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ORIGINAL ARTICLE

Assessing full immunisation coverage using lot quality assurance sampling in urban and rural districts of southwest Nigeria

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Background: This study was conducted to identify administrative wards (lots) with unacceptable levels of full child immunisation coverage, and to identify factors associated with achievement of a complete child immunisation schedule in Ibadan North East (IBNE) and Ido local government areas (LGAs) of Oyo State, Nigeria.

Methods: A cross-sectional survey involving 1178 mothers, 588 from IBNE LGAs and 590 from Ido LGAs, with children 12–23 months of age was conducted. Children were considered 'fully-immunised' if they received all the vaccines included in the immunisation schedule. Lot quality assurance sampling was used to determine lots with acceptable and non-acceptable coverage. Samples were weighted based on the population by lot to estimate overall coverage in the two LGAs and a logistic regression model was used to identify factors associated with the fully immunised child.

Results: Mean age of the mothers was 28.5 ± 5.6 and 28.1 ± 6.0 years in IBNE and Ido LGAs, respectively. Eleven of 12 wards in IBNE and all the wards in Ido had unacceptable coverage. The proportion of fully immunised children was 40.2% in IBNE and 41.3% in Ido. Maternal age $\geq$30 years, retention of an immunisation card, completion of tertiary education, or secondary education, hospital birth and first-order birth were significant predictors of complete childhood immunisation.

Conclusion: The level of full immunisation coverage was unacceptable in almost all the wards. Educational intervention on the importance of completion of immunisation schedule should target young, uneducated mothers, mothers who delivered their babies at home and those with a high birth order.

Keywords: Immunisation coverage, Full immunisation, Vaccination schedule, Lot quality assurance sampling, Nigeria, Vaccine preventable diseases

Introduction

The importance of a high quality routine immunisation delivery system as part of a comprehensive primary health care system in reducing childhood morbidity and mortality has been well-described.[1] Over the past three decades, since 1978, substantial resources have been invested through global initiatives and programmes to scale up immunisation coverage.[1,2] In Nigeria, despite a high level of political will demonstrated in recent times by the government, and appreciable contributions made by development partners to boost immunisation service delivery, coverage remains generally low with administrative and survey data showing inconsistencies.[3] Of the estimated six million Nigerian children born every year, more than one million fail to complete appropriate vaccination by their first birthday.[4] An analysis of the immunisation programme in the country indicated a weak system with most immunisation activities still conducted through vaccination campaigns especially in the northern states. Inefficient use of funds, vaccine stock outs, poor accountability, unreliable administrative data, poor access and poor demand for services are among identified barriers to immunisation coverage.[5] Although Nigeria has maintained a very high, though declining incidence of poliomyelitis and measles over the years, and served as a reservoir for the international spread of poliomyelitis and measles, a multifaceted approach to strengthen the immunisation delivery system has brought about a number of improvements.[3,6] These improvements include an improved cold chain system across the country, increased community awareness and participation, adoption of the reaching every district (RED) strategy and capacity building for immunisation service delivery personnel. Findings from immunisation system analysis, including the National Immunisation Coverage Surveys (NICS; 2003, 2006 and 2010), and the National Demographic Health Survey (NDHS; 2003 and 2008), show an increasing trend in national full immunisation coverage from 13% in 2003 to 53% in 2010.[3] During the 2000 to 2010 decade, the coverage for the third dose of diphtheria-pertussis-tetanus (DPT) vaccine increased from 29 to 69%.[3,4] However, substantial gaps exist between the target and overall coverage, as well as coverage between various geo-political zones, including rural and urban locations in the country.[4]

Improving immunisation coverage requires regular assessment of the immunisation delivery system to determine whether programme objectives are being met, to identify problems and causes of low coverage, and to plan activities to increase coverage.[7] Various methods have been used to assess immunisation coverage on a routine and periodic basis,[1–30] including the routinely collected data during service delivery for the immunisation information system (administrative data), the NICS, the NDHS and the Multiple Indicator Cluster Survey (MICS). The sampling designs for the various survey methods differ. The two most often used sampling designs are the 30 x 7 cluster method and the lot quality assurance sampling (LQAS) method.[13] Immunisation coverage has been commonly evaluated in Nigeria using the 30-cluster sampling method, as recommended by the World Health Organization.[3,11,12,26] While the 30-cluster sampling method offers valuable information about the status of overall immunisation coverage, it does not indicate the precise location of areas where vaccination coverage is low.[13] The LQAS method was adapted from industry for use in primary health care, using only a small sample size to differentiate clearly between areas that have or have not met performance targets. The detailed descriptions of the two sampling strategies, relative advantages and disadvantages of the sampling strategies, as well as the operational feasibility of the sampling strategies have been described.[13–24]

Despite the relative advantage of the LQAS to identify small subunits where immunisation has not been delivered adequately, very few published studies have utilized the LQAS to monitor or evaluate immunisation performance in Nigeria.[14] Information about specific areas with low coverage could help programme managers prioritize areas for deployment of resources and supportive supervision, as well as identification of the causes of low coverage and potential solutions.[17] The current study was conducted in March 2012 to evaluate the routine immunisation programme using the LQAS and to identify factors associated with non completion of immunisation schedule in two local government areas (LGAs; one urban and one rural LGA of Ibadan) located in southwest Nigeria.

Methods

Study setting

Ibadan is the capital of Oyo-State and the third largest metropolitan city in Nigeria, with a population of 1 338 659 according to the 2006 population census. Ibadan is comprised of 11 LGAs; of which five are urban and six are rural, based on locations of their headquarters.[15] Two LGAs, Ibadan North East (IBNE) and Ido, were purposively selected for this survey because they had the lowest rates of full immunisation against vaccine-preventable childhood diseases among the urban and rural LGAs, respectively based on the NDHS, 2008 survey report.[15] The total population in these LGAs in 2010 based on projections from the 2006 census was 374 772 in IBNE and 118 037 in Ido. The LGAs are further divided into administrative wards (12 in IBNE and 10 in Ido; Figure 1). Vaccine delivery in the LGAs is through routine vaccination, with supplemental vaccination campaigns conducted for OPV twice a year. The Federal Government of Nigeria is responsible for the distribution of vaccine to the State, from where the LGAs collect their vaccines. The health facilities in the wards collect vaccines from the LGAs depending on session plans and storage capacity.[3]

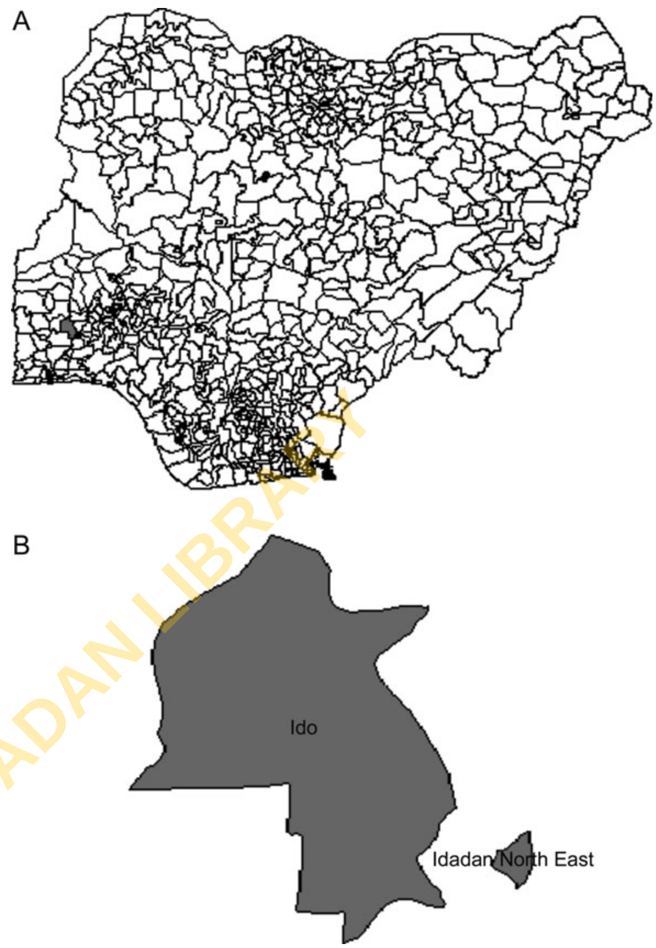

Figure 1. Map of Ibadan North East and Ido Local Government Areas showing their (A) locations within Nigeria and (B) relative locations to each other

Study design

A comparative cross-sectional study design was used. The study population consisted of household caregivers/mothers of children, 12–23 months of age, who were resident in the LGAs at the time of the survey. The LQAS technique was used to determine administrative wards (lots) with acceptable or unacceptable vaccination coverage. The two LGAs were covered by 22 non-overlapping lots, 12 in IBNE and 10 in Ido.

Sample size determination

In estimating the sample size required per lot, we assumed that the variable of interest, full immunisation coverage, follows binomial distribution. We set a low threshold of 53% of fully immunised children (coverage figure achieved in Oyo state and obtained from NICS 2006) and a high threshold of 80% of immunisation coverage for all antigens, which is the immunisation target set in the national programme objectives.[3] We used the single sampling plan for LQAS nomogram, previously described,[31] to obtain a sample size of 33 at type 1 error of 1% and type 2 error of 20% in a one-sided test. We increased the sample size per lot in order to be able to analyse risk factors for vaccination/non vaccination for each LGA as follows. We determined that children, 12–23 months of age, from approximately 580 households in each LGA were required to obtain a $\geq$ 10% difference in full immunisation coverage between the urban (55%) and rural LGAs (45%) assuming a two-sided test, a power of 90%, a non-response rate and a level of significance of 5% each. We designated the administrative wards as non overlapping lots and divided the sample size in each LGA by the number of lots to obtain the lot sample size required.[17] An approximate total of 49 and 59 participants was thus required per lot in the IBNE and Ido LGAs, respectively. To set our decision value, which is the highest number of individuals in a lot that had not completed the immunisation schedule and yet classified the lot as acceptable, we used the freeware programme SampleLQ, a sampling plan calculator for LQAS survey,[32] and obtained decision values of 16 and 19 for lots in IBNE and Ido LGAs, respectively with misclassification probabilities of $\alpha = 1\%$ and $\beta = 2–4\%$.

Sampling procedure

We used the grid technique to select eligible participants from each lot.[17,24] The sampling procedure entailed two stages: the primary sampling units being the squares in the grid placed over the lot map and the second sampling units, the households in the squares. To select the sample points (equivalent to the sample size per lot) from a lot, we first selected sampling point areas using a grid placed over the lot map. Maps of the lots were obtained from the immunisation sections of the primary health care of each LGA department. These maps were developed from the LGA maps by the LGA cartographers and were used by house-to-house vaccination teams after an update for each round of the national immunisation days for polio immunisation campaign. Ten rows and 10 columns of the grid were numbered and by simple random sampling technique, using the table of random numbers, we selected an adequate number of sample point areas based on the lot sample size from 00–99. The double-digit numbers represent squares on the grid. The households selected in a sampling point area were identified during data collection by spinning a pen at the center of the selected area, spin-the-pen (random walk), a method, which has been described in several manuals[17,20,23,24] The households in the direction indicated by the pen were numbered from the centre to the border of the lot. One household was then randomly selected, using table of random numbers, as the only household surveyed in a sampling point area. This procedure was repeated for every sampling point in each lot.

Outcome measures

The vaccination schedule in Nigeria included Bacille Calmette-Guerin (BCG) given at birth and administered intradermally on the outer-upper left arm or shoulder over the insertion of the deltoid muscle. In addition, four doses of oral polio vaccine (OPV) and three doses each of DPT and hepatitis B were administered intramuscularly on the outer mid-thigh. The OPV was administered at 0, 6, 10 and 14 weeks of age. The DPT was administered at 6, 10 and 14 weeks of age. Hepatitis B was given at 0, 6 and 14 weeks of age. Furthermore, one dose each of measles and yellow fever vaccines were administered subcutaneously to the left and right upper-arms, respectively, at 9 months of age.[3,23] A fully immunised child was a child who had received all of the immunisations recommended in the official immunisation schedule by the age of 12 months. Although, a partially immunised child has not received all of the immunisations, he or she has received at least one of the vaccines, whereas an unvaccinated child has not received any of the immunisations recommended in the schedule.

Data collection

The unit of enquiries was mothers or household caregivers of children, 12–23 months of age, who gave verbal informed consent. If a caregiver had more than one child in the set age group, information on the immunisation of a child which was randomly selected using balloting was obtained. A questionnaire adapted from the standard Expanded Programme on Immunisation survey was used for data collection.[17,20,23,24] The data obtained included the sociodemographic characteristics of the caregivers, and immunisation status of the children and reasons for non-vaccination or non-completion of vaccination schedule. A valid immunisation status was determined by examining the vaccination card of the child. In its absence, a history (verbal report) was taken that included a description of the site, and when and how vaccinations were administered. In addition, evidence of a scar on the skin over the insertion of the deltoid muscle on the left upper arm was used as a confirmation of receipt of BCG. A child was not immunised for a particular antigen if there was no evidence from the card, observation or from questioning that s/he had received vaccination with the antigen. A child was considered fully immunised if there was evidence of administration of all antigens in the schedule (excluding a birth dose of OPV) and partially immunised if any one dose was missing. Caregivers who reported partial or no vaccination of their children were requested to indicate the reasons for non-vaccination/non completion of vaccination from a list. Trained interviewers assisted in data collection.

Data analysis

Data were entered and analysed using SPSS version 17 (SPSS Inc., Chicago, IL, USA). Full childhood immunisation coverage was estimated by calculating the proportion of children who were fully immunised at 12 months of age. We classified the lots as with acceptable coverage if $\leq$16 and $\leq$19 not fully vaccinated children were found in lots located in IBNE and Ido LGAs respectively. Otherwise lots were deemed unacceptable or rejected. To provide overall full immunisation coverage estimates for each LGA, lot sample sizes were weighted by ward population

Table 1. Sociodemographic characteristics of household caregivers/mothers of children 12–23 months in Ibadan North East (IBNE) and Ido Local Government Areas, Nigeria, March 2012

Variables	IBNE n = 588 n (%)	Ido n = 590 n (%)	p-value
Mean age ± SD years	28.5 ± 5.6	28.1 ± 6.0	NS
Age group in years			
<20	17 (2.9)	20 (3.4)	
20-24	125 (21.3)	142 (24.1)	
25-29	197 (33.5)	189 (32.0)	
30-34	147 (25.0)	129 (21.9)	
≥35	102 (17.3)	110 (18.6)	
Marital/Living Status			NS
Single	14 (2.4)	15 (2.5)	
Married, living with spouse	574 (97.6)	575 (97.4)	
Religion			<0.001
Christianity	217 (36.9)	301 (51.0)	
Islam	367 (62.4)	286 (48.5)	
Traditional	4 (0.7)	3 (0.5)	
Ethnic grouping			<0.001
Yoruba	575 (97.8)	446 (75.6)	
Ibo	10 (1.7)	16 (2.7)	
Hausa	1 (0.2)	10 (1.7)	
Others	2 (0.3)	118 (20.0)	
Educational level completed			<0.001
None	22 (3.7)	107 (18.1)	
Primary	214 (36.4)	254 (43.1)	
Secondary	320 (54.4)	203 (34.4)	
Post-secondary	32 (5.4)	26 (4.4)	
Employment Status			NS
Salaried employment	27 (4.6)	25 (4.2)	
Self-employment	523 (88.9)	535 (90.7)	NS
Unemployment/housewife	38 (6.5)	30 (5.1)	
Number of Children			
1	110 (18.7)	103 (17.5)	
2	132 (22.4)	145 (24.6)	
3	164 (27.9)	142 (24.1)	
≥4	182 (30.9)	200 (33.9)	
Gender of index child			NS
Male	300 (51.0)	285 (48.3)	
Female	288 (49.0)	305 (51.7)	
Position of index child (birth order)			NS
1	118 (20.1)	115 (19.5)	
2	130 (22.1)	140 (23.7)	
3 ≥	168 (28.6)172 (29.3)	143 (24.2)192 (32.5)	
Place of birth of index child			<0.001
Hospital	337 (57.3)	297 (50.3)	
Mission house/non-orthodox	161 (27.4)	108 (18.3)	
Home	90 (15.3)	185 (31.4)	
Walking distance to nearest health facility			<0.001
≤ 10 minutes	267 (45.4)	331 (56.1)	
>10 minutes	321 (54.6)	259 (43.9)	
Retention of immunisation card			0.02
Yes	425 (72.3)	393 (66.6)	
No	163 (27.7)	197 (33.4)	

NS: Not statistically significant at the p = 0.05 level.

Table 2. Adminstrative wards' (lots') performance in Ibadan North East (IBNE) and Ido Local Government Areas, Nigeria, March 2012

Local government	Lot's name	No. of children sample	No. of un-vaccinated children	No. of partially vaccinated children	No. of fully vaccinated children	Decision
Ido [a]	Akinware	59	10	36	13	Reject
	Akufo	59	19	32	8	Reject
	Apete	59	8	22	29	Reject
	Batake	59	15	31	13	Reject
	Eriwusin	59	14	30	15	Reject
	Gbekuba	59	4	19	36	Reject
	Ido	59	8	28	23	Reject
	Ilaju	59	23	23	13	Reject
	Ogundele	59	7	20	32	Reject
	Omi Adio	59	21	20	18	Reject
	Total	590	129 (21.9%)	261 (44.2%)	200 (33.9%)	
IBNE [b]	Agugu	49	8	15	26	Reject
	Alafara	49	1	26	22	Reject
	Aperin	49	3	33	13	Reject
	Basorun	49	3	8	38	Accept
	Irefin	49	17	17	15	Reject
	Ode Aje	49	10	27	12	Reject
	OdoOsun	49	8	23	18	Reject
	Oja'gbo	49	6	27	16	Reject
	Okeadu	49	11	18	20	Reject
	Oranyan	49	4	25	20	Reject
	Atipe	49	8	25	16	Reject
	Oje	49	13	24	12	Reject
	Total	588	92 (15.7%)	268 (45.6%)	228 (38.8%)	
	Total sample	1178	221 (18.8%)	529 (44.9%)	428 (36.4%)	
Ido and IBNE local governments						

[a] Accept the lot if no. of un-vaccinated children + no. of partially vaccinated children ≤19 ($\alpha = 0.01$; $\beta = 0.02$), otherwise reject.
[b] Accept the lot if no. of un-vaccinated children + no. of partially vaccinated children ≤16 ($\alpha = 0.01$; $\beta = 0.04$), otherwise reject.

projections. Bivariate association between household caregivers, including child demographic characteristics and full child immunisation status, were evaluated using the χ^2 test. The unadjusted ORs and 95% CIs were also calculated. A multivariate binary logistic regression model with full child immunisation as a dependent variable was built to assess the association for possible confounding variables. Independent variables that were significant ($p<0.2$) at the bivariate level were included in the model. The model was interpreted with adjusted ORs (aORs) and corresponding 95% CIs.

Results

Sample description

A total of 1178 interviews were conducted; 588 mothers responded in the IBNE LGA and 590 mothers responded in the Ido LGA. Table 1 shows a comparison of the sociodemographic characteristics and other attributes of women interviewed in the two LGAs. The proportion of women who retained their child immunisation cards was significantly higher in the IBNE LGA (425, 72.3%) than the Ido LGA (393, 66.6%). Furthermore, the ethnic and religion groupings were significantly different in the two LGAs (Table 1).

Lots' performance and vaccination coverage

Eleven of 12 and all 10 lots in the IBNE and Ido LGAs, respectively, were shown to have unacceptable levels of full immunisation coverage (Table 2). A significant proportion of children (221,18.8%) did not receive any of the antigens in the IBNE (92,15.7%) and Ido LGAs (129, 21.9%). The BCG vaccine had the highest percentage of immunisation coverage (476, 81.0 % and 423, 71.7%), while the yellow fever vaccine had the lowest coverage (244, 41.5% and 228, 38.6%) in the IBNE and Ido LGAs, respectively. The weighted full immunisation coverage was 40.2% (228) in the IBNE and 41.3% (200) in the Ido LGAs (Table 3).

Reasons for non-vaccination or not completing vaccination schedule

The most frequent reasons for not completing the immunisation schedule across the two LGAs (n = 750) as shown in Table 4,

Table 3. Vaccination coverage among children 12–23 months old in Ibadan North East and Ido Local Government Areas (LGAs), Nigeria, March 2012.

Vaccination coverage	IBNE		Ido		Total	
	Card only n = 425 n (%)	Card or verbal report n = 588 n (%)	Card only n = 393 n (%)	Card or verbal report n = 590 n (%)	Card only n = 818 n (%)	Card or verbal report n = 1178 n (%)
Coverage by immunization type						
BCG	407 (95.8)	476 (81.0)	360 (91.6)	423 (71.7)	767 (93.8)	899 (76.3)
DPT1	377 (88.7)	432 (73.5)	340 (86.5)	381 (64.6)	717 (87.7)	813 (69.0)
DPT2	311 (73.2)	362 (61.6)	287 (73.0)	322 (54.6)	598 (73.1)	684 (58.1)
DPT3	269 (63.3)	319 (54.3)	245 (62.3)	279 (47.3)	514 (62.8)	598 (50.8)
OPV1	402 (94.6)	535 (91.0)	363 (92.4)	528 (89.5)	765 (93.5)	1063 (90.2)
OPV2	364 (85.6)	485 (82.5)	314 (79.9)	463 (78.5)	678 (82.9)	948 (80.5)
OPV3	337 (79.3)	443 (75.3)	287 (73.2)	425 (72.0)	624 (76.4)	868 (73.7)
HBV1	402 (94.6)	469 (79.8)	368 (93.9)	427 (72.4)	770 (94.2)	896 (76.1)
HBV2	358 (84.2)	412 (70.1)	316 (80.6)	352 (59.7)	674 (82.5)	764 (64.9)
HBV3	277 (65.2)	327 (55.6)	262 (66.8)	296 (50.2)	539 (66.0)	623 (52.9)
Measles	218 (51.3)	254 (43.2)	211 (53.8)	241 (40.9)	429 (52.5)	495 (42.0)
Yellow fever	209 (49.2)	244 (41.5)	198 (50.5)	228 (38.6)	407 (49.8)	472 (40.1)
Un-weighted full vaccination coverage	195 (45.9)	228 (38.8)	172 (43.8)	200 (34.0)	367 (44.9)	428 (36.3)
Weighted full vaccination coverage[a]		228 (40.2)		200 (41.3)		

[a]Obtained by aggregating lots full vaccination coverage in each local government area (LGA) after assigning weights to each lot. Weighted full vaccination coverage in an LGA % = [Summation (proportion of fully vaccinated in a lot * lot weight) for all lots in an LGA]*100. Weight for a lot was obtained by dividing the lot population by the LGA total population.

included fear of side effects (117, 15.6%), lack of awareness of the need for immunisation/subsequent dose (112, 14.9%), and parent too busy to take the child for immunisation (64, 8.5%).

Factors associated with being fully vaccinated

Bivariate analysis showed that maternal age ($p = 0.02$), ethnic grouping ($p = 0.002$), level of education completed ($p < 0.001$), birth order ($p = 0.008$), place of birth ($p < 0.001$), and immunisation card retention ($p < 0.001$) were significantly associated with completion of the immunisation schedule. However, based on multivariate logistic regression, maternal age ≥30 years (aOR = 1.5; 95% CI,1.1–2.1), retention of the immunisation card (aOR = 3.1; 95% CI, 2.2–4.3), completion of a tertiary education (aOR = 15.0; 95% CI, 5.8–39.1), completion of a secondary education (aOR = 1.9; 95% CI, 1.1–3.2), hospital birth (aOR = 1.8; 95% CI, 1.2–2.6), birth at a mission house (aOR = 1.6; 95% CI, 1.1–2.5), and first order birth (aOR = 1.4; 95% CI, 1.1–2.5) were significant predictors of the full childhood immunisation schedule (Table 5).

Discussion

We evaluated the routine immunisation programme among children 12–23 months old in IBNE and Ido LGAs of Ibadan, Oyo State, south-west Nigeria using the LQAS technique. Eleven of 12 and all 10 lots in IBNE and Ido LGAs respectively were identified to have unacceptable levels of full immunisation coverage. The proportion of children who did not receive any vaccine was 15.7% in IBNE and 21.9% in Ido LGA. The weighted full vaccination coverage was 40.2 and 41.3% in IBNE and Ido respectively. Reasons for non completion of vaccination or non vaccination were similar in the two LGAs and were mainly fear of side effects and lack of awareness of the need for immunisation. Factors found to positively influence completion of the immunisation schedule in the present study after adjustment included mothers completion of tertiary education, immunisation card retention, having employment, maternal age >30 years, child birth at a hospital or mission home and first birth order child.

Using the LQAS technique, we were able to classify lots in the two LGAs on the basis of vaccination coverage into acceptable and unacceptable levels. To evaluate OPV coverage in five Northern Nigeria States with ongoing transmission of wild polio virus, Greenland et al. in 2009, pioneered a similar technique to classify 18 of 20 LGAs (lots) into three levels of insufficiently covered areas during one of the subnational polio immunisation campaigns, for which corrective actions were required.[14] Since then, LQAS has been recommended and implemented as one of the major means of evaluating every round of polio immunisation campaign in Nigeria.[3,4] Although we found the method we used to be time consuming, because we had to go to each sampling point to randomly select a participant, this time could potentially be reduced by using global positioning systems (GPS) hand held units to locate the houses to be included in the study. In addition, LQAS can be much less expensive and time consuming if the lot is

Table 4. Reasons for non vaccination/non-completion of vaccination by household caregivers of children 12–23 months old in Ibadan North East (IBNE) and Ido local government areas, Nigeria, March 2012

Reasons for non-vaccination/ non completion of vaccination	Number of respondents		
	IBNE n = 360 n (%)	Ido n = 390 n (%)	Total n = 750 n (%)
Fear of side effects	58 (16.1)	59 (15.1)	117 (15.6)
Unaware of the need for immunization or of the need to return for next dose	49 (13.6)	63 (16.2)	112 (14.9)
Parent too busy	37 (10.3)	27 (6.9)	64 (8.5)
Vaccine not available	26 (7.2)	28 (7.2)	54 (7.2)
Child ill - not brought	28 (7.8)	19 (4.9)	47 (6.3)
Vaccinator absent	5 (1.4)	27 (6.9)	32 (4.3)
Family problem, including illness of mother	14 (3.9)	14 (3.6)	28 (3.7)
Place of immunisation too far	6 (1.7)	22 (5.6)	28 (3.7)
Fear of injections	11 (3.1)	16 (4.1)	27 (3.6)
Child ill - brought but was not given	6 (1.7)	17 (4.4)	23 (3.1)
Time of immunisation not convenient	2 (0.5)	16 (4.1)	18 (2.4)
Place and/or time of immunisation unknown	6 (1.7)	5 (1.3)	11 (1.5)
Long waiting time	5 (1.4)	5 (1.3)	10 (1.3)
Rumors (specify)	4 (1.1)	1 (0.3)	5 (0.7)
Vaccinator told mother that child was already immunised	2 (0.6)	3 (0.8)	5 (0.7)
Others	101 (28.1)	67 (17.2)	168 (22.4)

not completed once the decision value is reached. However, if the lots are not completed a weighted average vaccination coverage cannot be calculated as was done in this study. If the objective is only to identify areas with low vaccination coverage, this shorter version is sufficient and can even be carried out on one individual lot. The fact that one of the objectives of the present study was to evaluate risk factors for non and under vaccinated children and to compare them between LGAs means that we could not stop the data collection in each lot once the lot was rejected. Stopping the data collection at that point would have resulted in a biased and underpowered sample for the evaluation. We believe that the overall coverage estimated from the method is a good representation of the wards and the LGAs. The results could help to focus limited resources on areas with unacceptable coverage; however, the efficiency of this method is called into question where all or most lots have unacceptable lots such that all or nearly all need to be focused on as a result of general poor performance. For instance, in the present study, we found only one of 22 lots being acceptable. We had expected that there would be at least differences in the coverage within, and by lots located in the urban and rural LGAs because of differences in population density, difficult to reach communities, health-seeking behavior, educational level, distribution of health care facilities and healthcare workers. However, this finding implies that all the lots except one will require the same attention for intervention.

Despite nearly all lots being rejected, the majority of children in both LGAs did receive at least one vaccine. Children who are not vaccinated are at increased risk of acquiring vaccine-preventable diseases. In a similar study conducted in southeast Nigeria in which authors used the two-stage cluster survey method, all children were reported to have received at least one vaccine.[23] There is a tendency to assume that children with no vaccinations are similar to undervaccinated children. Studies among undervaccinated children have demonstrated that this is not so, hence the need to look at the characteristics of the unvaccinated children.[24,25] This information will be important in designing interventions that are tailored for this group. We intend to examine the characteristics of the unvaccinated children and make a comparison between them and partially or undervaccinated children in a future report.

The weighted full immunisation coverage was similar in the two LGAs. The proportions were lower than the average proportions obtained from the NICS for rural and urban areas in the State.[3] The vaccination levels observed in the two LGAs may not protect the population from epidemics of vaccine preventable diseases. To improve herd immunity from its current level of about 40% to a target of at least 80% for these diseases, therefore, there is the need to implement measures to increase full immunisation coverage in the areas. The BCG vaccination had the highest coverage as the first antigen in the schedule, suggesting good access to immunisation services. However, the proportion of yellow fever vaccines administered at 9 months of age showed the least coverage with a drop out of >20%, indicating poor utilization of the service. Poor utilization of services have been reported by reports of surveys carried out on immunisation in some other parts of Nigeria.[23,26]

The reasons for not completing or not receiving any vaccinations which were reported by participants including fear of side effects, lack of awareness of the need for immunisation/subsequent dose, and parents too busy to take child for vaccination are in agreement with the findings of other studies.[23,26] These findings suggest the need for education of mothers on the importance of immunisation and completion of immunisation schedules. In reports evaluating immunisation campaigns, child absent, household not visited, non-compliance or refusals were identified as major reasons for non vaccination.[3,14-16]

The finding that level of education completed was independently associated with completion of the immunisation schedule is consistent with findings from other reports.[23–30] In a study involving mothers in southeastern Nigeria, those who completed post-secondary education were twice as likely to have fully immunised children compared with those who completed primary or secondary education.[23] In the present study, the magnitude of effect was higher and a dose-response relationship was demonstrated. Although the knowledge and perception of mothers regarding completion of immunisation was not assessed in this study, educated mothers, compared to their uneducated counterparts, have been found to be better at assimilating information from health workers and the media.[23,26] Retention of the immunisation card by mothers was high: 72.3% in IBNE (425/588) and

Table 5. Socio-demographic determinants of full vaccination in Ido and Ibadan North East Local Government Areas, Nigeria, March 2012

Variables	Full immunisation n (%)	Row total	Crude OR (95% CI)	Adjusted OR (95% CI)
Maternal age in years				
≥30	197 (40.4)	488	1.4 (1.1–1.7)[b]	1.5 (1.1–2.1)[a]
<30	231 (33.5)	690	1	1
Marital status				
Married	420 (36.6)	1149	1.5 (0.6–3.5)	NA
Single	8 (27.6)	29	1	NA
Religion				
Christianity	199 (38.4)	518	1.2 (0.9–1.5)	0.9 (0.7–1.2)
Islam/traditional	229 (34.7)	660	1	1
Ethnic grouping				
Yoruba	388 (38.0)	1021	1.7 (1.2–2.6)[b]	1.1 (0.7–1.7)
All others	40 (25.5)	157	1	1
Educational level completed				
Tertiary	51 (87.9)	58	31.9 (12.9–78.9)[b]	15.0 (5.8–39.1)[a]
Secondary	225 (43.0)	523	3.3 (2.1–5.3)[b]	1.9 (1.1–3.2)[a]
Primary	128 (27.4)	468	1.7 (1.0–2.7)	1.1 (0.7–1.9)
None	24.0 (18.6)	129	1	1
Employment status				
Employed	409 (36.8)	1110	1.5 (0.9–2.6)	1.8 (1.0–3.4)[a]
Unemployed/Housewife	19 (27.9)	68	1	1
Number of children				
≤2	194 (39.6)	490	1.3 (1.0–1.6)[b]	1.0 (0.7–1.4)
>2	234 (34.0)	688	1	1
Birth order				
1	102 (43.8)	233	1.5 (1.1–2.0)[b]	1.4 (1.1–2.5)[a]
≥2	326 (34.5)	945	1	1
Gender of child				
Male	215 (36.8)	585	1.0 (0.8–1.3)	NA
Female	213 (35.9)	593	1	NA
Place of birth of child				
Hospital	275 (43.4)	634	3.0 (2.2–4.2)[b]	1.8 (1.2–2.6)[a]
Mission house	96 (36.6)	262	2.3 (1.6–3.4)[b]	1.6 (1.1–2.5)[a]
Home	57 (20.2)	282	1	1
Walking distance to nearest health facility offering immunisation				
≤10 minutes	209 (34.9)	598	0.9 (0.7–1.1)	NA
>10 minutes	219 (37.8)	580	1	NA
Retention of immunisation card				
Yes	367 (44.9)	818	4.0 (2.9–5.4)[b]	3.1 (2.2–4.3)[a]
No	61 (16.9)	360	1	1

NA: not applicable: variable was not included in the multivariate logistic regression model.
[a]Significant at bivariate level.
[b]Significant after adjustment.

66.6% in Ido (393/590) in this study. Report from the NDHS (2008), showed an overall immunisation card retention rate of only 25%.[3] Mothers who retained the card were likely to know the importance of immunisation, hence tended to complete immunisation schedules for their ward. In the current study, mothers who retained their immunisation card were three times as likely to have fully immunised children compared with those without an immunisation card at the time of the survey. This finding is consistent with other reports in Nigeria.[23]

In the present study, mothers who were employed had a two-fold greater probability of having their children immunised compared with unemployed mothers (housewives). This finding is at variance with that reported in a survey carried out in south-east Nigeria, in which mothers who were employed were reported to have a lowered probability of having their children immunised compared with housewives.[23] Our result is consistent with studies that had linked maternal employment to a reduction in financial obstacles to vaccination, especially if these obstacles include money for transportation to distant health facilities.[27,28] The finding that older women were more likely to have fully immunised children is also in contrast to the finding from the study from southeast Nigeria.[23] The inconsistences in the findings on maternal employment and the maternal age relationship to full immunisation between the southeast report and the present study may be accounted for by differences in societal variables or by chance, as previously suggested by some authors.[29] The finding that mothers whose children were born in a health institution are more likely to have their children fully immunised compared to home birth is not surprising. Mothers who had their children in these institutions were likely to have a more positive health-seeking behavior and may have been exposed to positive health information, including the need to immunise their children, compared to women who had home births. Furthermore, our study suggests that first birth order increases the probability of a child completing the immunisation schedule. This is closely related to the finding of a study that concluded that higher birth order was associated with under immunisation.[30] This may be because mothers with their first child, because of their inexperience, are likely to obey health workers and implement measures recommended to improve their child care.

The cross-sectional nature of the present study makes it difficult to clarify the temporal relationship between the factors assessed and the outcome, completion of the full immunisation schedule, hence causal relationship could not be ascertained. However, consistencies in the direction of associations have been demonstrated in previous reports with some of the factors implicated in this report.[23,26,28] Furthermore, social desirability and recall biases are likely to lead to overestimation of effects, considering the retrospective nature of obtaining exposure and to a lesser extent the outcome information especially among those without immunisation record cards. However, more than two-thirds of our respondents in the two LGAs had immunisation cards. To minimise the effect of non-recall of immunisation history we depended on the information from the child immunisation card where possible, otherwise the types of vaccines received were ascertained using standard criteria, including recommended sites, routes of administration and known periods of administration of vaccines to obtain information on immunisation status of children.[23]

Conclusion

In conclusion, the LQAS method provided reliable information on areas at extreme ends of the spectrum of vaccination coverage: those in whom coverage rates were acceptable and required no additional attention and those in whom rates were low and were in need of support. We recommend educational intervention on the importance of immunisation and completion of immunisation schedules in areas with unacceptable coverage in the two LGAs. Such intervention should be targeted on young, unemployed mothers with lower level of or no education. Attention should also be paid to mothers who delivered their babies at home or who have higher birth orders.

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