Factors Associated with the Change in Vaccination Uptake in Nigeria: A Decomposition Analysis

Authors & Affiliation
Ntoimo Lorretta Favour Chizomam & Abatan Sunday Matthew
Department of Demography and Social Statistics, Faculty of Social Sciences, Federal University Oye-Ekiti, Nigeria
Correspondence: Email: lorretta.ntoimo@fuoye.edu.ng

Abstract

Background: Immunization is one of the cost-effective life-saving interventions to prevent child mortality and morbidity, yet, millions of children miss out on this life-saving intervention annually. In 2019, Nigeria was among the top ten countries with the highest number of children who are under-immunized and unimmunized with diphtheria, pertussis, and tetanus (DPT) vaccine. However, the country recorded some improvement in vaccination uptake between 2008 and 2018. This Study was a decomposition analysis to identify the factors that contributed to the observed improvement to inform policy and programmes towards achieving complete child immunization in Nigeria **Methods**: This study pooled data from Nigeria Demographic and Health Surveys of 2008 and 2018. The Oaxaca decomposition model in Stata was used to analyze data of 7,356 children aged 12-23 months who received the 3 doses of diphtheria- pertussis-tetanus- vaccine (DTP). This method allows the decomposition of changes over time in levels of an outcome variable into those due to differences in observable characteristics (*endowments*) and those due to the different effects of these characteristics (*coefficients*).

Findings: From 2008 to 2018, there was an increase in DPT vaccination uptake from 36% to 55%. The change in the uptake of immunization between 2008 and 2018 was mainly due to a change in behaviour toward immunization as 54.2% of the total change was explained by the coefficient effects of selected explanatory variables whereas 45.8% were explained by the endowment effects. The independent variables that contributed significantly to the increase attributed to change in coefficient were birth weight particularly babies whose weight were unknown (not weighed), no exposure to the media marital status, household wealth index particularly the poorest quintile, and region. The significant variables that contributed to the increase attributed to endowment include maternal education, place of delivery, region, household wealth index, and permission to visit a health facility.

Conclusion: The increase in DPT immunization uptake is mainly a result of improvement in immunization uptake behaviour in the North West region, among women who are not exposed to the media, in polygynous households, poorest wealth quintile, and unweighed children. This indicates a need to intensify programs to achieve complete immunization in these segments of the population as well as among those whose contributions were significantly negative such as the North Central region, South West region, and never-married mothers.

INTRODUCTION

Although the world witnessed a tremendous reduction in child mortality between 1990 and 2015, sub-Saharan Africa (SSA) is still characterized by high under-five mortality. In 2019, under-five mortality in the region remained the global highest at 76 deaths per 1000 live births. Out of the five countries that contributed about half of the global under-five deaths in 2019, three are in SSA – Nigeria, the Democratic Republic of Congo, and Ethiopia, and Nigeria had the highest number of under-five deaths with an estimated 858,000 deaths (The United Nations Inter-agency Group for Child Mortality Estimation (UN IGME), 2020). Most of these deaths occur among children aged 0-11 months and their leading causes are vaccine-preventable. To save children from dying from vaccine-preventable diseases before age five, the World Health Organization (WHO) recommends full immunization. According to the WHO, a child is considered fully vaccinated if she or he has received a BCG vaccination against tuberculosis; three doses of DPT vaccine to prevent diphtheria, pertussis, and tetanus; at least three doses of polio vaccine; and one dose of measles vaccine; during the first year of life (World Health Organization, 2020). It is expected that between ages 12-23 months a child would have received all basic vaccinations. Immunization is one of the cost-effective life-saving interventions to prevent child mortality and morbidity (Berendsen et al., 2019), yet, millions of children miss out on this life-saving intervention annually. In 2019, Nigeria was among the top ten countries with the highest number of children who are under-immunized and unimmunized with diphtheria, pertussis, and tetanus (DPT) vaccine (World Health Organization, 2020).

The Nigerian government has initiated several programmes and campaigns to increase the uptake of routine childhood immunization such as the Nigerian Expanded Programme on Immunization (EPI), the Universal Child Immunization (UCI), and Saving One Million Lives, Cerebrospinal Meningitis, Measles, Yellow Fever and Maternal Neonatal Tetanus Elimination (MNTE) initiative, the national routine immunization strategic plan (2013-15), among others (National Primary Health Care & Development Agency, Nigeria, 2012). The Nigerian EPI prescribes that BCG, OPV, DPT, MV, Yellow fever, and Hepatitis B vaccines should be given to every child within the first year of life in five routine contacts in primary health centres (National Primary Health Care Development Agency, 2012). The five routine contacts and prescriptions are BCG, OPV0, HepB0 at birth; OPV1, DPT1, HepB1 at 6 weeks; OPV2, DPT2 at 10 weeks, OPV3, DPT3, and HepB2 at 14 weeks, and Measles and Yellow fever at 9 months. In 2012, Nigeria began the replacement of diphtheria, pertussis, and tetanus (DPT) vaccine with the pentavalent vaccine (also known as DPT-HepB-Hib), which contains more antigens – Haemophilus influenzae type B, and hepatitis B. The inactivated polio vaccine

(IPV), which serves as a booster for oral polio vaccine, was introduced in February 2015 to boost children's immunity against type 1 and type 3 wild poliovirus (WPV) and tackle the risk of circulating vaccine-derived poliovirus (cVDPV) (National Primary Health Care Development Agency 2016). With the introduction of these, the new schedule for contact 3 became OPV1, Pentavalent 1 (DPT-Heb-Hib1), PCV1; contact 4 is now OPV2, Pentavalent2 (DPT-HepB-Hib2), PCV2; and contact 5 is now OPV3, pentavalent3 (DPT-HepB-Hib3), PCV3.

As a result of these initiatives, there has been some improvement in the percentage of children immunized. For instance, between 2008 and 2018, the percentage of children aged 12-23 months who received all basic vaccinations increased from 23% in 2008 to 31% in 2018, and the percentage who received none of the basic vaccinations declined from 29% to 19%. In August 2020, Nigeria was also certified wild polio-free by the Africa Regional Commission for Certification of Polio Eradication (ARCC). Despite these achievements, universal child immunization in Nigeria remains a serious public health problem. In 2018, only one-third (31%) of children age 12-23 months received all basic vaccinations, 28% received the basic vaccinations by the appropriate age of 12 months, and 19% received no vaccinations at all with 52-58% in some Nigerian States (National Population Commission (NPC) [Nigeria] and ICF, 2019). Many previous studies and reports point to several institutional, contextual, and individual-level factors as deterring factors to the uptake and implementation of immunization programmes in Nigeria. Some of the institutional factors include inadequate government funding, over-dependence on donor funds, ad-hoc campaigns sponsored by donors, weak health structure and systems, lack of community ownership, vaccine stock-out, distribution challenges, non-maintenance of Cold Chain Equipment (CCE), and poor staff performance at state and local government levels (Gooding et al., 2019; National Primary Health Care Development Agency, 2012; National Primary Health Care & Development Agency, Nigeria, 2012). The individual-level and contextual factors include the place of delivery, mother's level of education, distance to a health facility, mother's knowledge of vaccine-preventable diseases, household wealth among others (Abdulraheem et al., 2011; Adedokun et al., 2017; Adeloye et al., 2017; Akwataghibe et al., 2019; Antai, 2009; Babalola & Lawan, 2009; Odusanya et al., 2008; Tagbo et al., 2014). While identifying the factors that hinder optimal uptake of vaccination and programme implementation is important, identifying the factors that account for positive change is significant for sustained progress. With less than ten years to 2030, Nigeria must give priority attention to factors that account for positive change to strengthen the achievements and motivate uptake if the country would achieve the Sustainable Development Goal 3.2.1 and Nigeria's target to ensure full immunisation of children less than one year at 90% nationally, with at least 80% coverage in each State.

This study used decomposition analysis to identify the factors that account for the change in the proportion of children aged 12-23 months who received complete basic vaccination between 2008 and 2018. The result is expected to inform programmes and strategic plans to strengthen the gains made in immunization coverage, and pay more attention to the significant factors that have not contributed much over time.

METHODS

Study setting

Administratively, Nigeria is made up of thirty-six States, and a Federal Capital Territory, Abuja. The thirty-six States are further grouped into six geo-political zones (North Central, North East, North West, South East, South South, and southwest). The States comprise Local Government Areas (LGAs), and each LGA is divided into smaller administrative units called political/health wards. The country's health system is a tripartite system with apex teaching/tertiary hospitals managed by the Federal government, secondary hospitals called general hospitals managed by the State governments, and primary health care at the base, managed by the Local Government Authorities. There are over 33,000 primary health centres/post (PHCs) in Nigeria with at least one located in every political/health ward serving a population of 5000-10,000 people (Federal Ministry of Health, 2021) The PHCs offer all the basic emergency obstetric care, and immunization services, among others.

Data source

This study used data obtained from the 2008 and 2018 Nigeria Demographic and Health Surveys (NDHS). The NDHS is a national survey that collects data on demographic and health information which includes birth history, vaccination among others. A representative sample of women aged 15-49 and men aged 15-59 in randomly selected households is selected through a stratified, two-stage cluster design.

Study population and sample size

We analyzed data on children who were aged 12-23 months, using the kid recode in the 2008 and 2018 NDHS with a respective sample size of 4,903 and 2,453 children. Thus, the total sampled children was7,356. The analysis was limited to the uptake of DPT; DPT1-3 in 2008 and DPT—HepB-Hib1, DPT-HepB-Hib2, and DPT-HepB-Hib3 in 2018. The information about their vaccination status was collected from mothers. In both surveys, information on vaccination coverage was collected in two ways: from vaccination cards shown to the interviewer and from mothers' verbal reports. The interviewer copied the vaccination dates directly into the questionnaire if the card was available. If there was no vaccination card or a vaccine had not been recorded on the card as given, the respondent was asked to recall the vaccines given to her child.

Variables and Measures

The explanatory variables which were drawn from the literature on immunization in Nigeria included child characteristics, mother's characteristics, accessibility of health facilities, and contextual factors. Child characteristics were birth weight, birth order, birth interval, place of delivery, breastfeeding, sex of a child, and child age. Mother's characteristics included personal and household factors such as child wanted, exposure to the media (television and radio), marital status,

religion, household wealth index, highest education, occupation, number of children ever born, age at first birth, and age; geographical accessibility and affordability factors were distance to a health facility a big problem, and getting money for treatment a big problem; and gender-related factors such as permission to seek medical help a problem, going alone a big problem, Contextual variables were region, and place of residence. All these variables are used to decompose the changes in child vaccination between the two periods and isolate the contribution of the change in the composition of the population from the change which is due to shifts in the behaviour of the population.

Outcome Variable

The dependent variable is a binary indicator of the immunisation status of a child. The variable captures whether or not a child had received the three required doses of DPT basic immunization.

Statistical Analysis

This study estimated the contribution of each factor using both descriptive and multivariate analysis. Descriptive statistics were used to present the characteristics of the respondents in each category for each independent variable in each survey, and show, in percentage points, the changes between surveys indicating improvements or otherwise in the characteristics of the sample population. The multivariate analysis was based on the Oaxaca-Blinder decomposition analysis, or as multivariate decomposition, component analysis, shift-share analysis as explained by Powers et al. (2011). This approach provides a method of analysing the outcomes of two different groups. The differences between two groups could be explained either in the composition or characteristics of the groups (endowments) or by the effects of those characteristics (coefficients) or the interaction term which measures the simultaneous effect of differences in endowments and coefficients. This means that the Oaxaca-Blinder technique reveals the real contribution of each independent variable to the total difference in characteristics or the effects of characteristics. This technique has been used to study changes over time in contraceptive use (Muhoza et al., 2016), women's status and fertility (Banjo et al., 2018); child nutritional status (Fagbamigbe et al., 2020; Menon et al., 2018), inequalities in food consumption (Duro et al., 2020), and inequalities in maternal health care utilization (Samuel et al., 2021), among others.

The decomposition model is derived as follows:

Y=Complete DPT3 Vaccination$_{2018}$ - Complete DPT3 Vaccination$_{2008}$

$$\Delta\hat{Y}^{2018\text{-}2008} = (\ddot{X}^{2018} - \ddot{X}^{2008}) + \ddot{X}^{2008}(\Delta^{2018} - \Delta^{2008}) + \{(\ddot{X}^{2018} - \ddot{X}^{2008})\,(\Delta\,\Delta^{2018} - \Delta^{2008}\}$$

Similarly, we have

$$\ddot{X}_{2008}'\beta_{2008} - \ddot{X}_{2018}'\beta_{2018}$$

The equation describes the difference in the average number of children that complete their DPT3 vaccination between 2008 and 2018 as a function of the means of the explanatory variables $\ddot{X}$ and the estimated coefficients

β. The Oaxaca-Blinder decomposition separates the changes into explained and unexplained portions.

Complete DPT3 Vaccination$_{2018}$ - Complete DPT3 Vaccination$_{2008}$

$= (\ddot{X}^{2018} - \ddot{X}^{2008})' \beta_{pooled} + \ddot{X}^{2008'} (\beta_{2008} - \beta_{pooled}) + \ddot{X}^{2018'} (\beta_{pooled} - \beta_{2018})$

Explained part **unexplained part**

Our focus is the explained portion i.e changes in the mean of explanatory variable $\ddot{X}$ between 2008 and 2018 multiplied by the corresponding coefficients from the pooled cross-section $\beta_{pooled.}$ The explained portion can be decomposed further in a sum of contributions of each of the respective explanatory variables. For the categorical variables with more than 2 categories, all categories are included in the decomposition and the contributions are expressed as the deviation from grand mean following normalization of dummy variable suggested by Powers et al. (2011).

RESULTS

Descriptive Analysis

Table 1 presents the change over time in the uptake of complete vaccination and the characteristics of the sample population. The results illustrate that during the period under review 2008 -2018, there were notable changes in the pattern of complete vaccination and some demographic characteristics. The changes in the characteristics of the study population are expected to have a positive effect on complete vaccination uptake for the newborns in the study area.

Change in Complete Vaccination Overtime

The proportion of children in Nigeria who had complete DPT3 vaccine changed from 36% in 2008 to 55% in 2018, a percentage point difference of 19%.

Change in the potential explanatory variables over time

Newborns and child's characteristics

The proportion of children with birth weight <2500g (underweight) only increased by 0.6% from 2008 to 2018. The proportion of children with 2500-3600g birthweight increased from 12.3% in 2008 to 22% in 2018 whereas the proportion of children with 3600+g birth weight increased from 5.9% in 2008 to 9.0% in 2018. The most striking finding here is that there was a huge change over time in the proportion of children not weighted, which reduced by 13.4%. There was an increase of less than 2% in the number of children whose birth order was 1-2 and a slight decline in the

proportion of children whose birth order is 3 and above. The proportion of children whose birth interval was less than 37 months declined whereas those whose birth interval was 37 months and above increased.

During the period under review, there are notable improvements in place of delivery. The proportion of mothers who delivered at health facilities increased by 11.9%, and delivery at home reduced by a similar percentage point from 2008 to 2018. The proportion of mothers who reported that they wanted the child at the time of pregnancy and those who wanted no more decreased over the ten years whereas those who wanted later increased by close to 4%. The percentage of mothers who never breastfed increased by less than 1% whereas the percentage who ever breastfed increased by about 9%. Respondents who were still breastfeeding declined. The change in proportion by sex was similar (about 1%) for males and females but in the opposite direction. A similar trend was observed for the age of the children.

Maternal Characteristics

The proportion of mothers who resided in the North Central, North East, South East, and South West increased over the ten years, whereas the proportion from the North West and South South decreased. Exposure to mass media among mothers was reduced by 2.4% over time. Most of the mothers were in the monogamous union during the two surveys, however, the proportion in polygynous union decreased by 4.2% and there was a slight increase in the proportion who were never married. By religious affiliation, the percentage of Muslims remained almost the same, and there was a slight increase in the proportion who are Christians and a decline for traditionalists. The proportion of mothers who had no education and primary education declined whereas those who attained secondary and higher education increased. A marked increase of 11.4% was observed in those who attained secondary education. The portion who were not working decreased. Rural residents decreased and urban residents increased by about 15%. The mothers who reported that distance to a health facility, and getting money for treatment was a big problem declined by about 10%. Also, those for whom permission to seek medical help, and going alone was a problem declined. The proportion who had 1-2 children increased slightly, those who had 3-4 children remained the same, whereas those who have had 5 or more children decreased. The percentage of mothers whose age at first birth was less than 18 decreased by 7.2% whereas the proportion whose age at first birth was 18 and over increased. Most of the mothers were currently aged 20-39 years old. There was a decline in the proportion aged 15-19, 25-29, and 45-49.

Table 1: Descriptive Statistics of Change over time in complete vaccination and the potential explanatory variables (2008-2018)

Variable	**Category**	2008 (%)	2018 (%)	Change (% point)
DPT3	Incomplete	63.9	44.6	-19.3
	Complete	36.1	55.4	19.3

CHILD'S CHARACTERISTICS				
Birth weight	Underweight	1.58	2.1	0.6
	normal	12.3	22.0	9.7
	Overweight	5.9	9.0	3.1
	Not weighted	80.2	66.9	-13.4
Birth Order	1-2	36.9	38.1	1.2
	3-4	29.3	29.0	-0.4
	5+	33.8	33.0	-0.8
Birth Interval	<24months	22.3	18.7	-3.6
	24-36months	40.8	40.6	-0.2
	37+	36.9	40.7	3.8
Place of Delivery	Non-Facilities	65.2	53.3	-11.9
	Health Facilities	34.8	46.7	11.9
Child Wantedness	Wanted then	87.8	85.2	-2.61
	Wanted Later	7.5	11.3	3.79
	Wanted no more	4.8	3.6	-1.18
Breastfeeding	Never Breastfed	0.8	1.5	0.67
	ever Breastfed	36.1	44.6	8.5
	Still Breastfeeding	63.1	53.9	-9.17
Sex of Child	Male	49.6	50.6	0.95
	Female	50.4	49.4	-0.95
Child age	12 Months	11.3	10.0	-1.3
	13-23 Months	88.8	90.1	1.3
MATERNAL CHARACTERISTICS				
Region	North Central	12.71	13.72	1.01
	North East	15.99	16.21	0.22
	North West	31.09	26.89	-4.2
	South East	10.1	13.38	3.28
	South South	13.49	11.48	-2.01
	South West	16.62	18.32	1.7
Mother Exposure to media	Exposed	30.8	33.2	2.36
	Not Exposed	69.2	66.8	-2.36
Marital Status	Monogamous	67.5	71.0	3.41
	Polygamous	28.8	24.6	-4.24
	Never in Union	3.6	4.5	0.82
Religion	Traditional/Others	1.5	0.5	-0.99
	Christianity	44.6	45.6	0.95

	Muslim	53.8	53.9	0.05
Wealth Index	Poorest	23.6	19.7	-3.98
	Poorer	22.3	19.0	-3.31
	Middle	18.9	19.2	0.34
	Richer	17.8	21.0	3.2
	Richest	17.4	21.1	3.74
Educational Attainments	No Formal Education	45.6	37.8	-7.85
	Primary	22.4	14.9	-7.58
	Secondary	25.7	37.1	11.36
	Higher	6.2	10.3	4.1
Work Status	Not Working	34.8	30.7	-4.11
	Working	65.2	69.3	4.11
Place of Residence	Urban	30.3	45.1	14.86
	Rural	69.7	54.9	-14.86
Distance to Facility is a big problem	Yes	38.4	28.7	-9.7
	No	61.6	71.3	9.7
Permission for medical Help a big problem	Yes	15.4	12.3	-3.15
	No	84.6	87.7	3.15
Getting Money for treatment a big problem	Yes	58.0	48.6	-9.41
	No	42.0	51.4	9.41
Going Alone a big problem	Yes	16.7	15.0	-1.74
	No	83.3	85.0	1.74
Children Ever Born	1-2c	36.06	37.20	1.14
	3-4c	29.5	29.5	0.04
	5+	34.5	33.3	-1.19
Age at First Birth	Less 18yrs	38.3	30.8	-7.52
	18-25	51.3	56.1	4.78
	26-49	10.4	13.1	2.74
Current Age	15-19	7.1	4.4	-2.68
	20-24	20.9	20.2	-0.73
	25-29	30.3	27.9	-2.31
	30-34	20.4	21.7	1.25

	35-39	13.0	17.9	4.94
	40-44	5.7	6.1	0.39
	45-49	2.6	1.7	-0.86

Decomposition Analysis

The multivariate parameters reveal the factors that contributed significantly to the positive change in complete vaccination in Nigeria when other factors are controlled. Table 2 presents how much of the difference in the uptake of vaccination is attributable to changes in mother and child characteristics (endowments), the effects of these characteristics (coefficients), and their interaction.

DPT3 vaccination uptake increased from 36% in 2008 to 55% in 2018, a percentage point difference of 19%. The proportion of the change explained by the coefficient effects of selected explanatory variables was more (54.2% of the total change) than the part explained by the endowment effects (45.8%). The endowment, coefficient, and interaction term were significant at $p<0.001$. However, not all the variables made a significant contribution to the change between 2008 and 2018, and within variables, some categories were more significant than the others.

Endowment – the proportion of change due to variation in characteristics

Changes in the characteristics of mothers who were resident in the various regions (geo-political zones) contributed 6.55% of the change due to endowment. The significant changes were in the North East, North West, and South East. The largest contribution was observed in the South East. The largest percentage positive contribution in endowment was in highest attained education (13.92%). In particular, change in the characteristics of mothers who had no education and those who attained secondary, and higher education made significant positive contributions to the change attributable to the endowment. The largest percentage contribution was from women who had no education (6.44%). A significant positive contribution was observed in the characteristics of women whose place of delivery was home (5.78%), and government health centres (2.57%) whereas the contribution of private hospitals/clinics was slightly above 1% and significantly negative. The effect of the change in marital status characteristics was about 1% and negative. The negative contribution was attributable to women in polygynous unions and those not in a union. Change in the work status characteristics of the respondents (working and not working) contributed about 1% to the endowment effect. Other characteristics that contributed positively to the endowment effect included permission to visit a health facility, about 2%, poorer household wealth index, exposure to the media, and mother's current age (15-34 years old).

Coefficient – the proportion of change due to the effect of the characteristics

Although the overall increase explained by the coefficients was higher than the increase explained by the endowments, the contribution of different independent variables varied substantially from one variable to another and according to categories within variables. Regarding the total increase

attributable to the changes in coefficients (54.16%), the independent variables that provide significant positive contributions were the Northwest region (9.4%) marital status, with women in polygynous unions contributing close to 11%; women from the poorest household wealth quintile, contributing 13.5%; children who were not weighed (26.%), women who were not exposed to the media (35.9%), and mother's current age 15-34 years contributing close to 9%, women not in a union (1%), Negative significant contribution to the change due to coefficients were the Northcentral region (6.4%), the Southwest region (4.2%), women who are Muslims (13.9%), and women who are exposed to the media (1.6%).

Table 2: Mean value of Change in Complete vaccination predicted between 2008 and 2018 by controlled variables

Complete Vaccine	Coefficient	P-value	Percentage
E	0.090262	<0.001	45.84
C	0.1066	<0.001	54.16
R	0.1969	<0.001	

Table 3: Contribution of selected explanatory variables to the gap in actual Change in Complete Vaccination between 2008 and 2018 in Nigeria

Variable/Category	Endowment	Sig	(%)	Coefficients	Sig	(%)
Residence						
Urban	0. 00089742	0.587	0.46	0. 0042142	0.185	2.14
Rural	0. 00089742	0.587	0.46	-.011801	0.185	-5.99
Sub-total			0.92			-3.85
Region						
North Central	-0.000021791	0.602	-0.01	-.012668*	0.000	-6.43
North East	0. 0029758*	0.009	1.51	-0. 0020442	0.715	-1.04
North West	0. 002858*	0.002	1.45	0. 018529*	0.010	9.41
South East	0. 0071623*	0.000	3.64	0. 0034878	0.171	1.77
South South	-0. 00019773	0.275	-0.10	0.0055024	0.082	2.79
South West	0. 00011217	0.866	0.06	-0.0082465*	0.005	-4.19
Sub-total			6.55			2.31
Education						
None	0. 01268*	0.000	6.44	-0. 011894	0.308	-6.04
primary	0. 0022354	0.215	1.14	0. 0018993	0. 700	0.97
Secondary	0. 0091552*	0.002	4.65	0. 0044099	0.250	2.23

Higher	0. 0033178*	0.019	1.69	-0. 0002859	0.863	-0.15
Sub-total			13.92			2.99
Sex of Child						
Male	-0. 00011713	0.731	-0.06	-0. 0013869	0.767	-0.70
Female	-0. 00011713	0.731	-0.06	0. 0013869	0.767	0.71
Sub-total			-0.12			-0.01
Place of Delivery						
Home	0. 011388*	0.000	5.78	0. 0051663	0.677	2.62
Govt Hospital	0. 0017322	0.055	0.89	0. .002702	0.245	1.37
Govt /other public health centre	0. 0050582*	0.002	2.57	-0. 0013898	0.459	-0.71
Private hospital/clinic	-0. 0021264*	0.049	-1.08	-0. 0020394	0.452	-1.04
Sub-total			8.16			2.24
Marital Status						
Monogamous Union	0. 0021573	0.063	1.10	0. 014543	0.253	7.39
Polygamous	-0. 0033004*	0.030	-1.68	0. 021629*	0.004	10.99
Not in union	-0. 00080747*	0.015	-0.41	-0.0020496*	0.015	-1.04
Sub-total			-0.99			17.34
Currently Working						
No	0. 0010857*	0.035	0.55	-0. 001506	0.680	-0.77
Yes	0. 0010857*	0.035	0.55	0. 0029722	0.680	1.51
Sub-total			1.10			0.74
Permission to Health facility						
Big Problem	0. 0015283*	0.018	0.78	-0. 0017187	0.510	-0.87
Not Big Problem	0. 0015283*	0.018	0.78	0. 0087548	0.510	4.45
Sub-total			1.56			3.58
Money **to Health facility**						
Big Problem	0. 0012874	0.211	0.65	-0. 0035016	0.589	-1.78
Not Big Problem	0. 0012874	0.211	0.65	0. 0023784	0.589	1.21
Sub-total			1.30			-0.57
Distance **to Health facility**						
Big Problem	0. 001324	0.414	0.67	0.00331980	0.522	1.69
Not Big Problem	0. 001324	0.414	0.67	-0.0048663	0.522	-2.48
Sub-total			1.34			-0.79
Go_alone **to Health facility**						
Big Problem	-0. 00014382	0.772	-0.07	0. 0018669	0.517	0.95
Not a Big Problem	-0. 00014382	0.772	-0.07	-0. 0081817	0.517	-4.16
Sub-total			-0.14			-3.21
Child Age						
12 Months	0. .00026326	0.439	0.13	0. 0013554	0.448	0.69
13-23 months	0. .00026326	0.439	0.13	-0. 010434	0.448	-5.30

Sub-total			0.26			-4.61
Religion						
Christianity	0. 00029476	0.672	0.15	0. 0010204	0.366	0.52
Islam	0. 001267	0.324	0.64	-0. 027412*	0.039	-13.92
Others	0. .00016962	0.864	0.09	0. 0065608	0.738	3.33
Sub-total			0.88			-10.07
Household Wealth Index						
Poorest	0.00087	0.397	0.44	0. 026508*	0.000	13.46
Poorer	0. 0024964*	0.003	1.27	-0. 0058008	0.236	-2.95
Middle	1.2030e-06	0.991	0.00	-0. 0012376	0.729	-0.63
Richer	0. 0015563	0.060	0.79	-0. 0037335	0.249	-1.90
Richest	0. 0016706	0.150	0.85	-0. 0057714	0.106	-2.93
Sub-total			3.35			5.05
Children Ever Born						
1-2	-0. 00047382	0.801	-0.24	0. 0078568	0.610	3.99
3-4	0. 00012217	0.807	0.06	0. 001469	0.935	0.75
5+	-0. 00023824	0.934	-0.12	-0. 018574	0.604	-9.43
Sub-total			-0.30			4.69
Birth weight						
Underweight	-0. 00014837	0.720	-0.75	-0. 00039357	0.535	-1.00
Normal	0. 0048821	0.077	2.48	0. 0027753	0.335	1.41
Overweight	0. 000065957	0.961	0.33	-0. 0023484	0.161	-1.19
Not weighted	0. 0046153	0.214	2.34	0. 051834*	0.026	26.31
Sub-total			4.40			25.53
Birth Order						
1-2	0. 00065382	0.744	0.33	-0. 0063876	0.691	-3.24
3-4	-0. 000036721	0.915	-0.19	-0. 0040333	0.821	2.05
5+	0. 00064455	0.817	0.33	0. 0080517	0.820	4.09
Sub-total			0.47			2.90
Birth _interval						
<24months	0. 0003983	0.275	0.20	-0. 0015086	0.661	-0.77
24-36months	8.4792e-06	0.938	0.00	0. 0040991	0.444	2.08
37+	0. 00023285	0.216	0.11	-0. 0010589	0.838	-0.53
Sub-total			0.31			0.78
Exposure to the media						
Not Exposed	-0. 0016432*	0.003	0.84	0. 07061*	0.007	35.86
Exposed	-0. 0016432*	0.003	0.84	-0. 0032218*	0.007	-1.64
Sub-total			1.68			34.22
Wanted Last Child						
wanted then	-0. 0016177	0.100	-0.82	0. 00070912	0.969	0.36
wanted later	-.00012335	0.901	-0.06	0. 0010303	0.531	0.52
wanted no more	-0. 00030055	0.347	-0.15	-0. 00065042	0.582	-0.33
Sub-total			-1.03			0.55

Mothers Current Age						
15-34	0. 0032167*	0.001	1.63	-0. 017274*	0.017	8.78
35-49	0. 00011901	0.140	0.60	-0. 021985	0.105	-11.17
Sub-total			2.23			-2.39
Intercepts				0.017332	0.758	8.80

Note *p<0.05

DISCUSSION OF THE FINDINGS

This study seeks to identify the relevant explanatory variables that are associated with the change in complete vaccination (DPT3) between 2008 and 2018 in Nigeria. The proportion of children who completed the DPT3 vaccine increased over the ten years. The result indicates a positive contribution of some individual-level factors.

One of the observed marked differences in child characteristics is the less than 1% increase in the proportion of underweight children over the ten years and the impressive decline in the proportion not weighed, and the proportion delivered outside health facilities. Also, the proportion of women who reported problems of geographical accessibility, affordability, and gender-related problems declined over the ten years. These results suggest an improvement in the delivery of child care in the health facilities and a positive impact of Nigeria's National Strategic Plan of Action for Nutrition (NSPAN) 2014-2019, the Saving One Million Lives Programme, and other maternal and child health programmes in Nigeria that aim at improving immunization, nutritional status of under-five children, accessibility and affordability of health care, and elimination of gender-related bottlenecks.

One of the media through which information on vaccination is disseminated is the traditional media – television and radio. Exposure to these declined over the ten years, although by 2.5%. This is worrisome because the proportion of women who had no or primary education increased over the same period. Achieving the national target on immunization requires a multi-sectoral approach. The gains in the relevant sectors must be consolidated. Exposure to child health information including vaccination positively predicts the uptake of immunization in Nigeria (Abdulraheem et al., 2011; Babalola & Lawan, 2009), and other countries (Eshete et al., 2020; Gupta et al., 2015).

Overall, both the coefficient and endowment effects significantly contributed to the change in the proportion of children who received DPT3 between 2008 and 2018. However, the coefficient effect significantly accounted for a higher proportion of the change compared to the differences in characteristics (endowment). This result indicates that the increase in uptake between 2008 and 2018 is attributable more to the change in the effect of the characteristics than the difference in the composition of women in the sample in both surveys. This is suggestive of positive behavior change towards vaccination of children in Nigeria. Studies in Nigeria and other countries point to misconceptions and fear of side effects as some of the major drivers of incomplete or non-

immunization (Adedokun et al., 2017; Gupta et al., 2015). Appropriate behaviour change programmes address these barriers.

The largest positive contribution to the behavior change was among women who were not exposed to the media, children who were not weighed, women from the poorest household wealth quintile, women in polygynous unions, and women from the Northwest region. This result indicates that the several vaccination programmes and initiatives in Nigeria that aimed at vulnerable women and children may have accounted for the large contributions from these categories of vulnerable women and children. A previous study in Rwanda presented a similar pattern in contraceptive use where women of lower status contributed more to the positive change over time (Muhoza et al., 2016). The effort to reach these categories of women and children with vaccination should be intensified. On the other hand, negative contributions to the coefficient effect were observed among Muslim women, the Northcentral and Southwest regions. This result indicates the need to do more among women who are affiliated with Islam. Although the coverage of DPT3 in 2018 is 74% and 54% in the Southwest and Northcentral, respectively (National Population Commission (NPC) [Nigeria] and ICF, 2019), no State in the Northcentral has attained the minimum 80% coverage for each State, and three States in the Southwest are still below this coverage target for States. There is a need to give attention to these two regions so that the gains in these regions are not lost.

This study has limitations. One is the exclusion of institutional factors that may have contributed to the change in the proportion vaccinated over the period studied. This is due to the limitation of the data source (DHS), which provides no information from the supply side (health facilities and government). Also, the data is cross-sectional and causality cannot be inferred

CONCLUSION

The factors that contributed significantly and substantially to the change in the proportion of children who received DPT3 between 2008 and 2018 should receive more attention in immunization programmes in Nigeria. This will enhance the country's progress towards achieving SDG goal 3.2.1 to end preventable deaths of newborns and under-5 children, and the country's target to ensure full immunisation of children less than one year at 90% nationally, with at least 80% coverage in each State.

References

Abdulraheem, I., Onajole, A., Jimoh, A., & Oladipo, A. (2011). Reasons for incomplete vaccination and factors for missed opportunities among rural Nigerian children. *J Public Health Epidemiol*, *3*(4), 194–203.

Adedokun, S. T., Uthman, O. A., Adekanmbi, V. T., & Wiysonge, C. S. (2017). Incomplete childhood immunization in Nigeria: A multilevel analysis of individual and contextual factors. *BMC Public Health*, *17*(1), 1–10.

Adeloye, D., Jacobs, W., Amuta, A. O., Ogundipe, O., Mosaku, O., Gadanya, M. A., & Oni, G. (2017). Coverage and determinants of childhood immunization in Nigeria: A systematic review and meta-analysis. *Vaccine*, *35*(22), 2871–2881.

Akwataghibe, N. N., Ogunsola, E. A., Broerse, J. E., Popoola, O. A., Agbo, A. I., & Dieleman, M. A. (2019). Exploring Factors Influencing Immunization Utilization in Nigeria—A Mixed Methods Study. *Frontiers in Public Health*, *7*, 392.

Antai, D. (2009). Inequitable childhood immunization uptake in Nigeria: A multilevel analysis of individual and contextual determinants. *BMC Infectious Diseases*, *9*(1), 1–10.

Babalola, S., & Lawan, U. (2009). Factors predicting BCG immunization status in northern Nigeria: A behavioral-ecological perspective. *Journal of Child Health Care*, *13*(1), 46–62.

Banjo, O. O., Bamiwuye, O. S., Bisiriyu, L. A., & Akintayo, O. A. (2018). Decision making autonomy and fertility behaviour among currently married women in Nigeria. *African Population Studies*, *32*(3).

Berendsen, M. L., Van Gijzel, S. W., Smits, J., De Mast, Q., Aaby, P., Benn, C. S., Netea, M. G., & Van Der Ven, A. J. (2019). BCG vaccination is associated with reduced malaria prevalence in children under the age of 5 years in sub-Saharan Africa. *BMJ Global Health*, *4*(6).

Duro, J. A., Lauk, C., Kastner, T., Erb, K.-H., & Haberl, H. (2020). Global inequalities in food consumption, cropland demand and land-use efficiency: A decomposition analysis. *Global Environmental Change*, *64*, 102124.

Eshete, A., Shewasinad, S., & Hailemeskel, S. (2020). Immunization coverage and its determinant factors among children aged 12–23 months in Ethiopia: A systematic review, and meta-analysis of cross-sectional studies. *BMC Pediatrics, 20*, 1–13.

Fagbamigbe, A. F., Kandala, N. B., & Uthman, A. O. (2020). Demystifying the factors associated with rural–urban gaps in severe acute malnutrition among under-five children in low-and middle-income countries: A decomposition analysis. *Scientific Reports, 10*(1), 1–15.

Federal Ministry of Health. (2021). *Nigeria Health Facility Registry*. https://hfr.health.gov.ng/statistics/tables

Gooding, E., Spiliotopoulou, E., & Yadav, P. (2019). Impact of vaccine stockouts on immunization coverage in Nigeria. *Vaccine, 37*(35), 5104–5110.

Gupta, P., Prakash, D., & Srivastava, J. P. (2015). Determinants of immunization coverage in lucknow district. *North American Journal of Medical Sciences*, *7*(2), 36–40. PubMed. https://doi.org/10.4103/1947-2714.152076

Menon, P., Headey, D., Avula, R., & Nguyen, P. H. (2018). Understanding the geographical burden of stunting in India: A regression-decomposition analysis of district-level data from 2015–16. *Maternal & Child Nutrition, 14*(4), e12620.

Muhoza, D. N., Rutayisire, P. C., & Umubyeyi, A. (2016). Measuring the success of family planning initiatives in Rwanda: A multivariate decomposition analysis. *Journal of Population Research, 33*(4), 361–377.

National Population Commission (NPC) [Nigeria] and ICF. (2019). *Nigeria Demographic and Health Survey 2018*. NPC and ICF.

National Primary Health Care Development Agency. (2012). *National Guidelines for the Development of Primary Health Care System in Nigeria* (Fourth Revised Edition). National Primary Health Care Development Agency, Federal Republic of Nigeria.

National Primary Health Care & Development Agency, Nigeria. (2012). *Nigerian National Routine Immunisation Strategic Plan (2013-15),*.

Odusanya, O. O., Alufohai, E. F., Meurice, F. P., & Ahonkhai, V. I. (2008). Determinants of vaccination coverage in rural Nigeria. *BMC Public Health*, *8*(1), 1–8.

Powers, D. A., Yoshioka, H., & Yun, M.-S. (2011). mvdcmp: Multivariate decomposition for nonlinear response models. *The Stata Journal*, *11*(4), 556–576.

Samuel, O., Zewotir, T., & North, D. (2021). Decomposing the urban–rural inequalities in the utilisation of maternal health care services: Evidence from 27 selected countries in Sub-Saharan Africa. *Reproductive Health*, *18*(1), 1–12.

Tagbo, B. N., Eke, C. B., Omotowo, B. I., Onwuasigwe, C. N., Onyeka, E. B., & Mildred, U. O. (2014). Vaccination coverage and its determinants in children aged 11-23 months in an urban district of Nigeria. *World Journal of Vaccines*, *4*(04), 175.

The United Nations Inter-agency Group for Child Mortality Estimation (UN IGME). (2020). *Levels & Trends in Child Mortality*. UNICEF.

World Health Organization. (2020). *Global vaccine action plan: Monitoring, evaluation and accountability. Secretariat annual report 2020*.