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Factors predicting BCG immunization status in northern Nigeria: a behavioral-ecological perspective

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Abstract

This study examines the predictors of Bacille Calmette-Guérin (BCG) immunization status among infants in northern Nigeria using a behavioral-ecological model. The findings show only 37.3 percent of the children had received BCG vaccine, and reveal that BCG immunization status in northern Nigeria is influenced by multiple layers of factors, including child's characteristics, parental or household factors, community characteristics, vaccine supply and the policy environment. At the child's level, place of birth and ownership of an immunization card are the two most significant predictors. The parental and household predictors of BCG immunization status include maternal use of antenatal care, maternal knowledge about immunization, maternal exposure to child health information, social influence and paternal approval of immunization. Both the regularity of vaccine supply to the health facility and the state of residence are associated independently with BCG immunization status. These findings stress the need for interventions at multiple levels in order to increase BCG immunization status.

Keywords action research • child health • immunization • Nigeria

Introduction

Child immunization coverage rate continues to be unacceptably low in Nigeria, particularly in the northern states. The results of the 2006 National Immuniza-

tion Coverage Survey (NICS) revealed a national immunization coverage rate of 18.1 percent, ranging from 29.9 percent in the south-west zone to 6.2 percent in the north-west zone. Equally, there are significant regional variations in the coverage of Bacille Calmette-Guérin (BCG) vaccine coverage, which prevents tuberculosis: from 53.1 percent in the south to 20.5 percent in the north-west (NICS Study Group, 2007).

In Nigeria, the National Program on Immunization (formerly Expanded Program on Immunization) targets eight main childhood diseases:

- tuberculosis;
- polio;
- pertussis;
- diphtheria;
- tetanus;
- measles;
- hepatitis B; and
- yellow fever.

Routine immunization is provided mostly through the public health system, with the three tiers of government (federal, state and local government) playing specific and sometimes duplicating roles. The federal government sets national health policies, implements national health programs and coordinates, evaluates and monitors these health policies and programs. Through the National Program on Immunization, a parastatal, the federal government is responsible for procuring vaccines and distributing them to zonal cold stores. The state government is responsible for distributing vaccines to local government central storage facilities and managing state health and other budgets. The state also employs key officials responsible for immunization service provision and coordinates immunization activities within the state. Actual implementation of routine immunization activities is done by primary health care facilities which are managed by the local government (Feilden Battersby Analysts, 2005).

It is widely recognized that sociodemographic and psychosocial factors alone are not enough to explain human behavior or are sufficient to guide the design of effective behavior change interventions (Cohen et al., 2000). This article explores the determinants of BCG immunization status from a behavioral-ecological perspective and examines multiple levels of influences.

Conceptual framework

Drawing on recent literature on health behavior change, a behavioral-ecological model was used to guide the analyses. The behavioral-ecological model has its

foundation in the works of Brofenbrenner (1977) and McLeroy et al. (1988), and recognizes the influence of factors operating at five levels:

- intrapersonal;
- interpersonal;
- institutional;
- community; and
- public policy.

Central to an ecological perspective on health behaviors is recognition of the need to address factors operating at all relevant levels as well as sensitivity to cross-level interactions and feedback (Sallis and Owen, 2002). This article explores the influence of five categories of determinants on BCG immunization status:

- individual child's characteristics;
- parental and household factors;
- community characteristics;
- service delivery factors; and
- the policy environment.

Behavior change literature abounds with evidence that shows that the child's place of birth, rank, age, gender and presence of an immunization card are strong predictors of immunization (Bobo et al., 1993; Chhabra et al., 2007; Cutts et al., 1989; Waters et al., 2004). The parental and household factors which have been found to be associated with immunization status include:

- parental education;
- employment status and knowledge about immunization;
- maternal use of prenatal care;
- household structure;
- socio-economic status; and
- availability of surrogate caregivers (Bates and Wolinsky, 1998; Gage et al., 1997).

Relatively few studies have examined the role of community variables in immunization status (Parashar, 2005). However, examples of studies that explore the link between the quality of community infrastructure and health outcomes abound in literature (Cohen et al., 2000, 2003).

The importance of service delivery and product availability for behavior change has been stressed in earlier works (Cohen and Chehimi, 2007; Favin et al., 2004). With specific reference to immunization, the supply-side factors which have been identified as important in fostering immunization status include:

- adequate and regular supply of vaccines;
- accessibility of vaccination sites;
- convenient hours for vaccination;
- adequate number of immunization service providers;
- short waiting times; and
- low rates of missed opportunities for vaccination (Anand and Bärnighausen, 2007; Belcher et al., 1978; Cutts et al., 1991).

Ecological models recognize the importance of social structures (laws and policies) in human behaviors and health outcomes. It is reasonable to assume that since efforts to immunize children are premised on financial and infrastructural outlay from various tiers of government, policies and laws have a strong role to play in determining immunization coverage. However, while many previous studies have attempted to link social structures with various aspects of the health of individuals, studies that assess the role of policies and laws in childhood immunization status are relatively few. In general, the studies that examine the link between policies and immunization coverage found the expected significant relationship between the two (Al-Sheikh et al., 1999).

Method

Data collection

The data analyzed in this article derive from a study conducted in four states (Jigawa, Katsina, Yobe and Zamfara) in July and August 2007 to provide baseline data for the United Kingdom government's Department for International Development-funded project in northern Nigeria (Partnership for Reviving Routine Immunization in Northern Nigeria, PRRINN). Data collection involved various sources, including women who gave birth during the previous two years, heads of households and selected health facilities serving the study communities. The sampling strategy involved a multi-stage random process that started with the selection of local government areas and ends with the selection of one eligible woman per household. In approximately one-third of the selected households, the male head of household was interviewed in addition to the woman. The sampling procedure is described in greater details elsewhere (Babalola, 2007). In addition to interviewing eligible men and women, supply-related information were collected from a total of 255 health facilities serving the study communities, ranging from 40 to 95 per state.

Ethical considerations

The survey followed standard ethical procedures, including obtaining verbal consent from the respondents prior to conducting the interviews, face-to-face private interviews with no third party, appropriate training for interviewers, adequate field supervision, limited access to completed questionnaires and no individual identifiers in the electronic dataset. In addition, the study protocol and guidelines were reviewed and approved by a specially constituted internal review board in Nigeria prior to data collection.

Measurement

The dependent variable is BGC immunization status among children aged less than one year. Data for this variable derive from immunization cards, where available (6.6% of study children), and the caregiver's verbal report in the absence of an immunization card.

We assessed the role of multiple predictors, including child, maternal, household, community, service delivery and policy environment factors (see Table 1).

The predictors assessed at the level of the child include age, gender, place of birth, rank of birth and whether or not the child has an immunization card that could be seen. At the maternal or household level, the following were assessed:

- maternal use of antenatal care;
- maternal knowledge about the routine immunization schedule;
- maternal awareness of vaccine-preventable diseases;
- whether or not the mother received information on child health through the media or community sources;
- whether or not the mother was encouraged by someone to practise immunization during the last year;
- whether or not the mother had someone who could assist with taking the child for immunization;
- maternal education;
- household socio-economic status; and
- paternal approval of immunization.

At the community level, we assessed the effects of community activism regarding immunization and the conditions of access roads. Community activism regarding child immunization was measured through a question asking respondents whether there were any individuals or groups that educate community members about child immunization. The indicator of the conditions of access roads derive from the service availability form and was based on questions about the condition of the roads linking the local government area headquarters

Table 1: Summary of study variable statistics (by percentage) of children aged under one year

Variables	%
<i>Child's characteristics</i>	
Age:	
<3 months	21.03
3–5 months	21.74
6–8 months	13.63
9–11 months	44.61
Place of birth:	
Health facility	14.88
Home	85.12
Gender:	
Male	51.67
Female	48.33
Rank of child:	
1–2	37.60
3–4	32.94
5 and higher	29.46
Immunization card was seen:	
Yes	6.60
No	93.40
<i>Mother/household characteristics</i>	
Mother received antenatal care during pregnancy:	
Yes	46.30
No	53.70
% distribution by maternal education:	
No formal education	68.04
Primary	19.42
Secondary and above	12.54
Mothers knowledgeable about the timing of routine immunization visits:	
Yes	9.48
No	90.52
Mothers exposed to information on child health through the media or community sources:	
Yes	65.54
No	34.46
Mother has a high level of awareness about vaccine-preventable diseases:	
Yes	46.84
No	53.16
<i>continues</i>	

Table 1: cont.*Mother/household characteristics (cont.)*

Mother was encouraged by someone to immunize the child during the last year:	
Yes	51.30
No	48.70
Mothers has someone to assist with taking the child for immunization:	
Yes	75.20
No	24.80
Household socio-economic status:	
Low	47.41
Medium	28.95
High	23.64
Father approves of immunization:	
Yes	87.27
No	12.73
<i>Community characteristics</i>	
Individuals or groups educate community about immunization:	
Yes	67.09
No	32.91
Condition of access roads in the local government area:	
Poor	34.77
Fair	34.72
Very good	30.51
Regularity of vaccine supply to health facility during last 12 months:	
Irregular (< 2/month)	37.60
Fairly regular (2–3 times/month)	30.95
Very regular (<3 times/month)	31.45
Lives in a community with BCG included in last vaccines supply to health facility:	
Yes	54.34
No	45.66
State of residence:	
Jigawa	21.92
Katsina	21.69
Yobe	25.65
Zamfara	30.74
Number of observations	4242

Source: Babalola (2007) PRRINN Household Survey on Immunization.

and the various health facilities that serve the study communities. Each local government area was scored based on the proportion of its access roads which are of excellent or good condition during both rainy and dry seasons. The resulting score was then split into three to denote poor, fair and good road network conditions.

The service delivery factors assessed related to vaccine supply and include regularity of vaccine supply to the health facility serving the community in which the child resides and whether or not BCG was included in the most recent vaccine supply to the health facility. Both variables derive from the service availability form.

Whereas provision of childhood immunization devolves to the local government area, it is reasonable to assume that immunization status is affected directly and indirectly by social structures at the state level that foster or inhibit immunization. To account for the influence of the policy environment, we included the state of residence in one of the estimated models.

Statistical methods

To assess the relative contribution of the various categories of predictors, five separate logistic models were estimated. Model 1 includes only the child's characteristics, while model 2 includes maternal and household characteristics in addition to the child's information. Model 3 includes community characteristics in addition to the predictors in model 2; model 4 includes service provision variables in addition to the predictors in model 3; model 5 includes all the predictors in model 4 and the state of residence.

Results

The data suggest considerable delay in obtaining the BCG vaccine: 81.6 percent of the children aged 12–23 months, compared to only 37.3 percent of their peers aged less than one year, had obtained the vaccine. It is not clear whether this delay was due to attitudinal factors or results from supply-side inadequacies. Among the children aged less than one year, girls (38.7%) were slightly more likely than boys (36%) to have received the vaccine ($t = 1.84, p = 0.065$).

The results of the logistic regression models are provided in Table 2.

As the various goodness of fit statistics show, the models fit the data reasonably well. Model 1 reveals that children born in a health facility are more than twice as likely to have obtained BCG as the ones born at home. Similarly, having an immunization card that the interviewer was able to see is a strong predictor of BCG immunization status, increasing the odds by 89 percent. There is a strong negative relationship between the rank of the child and BCG immunization status. There is also a significant reduction in the odds of being immunized

Table 2: Results (odds ratio) of logistic regression of child BCG vaccination status on selected variables

Predictor	Model 1	Model 2	Model 3	Model 4	Model 5
<i>Child's characteristics</i>					
Age group:					
<3 months (reference category)	1.00	1.00	1.00	1.00	1.00
3–5 months	1.05	1.03	1.05	1.05	1.06
6–8 months	0.70**	0.71**	0.75*	0.74*	0.79§
9–11 months	1.15	1.14	1.15	1.14	1.16
Place of birth:					
Home (reference category)	1.00	1.00	1.00	1.00	1.00
Health facility	2.56***	1.69***	1.62***	1.67***	1.78***
Gender of child:					
Female (reference category)	1.00	1.00	1.00	1.00	1.00
Male	0.95	0.95	0.94	0.94	0.93
Rank of birth (range 1–14)	0.96**	0.95**	0.96**	0.97§	0.97§
Immunization card was seen:					
No (reference category)	1.00	1.00	1.00	1.00	1.00
Yes	1.89***	1.39*	1.38*	1.47**	1.34*
<i>Mother/household characteristics</i>					
Mother's education:					
No formal education (reference category)	—	1.00	1.00	1.00	1.00
Primary	—	0.88	0.93	0.97	0.95
Secondary and above	—	1.12	1.13	1.16	1.23§
Mother received antenatal care during pregnancy	—	2.45***	2.32***	2.31***	2.28***
Mother knows the timing of routine immunization visits	—	1.38**	1.43**	1.44**	1.38**
Mother was exposed to information on child health through the media or community sources during last six months	—	1.37***	1.24**	1.29**	1.33***
Mother's awareness about vaccine-preventable diseases:					
Low level (reference category)	—	1.00	1.00	1.00	1.00
High level	—	1.88***	1.73***	1.65***	1.52***
Mother was encouraged by someone to immunize the child during the last year	—	1.35***	1.27***	1.34***	1.25**
Mother has someone to assist with taking the child for immunization	—	1.50***	1.25*	1.24*	1.25*
Household socio-economic status:					
Low (reference category)	—	1.00	1.00	1.00	1.00
Medium	—	0.95	0.91	0.98	0.95
High	—	0.94	0.85	1.02	1.02
Spouse (child's father) approves of immunization	—	2.78***	2.51***	2.44***	2.42***

continues

Table 2: cont.

<i>Community</i>					
Community activism: presence of individuals or group that educate community about immunization	—	—	2.32***	2.41***	2.24***
Condition of access roads in the local government area:					
Poor (reference category)	—	—	1.00	1.00	1.00
Fair			1.76***	1.54***	1.19§
Very good			2.17***	2.04***	1.10
<i>Service provision</i>					
Regularity of vaccine supply to health facility during last 12 months:					
Irregular (average: <2/month) (reference category)	—	—	—	1.00	1.00
Fairly regular (average: 2–3 times/month)				1.35*	1.32*
Very regular (average: >3 times/month)				2.02***	1.75***
BCG included in last vaccines supply to health facility:					
Not included (reference category)	—	—	—	1.00	1.00
Included				1.21*	1.09
Interaction terms:					
Fairly regular vaccine supply X medium socio-economic status	—	—	—	0.87	0.85
Fairly regular vaccine supply X high socio-economic status				0.55**	0.67§
Very regular vaccine supply X medium socio-economic status				0.81	0.80
Very regular vaccine supply X high socio-economic status				0.77	0.74
<i>Policy environment</i>					
State of residence:					
Jigawa (reference category)	—	—	—	—	1.00
Katsina					2.41***
Yobe					1.51**
Zamfara					0.86
Pseudo- R^2	3.2%	13.4%	16.5%	17.4%	18.5%
Hosmer-Lemeshow goodness of fit: χ^2/p (10 groups)	10.6/0.226	8.2/0.409	8.5/0.384	1.9/0.982	6.6/0.584
Log likelihood ratio test: χ^2/p	—	568.5/.0001	176.3/0.0001	51.9/0.0001	60.9/0.0001
Number of observations	4242	4242	4242	4242	4242

Source: Babalola (2007) PRRINN Household Survey on Immunization.

§ $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Model 1 includes only child's characteristics; Model 2 includes maternal and household characteristics in addition to child's characteristics; Model 3 includes community variables in addition to the predictors in Model 2; Model 4 includes service indicators in addition to the predictors in Model 3; Model 4 includes a proxy for the policy environment in addition to the predictors in Model 4.

among the children aged six to eight months, probably due to shortage in vaccine supply some six to eight months prior to the survey. When other characteristics of the child were controlled for, the data do not show any significant differences between boys and girls.

The results of the log-likelihood test in model 2 reveal that the introduction of maternal and household characteristics leads to a noticeable increase in predictive power, compared to model 1. It is pertinent to note that the presence of maternal and household characteristics in this model appears to weaken the significance of immunization card ownership.

Model 2 shows the children whose father approves of immunization are almost three times as likely to be immunized as those whose father disapproves. Similarly, receiving antenatal care increases the odds of receiving BCG by more than twofold. Other maternal variables positively associated with BCG vaccination include:

- knowledge about vaccine-preventable diseases and the immunization schedule;
- exposure to child health information during the six months preceding the survey;
- receiving encouragement to immunize during the past year; and
- the availability of someone willing and able to assist with taking the child for routine immunization.

In contrast, the data show that neither household socio-economic status nor the mother's education are significantly related to BCG immunization status.

The two community variables introduced in model 3 jointly contribute significantly to predicting BCG immunization status. Living in a community where individuals or groups are involved in community activism around immunization is associated with more than a twofold increase in the odds of obtaining BCG. The data further show that the better the road network in a community, the more likely it is that a child will be immunized. Note that all the variables that were significant in the two previous models remain significant in this model, although some maternal variables have become less significant: the availability of a surrogate to help take the child for immunization should the mother not be available; and exposure to information on child health.

A previous version of model 4 suggests the presence of interaction effects between household socio-economic status and vaccine supply to the health facility, probably because the choice a place to live is not completely random but dependent on socio-economic status. Therefore, interaction effects were included between these two predictors in the estimated model. The results demonstrate the importance of supply factors and reveal a positive and strong relationship between regularity of supply and immunization status. The data also show that BCG vaccine supply is a strong predictor of BCG immunization status, increas-

ing the odds of obtaining the vaccine by 21 percent. In addition, the model confirms that socio-economic status is not related significantly to immunization status, although it shows that high socio-economic status affects the relationship between vaccine supply and BCG immunization status. Specifically, the positive effects of vaccine supply appears reduced among children from high socio-economic households, probably because rich parents are better able to overcome the limitations of irregular vaccine supply and source vaccines for their children outside of their communities.

Model 5 demonstrates the importance of the policy environment for BCG immunization status beyond what could be due to differences among states in the child's characteristics, maternal and household factors, community factors and quality of immunization service provision. Moreover, inclusion of the measure of the policy environment in model 5 results in a marked decrease in the predictive value of some of the variables that were significant in earlier models. For example, the relatively lower odds of obtaining BCG that were noticed in previous models among the children aged six to eight months has practically disappeared. Similarly, the presence of the state of residence completely obliterates the strong positive 'effects' of BCG vaccine supply and good road networks. In contrast, some child characteristics, maternal and household factors, community variables and service delivery factors apparently have strong effects that are independent of the policy environment. These include:

- facility-based birth;
- availability of an immunization card;
- maternal use of prenatal care;
- maternal knowledge about immunization; and
- social influence.

Other predictors whose effects appear to transcend the policy environment include paternal approval of immunization, community activism and regularity of vaccine supply to the health facility.

In sum, each of the five categories of predictors contributes meaningfully to predicting BCG immunization status. The data show that the largest contribution comes from maternal and household factors. An analysis of variance found that about 55 percent of the explained variance is due to maternal and household factors, while 19.3 percent is attributable to the child's characteristics. Community activism and the condition of road networks contribute 15.2 percent of the explained variance. Vaccine supply factors and the policy environment contribute 3.6 percent and 6.9 percent respectively.

Discussion and conclusion

This article has examined the roles of multiple layers of factors in predicting BCG immunization status using a behavioral-ecological model. The findings that facility-based birth and ownership of an immunization card significantly and independently increase the chances of obtaining BCG, make intuitive sense, and are consistent with previous findings (Chhabra et al., 2007; Waters et al., 2004). Similarly, the finding that use of antenatal care by the mother is associated with increased odds of obtaining immunization is not new (Bates and Wolinsky, 1998). In contrast to what some previous studies have documented (Bates and Wolinsky, 1998; Bobo et al., 1993; Chhabra et al., 2007), this study found no independent association between immunization status and the mother's education or household socio-economic status. In this respect, its findings are similar to those of Al-Sheikh et al. (1999) for Iraq.

Furthermore, this study corroborates the findings of previous works and documents the importance of maternal knowledge about immunization (e.g. Bardenheier et al., 2003). The finding that the availability of a person to assist with taking the child for immunization increases the odds of obtaining BCG vaccine is in consonance with evidence from other cultural settings (e.g. Bates and Wolinsky, 1998), whereas it is in discordance with findings from other studies (e.g. Wood et al., 1998). In addition, this study demonstrated the positive and significant role of social influence in immunization status: children whose mothers were encouraged by someone to immunize their children were more likely to have received the BCG vaccine; this finding echoes what other studies have documented (e.g. Nuwaha et al., 2000). A related finding was the strong predictive role of groups or individuals that educate the community about immunization.

The finding that the regularity of vaccine supplies to the health facility significantly increases the odds of BCG immunization status is not surprising and reverberates evidence from many other studies (e.g. Al-Sheikh et al., 1999). Similarly, the finding that the state of residence is associated significantly and independently with BCG immunization status is as expected. The state is responsible for hiring and remunerating key immunization officials, disbursing funds for immunization activities, collecting vaccines from zonal vaccine cold stores, distributing vaccines to local government cold stores and enforcing immunization-related rules and regulations. It is clear that problems with the discharge of these key responsibilities can have significant ripple effects on immunization status in the state.

The greater importance of maternal and household factors relative to other factors testifies to the vital role of parental ideation and behavior in determining BCG immunization status. It is possible that due to the present study's choice of dependent variable, its results may have understated the relative importance of vaccine supply factors. Indeed, by focusing on the chances that a child will receive

BCG vaccine at any time during the first year of life, it is implicitly modeling the possibility that a caregiver could return to the health facility for a vaccine that was out of stock during an earlier visit. Had the study looked at the chances of obtaining BCG at birth or within the first week of life, it is likely that supply factors would have appeared to be more important.

It is pertinent to note that the predictive role of the child's age, BCG vaccine supply and conditions of road networks tapered off when the indicator of policy environment was introduced into the estimated model. Thus it seems that the apparent roles of these variables are attributable to factors operating at the state level.

Furthermore, this study demonstrates the relevance of a behavioral-ecological model in explaining BCG immunization status. For example, not including the policy environment could have resulted in model misspecification, thereby mis-estimating the predictive value of some variables in the model, especially some community and institutional variables.

The findings from this study have important programmatic implications. Obviously, efforts to promote childhood immunization will be more effective if they adopt a multilevel strategy, with targeted activities at the child, parental or household, community, service delivery and macro levels. The strong predictive roles of a child's place of birth and maternal use of antenatal care suggest that, for a specific child, efforts to promote BCG vaccination should start long before the birth of the child. Specifically, it is important to promote the use of medical health services for antenatal care and child delivery. Nonetheless, it is worth noting that the majority of births in northern Nigeria and similar regions occur outside of a health facility, usually attended by a traditional birth attendant. It is reasonable to assume that this pattern will continue in the short term. Therefore, interventions that target traditional birth attendants and seek to educate them about childhood immunization and motivate them to refer their clients to health facilities for childhood immunization are relevant.

Interventions aimed at the household level should target not only the mothers of infants but also the key decision-makers within the household, usually the male head of household. It is equally important to promote discussions about childhood immunization and encourage community members to advocate individually in favor of childhood immunization among their friends and family. In the same vein, there is a clear need for community interventions that emphasize community involvement in providing logistic support to mothers to facilitate child immunization, encourage community leaders to be positive role models in child immunization and support, and seeking to increase the capacity of community groups that promote childhood immunization.

There is no gainsaying the fact that the best communication and community mobilization efforts will yield little positive results without concomitant efforts to ensure the regular availability of vaccines and relevant supplies in health facilities and improve the technical and interpersonal skills of providers. Equally

relevant are advocacy efforts and structural interventions that seek to enable the local, state and federal tiers of government to play their mandated roles in respect of child immunization more efficiently.

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References

- Al-Sheikh, O.G., Al-Samarrai, J.I., Al-Sumaidaie, M.M., Mohammad, S.A. and Al-Dujaily, A.A. (1999) 'Immunization Coverage among Children Born between 1989 and 1994 in Saladdin Governorate, Iraq', *Eastern Mediterranean Health Journal* 5(5): 933–40.
- Anand, S. and Bärnighausen T. (2007) 'Health Workers and Vaccination Coverage in Developing Countries: an Econometric Analysis', *Lancet* 369(9569): 1277–85.
- Babalola, S. (2007) 'Household Baseline Survey on Factors Affecting Routine Immunization in Northern Nigeria, July/August 2007: Report of Pertinent Findings', report submitted to PRRINN (Available online at: http://www.jhuccp.org/africa/nigeria/documents/prinn_finalhousehold.pdf).
- Bardenheier, B., Gonzalez, I., Washington, M., Bell, B., Averhoff, F. Massoudi, M., Hyams, I., Simard, E. and Yusuf, H. (2003) 'Parental Knowledge, Attitudes and Practices Associated with Not Receiving Hepatitis A Vaccine in a Demonstration Project in Butte County, California', *Pediatrics* 112(4): e269–74.
- Bates, A.S and Wolinsky F.D. (1998) 'Personal, Financial and Structural Barriers to Immunization in Socioeconomically Disadvantaged Urban Children', *Pediatrics* 101(4): 591–6.
- Belcher, D.W., Nicholas, D.D., Ofori-Amaah, S. and Wurapa, F.K. (1978) 'A Mass Immunization Campaign in Rural Ghana: Factors Affecting Participation', *Public Health Reports* 93(2): 170–6.
- Bobo, J.K., Gale, J.L., Thapa, P.B. and Wassilak, S.G. (1993) 'Risk Factors for Delayed Immunization in a Random Sample of 1163 Children from Oregon and Washington', *Pediatrics* 91(2): 308–14.
- Brofenbrenner, U. (1977) 'Toward an Experimental Ecology of Human Development', *American Psychologist* 32(7): 513–31.
- Chhabra, P., Nair, P., Gupta, A., Sandhir, M. and Kannan, A.T. (2007) 'Immunization in Urbanized Villages of Delhi', *Indian Journal of Pediatrics* 74(2): 131–4.

- Cohen, D.A., Scribner, R.A. and Farley, T.A. (2000) 'A Structural Model of Health Behavior: a Pragmatic Approach to Explain and Influence Health Behaviors at the Population Level', *Preventive Medicine* 30(2): 146–54.
- Cohen, D.A., Mason, K., Bedimo, A., Scribner, R., Basolo, V. and Farley, T.A. (2003) 'Neighborhood Physical Conditions and Health', *American Journal of Public Health* 93(3): 467–71.
- Cohen, L. and Chehimi, S. (2007) 'Beyond Brochures: the Imperative for Primary Prevention', in L. Cohen, V. Chavez and S. Chehimi (eds) *Prevention Is Primary: Strategies for Community Well Being*, pp. 3–24. San Francisco, CA: Jossey-Bass.
- Cutts, F.T., Rodrigues, L.C., Colombo, S. and Bennett S. (1989) 'Evaluation of Factors Influencing Vaccine Uptake in Mozambique', *International Journal of Epidemiology* 18(2): 427–33.
- Cutts, F.T., Diallo, S., Zell, E.R. and Rhodes, P. (1991) 'Determinants of Vaccination in an Urban Population in Conakry, Guinea', *International Journal of Epidemiology* 20(4): 1099–1106.
- Favin, M., Naimoli, G. and Sherburne, L. (2004) *Improving Health through Behavior Change: A Process Guide on Hygiene Promotion*, Joint Publication 7, URL (consulted 22 December 2007): http://www.ehproject.org/PDF/Joint_Publications/JP007-CIMCIProcessGuideWeb.pdf.
- Feilden Battersby Analysts (2005) *The State of Routine Immunization Services In Nigeria and Reasons for Current Problems*. Bath: Health Systems Analysts, Feilden Battersby Analysts, URL (consulted 15 December 2007): <http://www.technet21.org/backgrounddocs.html>.
- Gage, A.J., Sommerfelt, E. and Piani, A. (1997) 'Household Structure and Childhood Immunization in Niger and Nigeria', *Demography* 34(2): 295–309.
- McLeroy, K., Bibeau, D., Steckler, A. and Glanz, K. (1988) 'An Ecological Perspective on Health Promotion Programs', *Health Education and Behavior* 15(4): 351–77.
- National Immunization Coverage Survey (NICS) Study Group (2007) *Preliminary Report on National Immunization Coverage Survey, 2006*. Abuja: National Program on Immunization.
- Nuwaha, F., Mulindwa, G., Kabwongyera, E. and Barenzi, J. (2000) 'Causes of Low Attendance at National Immunization Days for Polio Eradication in Bushenyi District, Uganda', *Tropical Medicine and International Health* 5(5): 364–9.
- 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.
- Sallis, J.F. and Owen, N. (2002) 'Ecological Models of Health Behavior', in G.K. Glanz, B.K. Rimer and F.M. Lewis (eds) *Health Behavior and Health Education: Theory, Research and Practice* (3rd edn), pp. 462–84. San Francisco, CA: Jossey-Bass.
- Waters, H., Dougherty, L., Tran, N., Charles, S., Tegang, S.P., Long, K., Wolfe, N.D. and Burke, D.S. (2004) 'Coverage and Costs of Childhood Immunizations in Cameroon', *Bulletin of the World Health Organization* 82(9): 668–75.
- Wood, D., Halfon, N., Donald-Sherbourne, C., Mazel, R., Schuster, M., Hamlin, J., Pereyra, M., Camp, P., Grabowsky, M. and Duan, N. (1998) 'Increasing Immunization Rates among Inner-city, African American Children: a Randomized Trial of Case Management', *Journal of the American Medical Association* 279(1): 29–34.

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