Uptake and Predictors of Newly Introduced Vaccines in Malawi – Monovalent Human Rotavirus Vaccine and Pneumococcal Conjugate Vaccines. Evidence from the 2015–16 Malawi Demographic and Health Survey

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ABSTRACT

Objectives: The purpose of this study was to examine the uptake and predictors of monovalent human rotavirus and pneumococcal conjugate vaccines in Malawi.

Methods: This study utilized cross-sectionl data obtained from the 2015-16 Malawi Demographic and Health Survey. The vaccination uptake was defined as children aged 12-35 months who received all two doses for rotavirus vaccines and all three doses for pneumococcal vaccines before first birthday. Multivariate logistic regression was used to identify the factors related to uptake of pneumococcal and rotavirus vaccination.

Results: The uptake of rotavirus vaccine was 90.96% whilst of pneumococcal vaccine was 88.84%. The multivariate results show that children born to women with no formal education, who did not have postnatal care for the baby within two weeks, had no vaccination card/had vaccination card but its whereabouts was not known were less likely to achieve vaccination uptake. Furthermore, children from northern region had increased odds of achieving vaccination uptake.

Conclusions: Strategies aimed at increasing further uptake of rotavirus and pneumococcal vaccines in Malawi should increase women's education so as to improve health related knowledge including vaccination.

KEYWORDS: Rotavirus vaccine, pneumococcal vaccine, Malawi

INTRODUCTION

Globally diarrhea and pneumonia are two major leading cause of morbidity and mortality among young children [1][2]. Most diarrheal disease in children are attributed to rotaviruses which cause gastroenteritis, an inflammation of the stomach and intestines that can lead to severe dehydration, hospitalization, and even death in young children [3][4]. On the other hand, diseases caused by Streptococcus pneumoniae constitute also a major global public health problem in children [5][6]. In 2010, it was estimated that there were about 1.73 billion episodes of diarrhea and 120 million episodes of pneumonia in children younger than 5 years. It was further estimated that 700 000 episodes of diarrhea and 1.3 million of pneumonia progressed to death [2].

In Malawi, approximately 11% of mortality in young children are caused by diarrhea [7][8]. Specifically, more than 2,500 deaths are attributed to Rotavirus accounting for 4.5 percent of all under five mortality. Moreover, it was reported that rotavirus causes an estimated one-third of diarrheal disease related hospitalizations [7][9]. In sub Saharan, pneumonia was reported to cause 935,000 deaths in young children and in Malawi 6903 of hospital death in preschool age children were attributed to severe pneumonia [10]. The pneumococcal vaccine protects against Streptococcus pneumoniae bacteria, which cause severe pneumonia, meningitis, otitis media and other illnesses [4][11]. On the other hand, the WHO ingeminates that rotavirus vaccines are an important measure that can be used to reduce severe rotavirus-associated diarrhea and child mortality [12]. Thus, the use of rotavirus and pneumococcal vaccines should be part of a comprehensive strategy to control diarrhea and pneumonia diseases among young children.

The Government of Malawi introduced the pneumococcal conjugate vaccine (PCV13) and monovalent human rotavirus vaccine (RV1) into the nation's infant immunization programme in November 2011 and October 2012 [13]. Studies in Malawi show that rotavirus vaccines are safe and effective against severe rotavirus disease and are a cost-effective intervention [14][15]. Despite that previous studies have explored predictors of uptake and timeliness of newly introduced rotavirus and pneumococcal vaccines in Malawi [16], these studies did not use nationally representative samples. Thus the aim of this study was to investigate the uptake and predictors of rotavirus and pneumococcal vaccines in Malawi.

MATERIAL AND METHODS

Data, sampling, and design

This paper used publicly available data obtained from the 2015-16 Malawi Demographic and Health Survey (MDHS) which were collected from October 2015 to February 2016. Methods used in this study has been described in details elsewhere [4]. Briefly, the 2015-16 MDHS utilized a stratified two-staged cluster sampling design and produced a nationally representative sample. In the first stage, 850 standard enumeration areas (SEAs) were randomly selected with probability proportional to the size. The second stage selected a sample of households with an equal probability systematic selection.

Data collection

The MDHS collected information from women of reproductive age (15–49 years) who had children below the age of 5 years prior to the survey by means of face to face interviews. In the interviewed households, 24,562 of the 25,146 eligible women were interviewed representing a 98% response rate. The main purpose of the MDHS is to provide the much needed data on the measures of population health, sociodemographic, environmental, anthropometry, HIV/AIDS, and child health

indicators. Information on the monovalent human rotavirus vaccine (RV1) and pneumococcal conjugate vaccine (PCV13) were obtained in two ways. Mothers were asked to show whether they had a vaccination card for each child born 5 years prior to the data collection. If the mother could not show an immunization card, she was then asked to report whether the child had received any vaccination. Mothers were asked; Has (NAME) ever received a rotavirus vaccination, that is, liquid in the mouth to prevent diarrhea? How many times did (NAME) receive the rotavirus vaccine? Furthermore, mothers were asked, has (NAME) ever received a pneumococcal vaccination (PCV), that is, an injection in the thigh to prevent pneumonia? How many times did (NAME) receive the pneumococcal vaccine (PCV)? [4]

MEASURES

Dependent variables

The dependent variables of this study were monovalent human rotavirus vaccine (RV1) and pneumococcal conjugate vaccine (PCV13). Uptake was defined as children aged 12-35 months who had received all two doses of the monovalent human rotavirus vaccine (RV1) and all three doses of the pneumococcal conjugate vaccine (PCV13) before their first birthday. To ensure that children who were born after October 2012, received all recommended vaccines, an age range 12–35 months was chosen. Furthermore, by means of a simple random procedure, one child per mother was sampled so as to avoid the clustering effects generated from children who resided in same households. Figure 1. Shows a flow chart of the sample inclusion and exclusion criteria.

Independent variables

Child-specific factors included child's sex (male/female), the birth order (1/2/3/4–5/and ≥ 6) and place of delivery (home and other/hospital/institution). Maternal and household characteristics included age in years (15–24/25–34/35–49), educational attainment (no formal education/primary/secondary education and above), employment status (no formal employment/ white collar/and blue collar), household wealth status (poorest/poorer/middle/richer/ and richest), perceived distance to health facility (no big problem/big problem). The number of under-5-year children in the household (≤1/ 2–3/and ≥ 4), the number of antenatal care visits (no visits/ inadequate visits/and adequate visits), vaccination card (no card or no longer has card/ has card but not seen/and has card and seen), place of residence (urban/rural), and geographical region (northern/central/and southern). The household wealth index is a composite measure of a household's cumulative living standard and was calculated using easy-to-collect data on a household's ownership of selected assets, such as televisions and bicycles. Household asset scores were generated through a principal component analysis by the measure DHS. The resulting asset scores were standardized and categorized into quintiles [17].

Data analysis

All data analyses were performed using statistical analysis software (SAS) for Windows, version 9.4 (SAS Institute, Cary, NC, USA) [18][13]. Baseline sociodemographic characteristics were presented as frequencies and percentages. By means of the Chi-Square test of independence, the bivariate analyses were performed to determine the association between sociodemographic characteristics and uptake of the pneumococcal conjugate vaccine (PCV13) and monovalent human rotavirus vaccine (RV1). The variables that showed significance at $p \leq 0.25$ on Chi-Square were retained for regression models. The multivariate analyses were conducted using a series logistic models (e.g., children, maternal/households, health care utilization, and community characteristics) to estimate

the effects of the sociodemographic predictors on the uptake of the pneumococcal conjugate vaccine (PCV13) and monovalent human rotavirus vaccine (RV1). The survey-specific SAS procedures for weighting, clustering, and stratification in the survey design (PROC SURVEYSELECT, PROC SURVEYFREQ and PROC SURVEYLOGISTIC) were conducted. Regression analyses were performed separately for each dependent variables. In each model, unadjusted and adjusted odds ratios (aORs) and 95% confidence intervals (CIs) with their *p* values were calculated. Statistical significance was defined as p value < 0.05.

Ethical considerations

The protocols of the MDHS 2015-16 were reviewed and approved by the Malawi National Health Sciences Research Committee (NHSRC) and the Institutional Review Board (IRB) of ICF Macro. All participants gave written and informed consent before each interview. The authors were granted permission by the DHS program for the use of the data.

RESULTS

Basic characteristics of the study sample

In total, 4938 children ageing between 12 to 35 months were analyzed in this study. The uptake of pneumococcal conjugate vaccine (PCV13) and monovalent human rotavirus vaccine (RV1) were estimated at 88.84% and 90.96% respectively. Table 1 show the baseline characteristics of the study sample. In terms of child characteristics, about 51% of children were female and a majority of children were in the 2–3 birth order. As regards household factors, approximately one-third of respondents were distributed in the age group 20 to 24 years, two-thirds of respondents had primary school education and a majority (60%) had blue collar job. Furthermore, about two-thirds (63%) households had at most one under-five year old child and nearly half (47%) of the households were not exposed to any form of media. In terms of health service utilization, a majority (94%) of births occurred in health faculties, 91% had tetanus toxoid injection during pregnancy. Similarly, 92% of respondents had skilled attendance during delivery. Nearly 60% of respondents had big problems with distance to the nearest health facility, and approximately 70% of respondents started their antenatal check in the second trimester. In addition, 74%, 53% and 45% of respondents had vaccination card and seen, adequate ANC visits and PNC check for the baby within two months respectively. In terms of community characteristics, a majority of respondents were rural (86%) and southern region (46%) dwellers.

Factors associated with rotavirus vaccine

Table 3 shows results of multivariate logistic regression results of monovalent human rotavirus vaccine (RV1). Achieving uptake was significantly lower among children whose mothers had no formal education (aOR: 0.40; 95% CI: 0.24–0.66) compared children whose mothers had secondary and post-secondary education. Achieving rotavirus vaccination uptake was also significantly lower among children whose mothers had no PNC check for the baby check within 2 months (aOR: 0.68; 95% CI: 0.49–0.92) compared to children born from mothers who had PNC check for the baby check within 2 months. Furthermore, achieving complete immunization was much lower among children who had no vaccination card/no longer had a card (aOR: 0.26; 95% CI: 0.49–0.92) and who had a card but its whereabouts was not known (aOR: 0.33; 95% CI: 0.22–0.39) compared to children who had vaccination card and its whereabouts was known.

Factors associated with pneumococcal conjugate vaccine

Table 3 also shows results of multivariate logistic regression results of pneumococcal conjugate vaccine, compared to children whose mothers had secondary school and post-secondary school education, achieving uptake (aOR: 0.52; 95% CI: 0.33–0.85) was significantly lower among children whose mothers had no formal education. Achieving pneumococcal conjugate vaccine uptake was also significantly lower among children whose mothers had no PNC check for the baby check within 2 months (aOR: 0.65; 95% CI: 0.49–0.86) compared to children born from mothers who had PNC check for the baby check within 2 months. Furthermore, achieving complete immunization was much lower among children who had no vaccination card/no longer had a card (aOR: 0.12; 95% CI: 0.09–0.15) and who had a card but its whereabouts was not known (aOR: 0.09; 95% CI: 0.06–0.13) compared to children who had vaccination card and its whereabouts was known. However, compared to children from southern region, the odds of achieving pneumococcal vaccination uptake was significantly higher among children from northern region (aOR: 1.82; 95% CI: 1.19–2.80).

DISCUSSION

This is the first study that has shown the predictors of childhood rotavirus and pneumococcal uptake in Malawi using a national representative sample. The study has demonstrated that uptake of these two vaccines was high, however, the coverage of pneumococcal vaccine is falling short the benchmark set by the WHO [19]. In the multivariate analysis, maternal education, PNC check for the baby within two months, vaccination card, and geographical region were significantly associated with uptake of these two vaccines among the children aged 12–35 months in Malawi.

The current study revealed that lack of PNC follow up was strongly linked with defaulting from achieving uptake of rotavirus and pneumococcal vaccination. Along with prior studies conducted in Ethiopia and Kenya with similar results [20][21][22][23], this may suggests that mothers who did not have PNC follow up are not getting sufficient information about the child vaccination schedule. In addition, women who have frequent ANC visits and PNC follow up might be more satisfied with the health care system and become aware of the need for vaccination which in turn may make them more likely to return for child vaccination [24][25].

In line with previous studies on vaccination coverage in general, the current study found that children who had vaccination card had increased odds of receiving complete sets of rotavirus and pneumococcal vaccines [26][27]. Prior research has demonstrated that being in possession of a child's immunization card allows the mother to easily follow the immunization schedule and as such they may be in apposition to return at health facilities in time to have their babies immunized. Moreover, it has been reported that having an immunization card which is well-kept and clearly-labeled can prevent mothers from missing out on vaccinations schedules [26]. On the other hand, mothers who do not have immunization cards might avoid seeking immunization services for fear of ill-treatment from some health care providers as a result of misplaced, lost or spoiled child health card [28].

As with previous studies [16][26][29][30], children born from mothers who had no formal education were less likely to achieve uptake of these two vaccines. Prior studies reported that maternal education influence women's autonomy, changes in traditional beliefs, and women's control over household resources [31][22]. Thus, women's healthcare-seeking behavior and as well as ability to understand health knowledge may be enhanced more quickly either through social circumstances or cognitive priming that education affords [26][29].

Children from the northern region were more likely to achieve the uptake of pneumococcal vaccination compared to those from the southern region. In this context, vaccination may reveal intra-regional and intra-ethnic differences because of economic, political, and climatic factors and diverse

sociocultural norms that might affect childcare practices [32]. In Malawi, the northern region has the most favorable health characteristics (e.g., a large percentage of men and women had completed primary and secondary education, exposure to mass media, and a better wealth status) [4][33]. All these factors are known to have influence on health seeking behavior including immunization.

This study was prone to recall bias since respondents who did not show vaccination cards were asked to remember the vaccines. Causal inferences could not be drawn due to the cross-sectional nature of the study design. The use of already existing tools limited prevent us from including other variables that could explain vaccination uptake.

CONCLUSIONS

Interventions aimed at increasing further uptake of rotavirus and pneumococcal vaccines in Malawi should be designed interventions based on the factors addressed in this study. Specifically, the focus should be emphasized more on the maternal education so that they should have the health knowledge related to childhood vaccination.

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CONFLICT OF INTEREST

The authors declare no conflict of interest

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Table 1. Socio-demographic characteristics of the study participants MDHS, 2015–16 (n= 4938)

Characteristics	n[⊀]	%[†]	SE
Outcome variables			
Pneumococcal conjugate vaccine (PCV13)			
Incomplete coverage	521	11.16	0.58
Complete coverage[a]	4417	88.84	0.58
Monovalent rotavirus vaccine (RV1)			
Incomplete coverage	427	9.04	0.53
Complete coverage[b]	4511	90.96	0.53
Child characteristics			
Sex of the child			
Male	2449	49.07	0.90
Female	2489	50.93	0.90
Birth order			
1	1439	30.20	0.94
2–3	1747	34.29	0.88
4–5	1100	22.14	0.73
≥6	652	13.37	0.59
Maternal/household Characteristics			
Maternal age (years)			
15–19	446	9.07	0.49
20–24	1538	31.79	0.96
25–29	1155	22.70	0.76
30–34	921	19.04	0.68
35–49	878	17.41	0.71
Maternal education levels			
No education	535	11.40	0.60
Primary	3265	66.78	0.91
Secondary and above	1138	21.81	0.81
Maternal employment			
Not working	1454	28.72	0.89
White collar[c]	576	11.17	0.59
Blue collar[d]	2908	60.10	0.99
Wealth index			
Poorest	1086	23.83	0.84
Poorer	1034	22.20	0.78
Middle	997	20.02	0.70
Richer	900	17.36	0.80
Richest	921	16.59	0.71
No of under-5-year children			
≤1	3097	62.68	0.90
2–3	1608	32.51	0.84
≥4	233	4.80	0.41

Amount of media exposure[e]			
0	2251	46.58	0.97
1	1589	32.66	0.86
2	756	14.81	0.70
3	342	5.95	0.46
Health Service utilization			
Place of delivery			
Home and other	291	6.25	0.50
Hospital/institution[f]	4647	93.75	0.50
Distance to health facility			
No big problem	2306	43.31	1.31
Big problem	2632	56.69	1.31
Timing of 1st antenatal check			
First trimester	1346	25.53	0.83
Second trimester	3307	67.87	0.89
Third trimester	285	6.60	0.46
Antenatal care visits			
Inadequate visits (1-3)	2307	47.15	0.96
Adequate visits (≥4)	2631	52.85	0.96
Baby PNC check within 2 months			
No	2658	54.52	1.06
Yes	2280	45.48	1.06
TTI during pregnancy			
No	474	9.03	0.48
Yes	4464	90.97	0.48
Vaccination card			
No card/no longer has card	942	19.04	0.67
Has card but not seen	386	7.34	0.47
Has card and seen	3610	73.61	0.78
Skilled assistance at delivery			
No	355	8.02	0.54
Yes[g]	4583	91.98	0.54
Community characteristics			
Place of residence			
Urban	829	13.99	0.60
Rural	4109	86.01	0.60
Geographical region			
Northern	974	12.58	0.52
Central	1678	41.57	0.87
Southern	2286	45.85	0.88

[ɀ]Unweighted frequency; [†]weighted percentage; SE, standard error; TTI, tetanus toxoid injection; PNC, postnatal care; [a]three doses of the pneumococcal vaccine; [b]two doses of the rotavirus vaccine; [c](professional/technical/managerial, clerical, sales, services); [d](agricultural - self-employed, agricultural - employee); [e](frequency of reading newspaper or magazine, frequency of listening to radio, frequency of watching television); [f](government hospital, government health center, government health post/outreach, other public sector, private hospital/ clinic, CHAM / MISSION

hospital, CHAM / MISSION health center, BLM, other private medical sector); [g](doctor/clinical officer/medical assistant, nurse/midwife).

Table 2 Factors Associated with Childhood Pneumococcal conjugate vaccine (PCV13) and Monovalent human rotavirus vaccine (RV1) in Malawi

Characteristics	Pneumococcal Conjugate Vaccine (PCV13)[a]				Monovalent Human Rotavirus Vaccine (RV1)[b]			
	CrOR 95%(CI)	*p*-value	AOR 95%(CI)	*p*-value	CrOR 95%(CI)	*p*-value	AOR 95%(CI)	*p*-value
Child characteristics								
Sex of the child								
Male	1.12 (0.89–1.49)	0.3230	—	—	1.10 (0.86–1.42)	0.4584	1.11 (0.86–1.43)	0.4199
Female	1.00		—	—	1.00	<.0001	1.00	
Birth order								
1	1.38 (0.96–0.88)	0.8778	1.88 (0.94–3.77)	0.1634	1.12 (0.75–1.67)	0.3029	1.18 (0.64–2.20)	0.8621
2–3	1.51 (1.05–2.18)	0.3791	1.51 (0.83–2.75)	0.8128	1.36 (0.93–1.99)	0.3572	1.28 (0.77–2.16)	0.6321
4–5	**1.80 (1.21–2.67)**	**0.0188**	1.62 (0.98–2.66)	0.4692	**1.58 (1.04–2.45)**	**0.0407**	1.44 (0.95–2.20)	0.2271
≥6	1.00		1.00		1.00		1.00	
Maternal/household Characteristics								
Maternal age (years)								
15–19	0.95 (0.62–1.46)	0.3044	0.66 (0.31–1.43)	0.2281	0.71 (0.43–1.18)	0.0984	0.68 (0.33–1.44)	0.4592
20–24	1.04 (0.74–1.46)	0.5307	0.76 (0.41–1.43)	0.3918	0.89 (0.61–1.31)	0.5936	0.78 (0.43–1.37)	0.6968
25–29	1.28 (0.87–1.90)	0.2158	0.91 (0.52–1.61)	0.6995	1.07 (0.72–1.59)	0.2641	0.79 (0.49–1.25)	0.7860
30–34	1.30 (0.86–1.97)	0.2287	1.03 (0.62–1.72)	0.2968	1.10 (0.72–1.68)	0.2683	0.86 (0.56–1.32)	0.7468
35–49	1.00		1.00		1.00		1.00	
Maternal education levels								
No education	**0.43 (0.29–0.64)**	**<.0001**	**0.52 (0.33–0.85)**	**0.0020**	**0.36 (0.23–0.55)**	**<.0001**	**0.40 (0.24–0.66)**	**0.0007**
Primary	0.80 (0.58–1.12)	0.1210	0.90 (0.61–1.34)	0.1435	0.56 (0.40–0.78)	0.6155	0.60 (0.39–0.90)	0.6711
Secondary and above	1.00		1.00		1.00		1.00	
Maternal employment								
Not working	0.89 (0.70–1.15)	0.8306	0.89 (0.66–1.18)	0.8741	0.96 (0.71–1.30)	0.6276	0.99 (0.73–1.35)	0.6962
White collar[c]	0.86 (0.56–1.32)	0.6577	0.74 (0.45–1.23)	0.3457	1.08 (0.73–1.60)	0.6232	0.86 (0.55–1.34)	0.5108
Blue collar[d]	1.00		1.00		1.00		1.00	
Wealth index								
Poorest	**0.68 (0.47–0.96)**	**0.0014**	1.05 (0.66–1.67)	0.3019	**0.51 (0.33–0.77)**	0.0011	0.78 (0.45–1.35)	0.1536
Poorer	1.20 (0.80–1.80)	0.0343	1.54 (0.96–2.45)	0.0447	0.81 (0.53–1.26)	0.3988	1.07 (0.63–1.81)	0.3135
Middle	0.84 (0.57–1.23)	0.3635	1.11 (0.70–1.76)	0.5726	0.60 (0.39–0.92)	0.0780	0.81 (0.49–1.34)	0.2041
Richer	1.00 (0.66–1.52)	0.4972	1.32 (0.82–2.11)	0.4591	0.87 (0.55–1.37)	0.2096	1.08 (0.65–1.79)	0.3207
Richest	1.00		1.00		1.00		1.00	
Amount of media exposure[e]								
1	**0.50 (0.27–0.92)**	**0.0079**	0.52 (0.25–1.07)	0.0808	0.72 (0.41–1.24)	0.0065	1.11 (0.56–2.20)	0.4809
2	0.56 (0.30–1.05)	0.1522	0.50 (0.25–1.01)	0.0357	0.91 (0.51–1.64)	0.6533	1.22 (0.61–2.43)	0.9815
3	0.69 (0.35–1.39)	0.7677	0.72 (0.34–1.50)	0.5894	1.36 (0.73–2.54)	0.0396	1.65 (0.82–3.30)	0.0772

4	1.00		1.00		1.00		1.00	
Health Service utilization								
Place of delivery								
Home and other	0.83 (0.54–1.26)	0.3763	0.86 (0.54–1.39)	0.5467	0.70 (0.45–1.08)	0.1033	0.70 (0.33–1.48)	0.3451
Hospital/institution[f]	1.00		1.00		1.00		1.00	
Distance to health facility								
No big problem	0.99 (0.78–1.25)	0.9049	0.98 (0.75–1.27)	0.8522	1.14 (0.87–1.50)	0.3478	1.10 (0.84–1.46)	0.4899
Big problem	1.00		1.00		1.00		1.00	
Baby PNC check within 2 months								
No	**0.62 (0.48–0.80)**	**0.0003**	**0.65 (0.49–0.86)**	**0.0030**	**0.63 (0.47–0.84)**	**0.0019**	**0.68 (0.49–0.92)**	**0.0140**
Yes	1.00		1.00		1.00		1.00	
TTI during pregnancy								
No	1.17 (0.71–0.90)	0.5294	1.11 (0.64–1.93)	0.7094	0.89 (0.60–1.32)	0.5585	—	—
Yes	1.00		1.00		1.00		—	—
Vaccination card								
No card/no longer has card	**0.11 (0.08–0.15)**	**<.0001**	**0.12 (0.09–0.15)**	**<.0001**	**0.27 (0.21–0.36)**	**<.0001**	**0.29 (0.49–0.92)**	**<.0001**
Has card but not seen	**0.12 (0.08–0.17)**	**<.0001**	**0.09 (0.06–0.13)**	**<.0001**	**0.35 (0.24–0.51)**	**0.0280**	**0.33 (0.22–0.39)**	**0.0093**
Has card and seen	1.00		1.00		1.00		1.00	
Skilled assistance at delivery								
No	0.99 (0.66–1.51)	0.9929	—	—	0.78 (0.51–1.19)	0.2444	0.90 (0.44–1.85)	0.7712
Yes[g]	1.00		—	—	1.00		1.00	
Community characteristics								
Place of residence								
Urban	**0.72 (0.52–0.99)**	**0.0440**	—	—	1.21 (0.82–1.77)	0.3411	0.84 (0.53–1.33)	0.4565
Rural	1.00		—	—	1.00		1.00	
Geographical region								
Northern	**1.73 (1.23–2.45)**	**0.0010**	**1.82 (1.19–2.80)**	**0.0014**	1.19 (0.84–1.69)	0.4356	0.99 (0.68–1.42)	0.8887
Central	**0.98 (0.76–1.25)**	**0.0233**	**0.85 (0.64–1.12)**	**0.0031**	1.09 (0.82–1.45)	0.9957	1.01 (0.75–1.34)	0.9095
Southern	1.00		1.00		1.00		1.00	

CrOR, crude odds ratio; AOR, adjusted odds ratio; TTI, tetanus toxoid injection; PNC, postnatal care; [a]three doses of the pneumococcal vaccine; [b]two doses of the rotavirus vaccine; [c](professional/technical/managerial, clerical, sales, services); [d](agricultural - self-employed, agricultural - employee); [e](frequency of reading newspaper or magazine, frequency of listening to radio, frequency of watching television); [f](government hospital, government health center, government health post/outreach, other public sector, private hospital/ clinic, CHAM / MISSION hospital, CHAM / MISSION health center, BLM, other private medical sector); [g](doctor/clinical officer/medical assistant, nurse/midwife). The bold text indicate a statistically significant association at a p-value less than 0.05.