.97***	0.97**
Perceived that most people in community favor immunization			3.75***	3.61***
Household characteristics				
Household socio-economic status				
Very poor (RC)				1.00
Poor				2.15**
Average				1.82‡
Rich				1.44
Very rich				2.58**
Gender of head of household				
Male (RC)				1.00
Female				0.20**
Random effects				
LGA level variance[f]	1.71***	1.29***	3.64***	1.28**
Rho—Intra-class correlation	.342	.281	.525	.280
Log likelihood	−616.4	−562.9	−467.1	−456.8
AIC	1236.87	1135.89	964.19	953.68
Log likelihood Ratio Test (X^2)[g]	–	106.98***	191.69***	20.51***
McFadden Pseudo-R^2	–	8.67%	24.2%	25.9%

Source: DFID/PATHS Survey on the Factors Influencing the Uptake of Immunization in Nigeria, Nov/Dec 2004. RC = reference category. Standard errors of random effects are in parentheses

[a] The parameters for predictors (fixed effects) are reported as odds ratio; for random effects, the parameter is the variance

[b] Empty model with no covariates

[c] Baseline model with child's characteristics alone

[d] Model with child's characteristics and mother's socio-demographic and ideational characteristics

[e] Full model with child's characteristics, mother's socio-demographic and ideational characteristics, and household variables

[f] Significance of random effects evaluated by comparing the model with a similar one in which random effects have been constrained to be zero

[g] Compared to the preceding model

* $P \leq 0.05$

** $P \leq 0.01$

*** $P \leq 0.001$

‡ $P \leq 0.1$

random effects remain significant. Moreover, the fixed effects of the child's characteristics appear to be statistically independent of maternal characteristics. The results of the likelihood ratio test indicate that maternal characteristics are jointly significant in predicting childhood immunization. Nonetheless, in this model, mother's age is the only socio-demographic characteristic that is a significant predictor. In contrast, all the psychosocial predictors included in this model are significant.

Turning our attention to the full model (Model 3), we find that the introduction of household characteristics further increases the predictive power of the model significantly. Moreover, the presence of household characteristics in the model does not appear to reduce the significance of the child's or maternal characteristics in any noticeable way. The model confirms that the independent effects of mother's age are such that children born to young mothers (aged less than 20 years) are the least likely to be immunized. The relationship between childhood immunization and maternal education is also significant and indicate that children whose mothers have primary education are less likely to be immunized than those whose mothers are illiterates. Religion is also a significant predictor of childhood immunization with Islamic religious affiliation being associated with lower odds of immunization. The mother's psychosocial profiles are strong predictors of child immunization. Children born to mothers with high immunization ideation are about six times as likely to have received DPT3 as those whose mothers demonstrated a low level of ideation. The relationship between mother's conjugal power and child immunization is curvilinear and not at all as expected. The magnitude and direction of the estimates for the measure of conjugal power and its squared value seem to indicate that while moderate levels of conjugal power is beneficial for child immunization, higher levels of conjugal power is not necessarily an advantage. In contrast, the positive relationship between perceived social approval of childhood immunization and the uptake of DPT3 is as expected.

Household socio-economic status is strongly correlated with child immunization although the expected dose-response relationship is absent. The data nonetheless show that poor households are significantly less likely to immunize their children compared with wealthier households. Furthermore, living in a household headed by a woman constitutes a significant disadvantage for child immunization.

Finally, even in the full model, community random effects remain significant, indicating that unobserved factors operating at the community level help to drive the uptake of immunization.

Discussion

This paper used data from a household survey to assess the roles of child-related, maternal, household and community factors in the uptake of DPT3. The findings confirm our general working hypothesis that the uptake of immunization is dependent on factors that operate at various levels.

The positive influence of a facility-based birth is in congruence with existing literature on child immunization. Studies that have examined the influence of the child's place of birth on the probability of immunization have consistently yielded strong positive effects [16, 22, 24]. This finding lends credence to the importance of promoting antenatal care and use of appropriate health care facilities for delivery and postnatal care. It also underscores the need for appropriate strategies for promoting child immunization among women who do not use health facilities for antenatal, delivery and postnatal care. This recommendation is particularly pertinent in a country like Nigeria where the majority of children are born at home or at other non-medical facilities.

This study joins previous studies in finding a positive relationship between immunization status and the possession of an immunization card. It is useful to note that the relationship may be spurious or genuine. It is possible that the relationship simply reflects the results of memory lapse on the part of caregivers whose children do not have an immunization card. It is also possible that the presence of an immunization card serves as a valuable cue for the caregiver to take a child for immunization. While ascertaining the exact nature of the observed relationship is beyond the scope of this paper, it indicates the need for strengthening the quality of immunization services, ensuring that children who come for services are provided with appropriate immunization cards and educating caregivers on the need to keep the immunization card in a safe place.

The strong effects of mother's ideation and perceived norms even after household factors are introduced into the model underscore the importance of maternal knowledge and attitudes. This finding points to the relevance of interventions that seek to positively influence maternal cognitive and emotional processes as a way of increasing the uptake of childhood immunization. In this respect interventions should target caregiver's understanding of vaccine-preventable diseases, the timing of various vaccines, response efficacy of vaccines and the required number of immunization visits. Strategically designed messages and activities should also seek to increase caregiver's perceived self-efficacy to overcome relevant logistic obstacles to immunization, encourage discourse about immunization and build social support for immunization. The finding also suggests that interventions that

showcase fully immunized children in the community as a way of promoting the notion that immunization is a community norm are relevant.

The curvilinear relationship between maternal conjugal decision-making power and child immunization is curious. Indeed, it is not clear why the positive relationship between conjugal power and child immunization is reversed at higher levels of conjugal power. Nonetheless, a few studies have found a similar relationship in sub-Saharan Africa [38]. One possible explanation could be that in a society where gender norms generally limit the participation of women in household decision-making power process, women with high conjugal power tend to be those who live away from their husbands and have limited access to substitute caregivers with whom to share the responsibility of household chores and childrearing thereby making limited time available for them to take their children for immunization. The possibility of a positive link between the presence of substitute caregivers in the household and child immunization status is supported in literature. For example, Coreil found that the opportunity cost of taking children for health care services is greatest in single-adult households in Haiti [39]. Further research is needed to understand the mechanisms through which maternal conjugal power influences child immunization.

The data show that community level random effects remain significant after controlling for predictors at the child, maternal and household levels, indicating that immunization uptake significantly depends on community context. The implication of this finding is that effective strategies to promote immunization should adopt an ecological perspective and address relevant community contextual factors. Such strategies should engage the community stakeholders in identifying contextual factors hindering immunization uptake, ascertaining the resources that foster positive immunization practices and designing and implementing appropriate interventions.

There are a few limitations of this study that deserve mention. First, the analyses were based on cross-sectional data thereby making causal inference problematic. There is a need to verify the validity of the observed relationships using longitudinal data obtained at more than one point in time. Second, due to data availability constraints, the estimated models did not include variables explicitly measured at the community level. We could have included community measures aggregated from individual responses. While such an approach is commonly used in literature [40–42], there have been concerns that inferring group effects from aggregated individual responses can lead to atomistic fallacy or the error of inferring causal relationships at a higher level based on data collected at a lower level [43, 44]. Third, treating the LGA as a community for immunization purposes is subject to criticism. Indeed, while people residing in a community can be seen as sharing health infrastructure, social norms, religion, and traditional practices, it can be argued that a smaller geographic unit (a ward, for example) provides a better basis on which to examine clustering effects. Nonetheless, the survey design does not allow us to conduct analyses at the ward level.

In summary, this paper has demonstrated that immunization uptake is influenced by factors at various levels: child, maternal, household and the community. Effective strategies to promote immunization uptake will have to engage the community while addressing the child, maternal and household factors that hinder full immunization.

References

1. UNICEF. (2005). Progress for children: A report card on immunization. Available at: http://www.unicef.org/progressforchildren/2005n3/PFC3_English2005.pdf. Retrieved on March 12, 2007.
2. National Population Commission (NPC) [Nigeria] ORC Macro. (2004). *Nigeria demographic and health Survey 2003*. Calverton, Maryland: National Population Commission and ORC Macro.
3. Feilden Battersby Analysts (FBA). (2005). The state of routine immunization services in Nigeria and reasons for current problems. Bath: FBA Health Systems Analysts. Available at: http://www.technet21.org/backgrounddocs.html. Retrieved on December 15, 2007.
4. Cassell, J. A., Leach, M., Fairhead, J. R., Small, M., & Mercer, C. H. (2006). The social shaping of childhood vaccination practice in rural and urban Gambia. *Health Policy and Planning, 21*(5), 373–391. doi:10.1093/heapol/czl020.
5. Center for Disease Control and Prevention. (1999). Vaccine-preventable diseases: improving vaccination coverage in children, adolescents, and adults—A report on recommendations of the task force on community preventive services. *Morbidity and Mortality Weekly Report* (MMWR)—*Recommendations and Reports, 48*(RR-8), 1–15.
6. Gauri, V., & Khaleghian, P. (2002). Immunization in developing countries: Its political and organizational determinants. *World Development, 30*(12), 2109–2132. doi:10.1016/S0305-750X(02)00151-1.
7. Cassell, J. (1976). The contribution of the social environment to host resistance. *American Journal of Epidemiology, 104*, 107–123.
8. House, J. S., Umberson, D., & Landis, K. R. (1988). Social relationship and health. *Science, 241*, 540–545. doi:10.1126/science.3399889.
9. House, J. S. (2001). Understanding social factors and inequalities in health: 20th Century Progress and 21st Century Prospects. *Journal of Health and Social Behavior*, *43*(2, Selecting Outcomes for the Sociology of Mental Health: Issues of Measurement and Dimensionality), 125–142.
10. Martikainen, P., Bartley, M., & Lahelma, E. (2002). Psychosocial determinants of health in social epidemiology. *International Journal of Epidemiology, 31*(6), 1091–1093. doi:10.1093/ije/31.6.1091.
11. Cohen, S. (2004). Social Relationships and Health. *The American Psychologist, 59*(8), 676–678. doi:10.1037/0003-066X.59.8.676.
12. Cutts, F. T., Diallo, S., Zell, E. R., & Rhodes, P. (1991). Determinants of vaccination in an urban population in Conakry,

Guinea. *International Journal of Epidemiology, 20*(4), 1099–1106. doi:10.1093/ije/20.4.1099.
13. Pebley, R., Goldman, A., & Rodriguez, G. (1996). Prenatal and delivery care and childhood immunization in Guatemala: Do family and community matter? *Demography, 33*, 231–247. doi:10.2307/2061874.
14. Desai, S., & Alva, S. (1998). Maternal education and child health: Is there a strong causal relationship? *Demography, 35*(1), 71–81. doi:10.2307/3004028.
15. Luman, E. T., McCauley, M. M., Shefer, A., & Chu, S. Y. (2003). Maternal characteristics associated with vaccination of young children. *Pediatrics, 111*, 1215–1218.
16. Chhabra, P., Nair, P., Gupta, A., Sandhir, M., & Kannan, A. T. (2007). Immunization in urbanized villages of Delhi. *Indian Journal of Pediatrics, 74,* 131–134. Available at http://www.ijppediatricsindia.org/article.asp?issn=0019-5456;year=2007;volume=74;issue=2;spage=131;epage=134;aulast=Chhabra [serial online]. doi:10.1007/s12098-007-0004-3.
17. Gage, A. J., Sommerfelt, E., & Piani, A. (1997). Household structure and childhood immunization in Niger and Nigeria. *Demography, 34*(2), 295–309. doi:10.2307/2061706.
18. Streatfield, K., Singarimbun, M., & Diamond, I. (1990). Maternal education and child immunization. *Demography, 27*, 447–455. doi:10.2307/2061378.
19. Steele, F., Diamond, I., & Amin, S. (1996). Immunization uptake in rural Bangladesh: A multilevel analysis. *Journal of the Royal Statistical Society Series A (Statistics in Society), 159*(2), 289–299. doi:10.2307/2983175.
20. McQuestion, M., & Jones, R. E. (1995). *A dynamic, multi-level analysis of recent immunization trends in Colombia*. CDE Working Paper No. 95–13. Madison, Wisconsin: Center for Demography and Ecology, University of Wisconsin-Madison.
21. Suarez, L., Simpson, D. M., & Smith, D. R. (2007). Errors and correlates in parental recall of child immunizations: Effects on vaccination coverage estimates. *Pediatrics, 99*(5), e3. Available at http://pediatrics.aappublications.org/. Retrieved March 15, 2008. doi:10.1542/peds.99.5.e3.
22. Rosenthal, J., Rodewald, L., McCauley, M., Berman, S., Irigoyen, M., Sawyer, M., et al. (2004). Immunization coverage levels among 19- to 35-month-old children in 4 diverse, medically underserved areas of the United States. *Pediatrics, 113*(4), 296–302. doi:10.1542/peds.113.4.e296.
23. Waters, H., Dougherty, L., Tran, N., Charles, S., Tegang, S. P., Long, K., et al. (2004). Coverage and costs of childhood immunizations in Cameroon. *Bulletin of the World Health Organization, 82*, 668–675.
24. Hill, K., & Upchurch, D. M. (1995). Gender differences in child health: Evidence from the demographic and health surveys. *Population and Development Review, 21*, 127–151. doi:10.2307/2137416.
25. Parashar, S. (2005). Moving beyond the mother-child dyad: Women's education, child immunization, and the importance of context in rural India. *Social Science and Medicine, 61*(5), 989–1000. doi:10.1016/j.socscimed.2004.12.023.
26. Pande, R. P. (2003). Selective gender differences in childhood nutrition and immunization in rural India: The role of siblings. *Demography, 40*(3), 395–418. doi:10.1353/dem.2003.0029.
27. Bhuiya, A., Bhuiya, I., & Chowdhury, M. (1995). Factors affecting acceptance of immunization among children in rural Bangladesh. *Health Policy and Planning, 10*(3), 304–312. doi:10.1093/heapol/10.3.304.
28. Becker, S., Peters, D. H., Gray, R. H., Gultiano, C., & Black, R. E. (1993). The determinants of use of maternal and child health services in Metro Cebu, the Philippines. *Health Transition Review, 3*, 77–89.
29. Kiros, G., & White, M. J. (2004). Migration, community context, and child immunization in Ethiopia. *Social Science and Medicine, 59*, 2603–2616. doi:10.1016/j.socscimed.2004.04.009.
30. Hong, R., & Banta, J. E. (2005). Effects of extra immunization efforts on routine immunization at district level in Pakistan. *Eastern Mediterranean Health Journal, 11*(4), 745–752.
31. PAHO. (2004). Organization of the vaccination week in the Americas (VWA) 24–30 April 2004—General Guidelines. Available at: http://www.paho.org/english/dd/pin/sv_organization.pdf. Retrieved on March 12, 2007.
32. Goldman, N., & Pebley, A. R. (1994). Health cards, maternal reports and the measurement of immunization coverage: The example of Guatemala. *Social Science and Medicine, 38*, 1075–1089. doi:10.1016/0277-9536(94)90225-9.
33. Kincaid, D. L. (2000). Social networks, ideation, and contraceptive behavior in Bangladesh: A longitudinal analysis. *Social Science and Medicine, 50*, 215–231. doi:10.1016/S0277-9536(99)00276-2.
34. Guo, G., & Zhao, H. (2000). Multilevel modeling for binary data. *Annual Review of Sociology, 26*, 441–462. doi:10.1146/annurev.soc.26.1.441.
35. Rountree, P. W., Land, K. C., & Miethe, T. D. (1994). Macro–micro integration of the study of victimization: A hierarchical logistic model analysis across Seattle neighborhoods. *Criminology, 32*(3), 387–414. doi:10.1111/j.1745-9125.1994.tb01159.x.
36. Rabe-Hesketh, S., Skrondal, A., & Pickles, A. (2004). *GLLAMM manual*. UC Berkeley Division of Biostatistics Working Paper Series, Number 160. Berkeley, CA: University of California.
37. Raudenbush, S. W., & Byrk, A. S. (2002). Hierarchical linear models (2nd ed.). Sage Publications, Inc.
38. Smith, L.C., Ramakrishnan, U., Ndiaye, A., Haddad, L., & Martorell, R. (2003). *The importance of women's status for child nutrition in developing countries*. International Food Policy Research Institute, Research Report 131. Washington DC: International Food Policy Research Institute.
39. Coreil, J. (1983). Allocation of family resources for health care in rural Haiti. *Social Science and Medicine, 17*(11), 709–719. doi:10.1016/0277-9536(83)90259-9.
40. Duncan, C., Jones, K., & Moon, G. (1998). Context, composition and heterogeneity: Using multilevel models in health research. *Social Science and Medicine, 46*(1), 97–117. doi:10.1016/S0277-9536(97)00148-2.
41. De Silva, M., Huttly, S., Harpham, T., & Kenward, M. (2007). Social capital and mental health: A comparative analysis of four low income countries. *Social Science and Medicine, 64*(1), 5–20. doi:10.1016/j.socscimed.2006.08.044.
42. Leyland, A. H. (2005). Socioeconomic gradients in the prevalence of cardiovascular disease in Scotland: The roles of composition and context. *Journal of Epidemiology and Community Health, 59*, 799–803. doi:10.1136/jech.2005.034017.
43. Diez-Roux, A. V. (1998). Bringing context back into epidemiology: Variables and fallacies in multilevel analysis. *American Journal of Public Health, 88*, 216–222.
44. Blalock, H. M. (1984). Contextual-effects models: Theoretical and methodological issues. *Annual Review of Sociology, 10*, 353–372. doi:10.1146/annurev.so.10.080184.002033.