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

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Abstract

Childhood immunization increased from 23% in 2008 to 31% in Nigeria. However, the factors that contributed to the change have not been systematically investigated. Using diphtheria, pertussis, and tetanus (DPT) as a measure of immunization, this study investigated the factors that account for the change in the proportion of children aged 12-23 months who received complete DPT vaccination between 2008 and 2018. Data were obtained from the Nigeria Demographic and Health Surveys of 2008 and 2018. The decomposition logit model was used to analyze data of 7,356 children aged 12-23 months. There was an increase in complete DPT-uptake from 36% in 2008 to 55% in 2018. The increase was mainly due to a change in behaviour toward immunization as 54.2% of the total change was explained by the coefficient effect of the selected explanatory variables. The independent variables that contributed significantly to the increase in DPT immunization were region, education, place of delivery, marital status, work status, needing permission to visit a health facility, religion, household wealth, birth weight, exposure to the media, and mother's age. Nigeria must prioritize attention to factors that account for positive change in vaccination if the country would achieve the 2030 global immunization agenda to halve the number of zero-dose children and 90% coverage, with at least 80% coverage in each State of Nigeria.

Keywords: Childhood vaccination, Child health, DPT vaccine, Decomposition analysis, Nigeria

Introduction

The World Health Organization recommends full childhood immunization to prevent children from dying from vaccine-preventable diseases before the age of five. A child is fully immunized when she or he has received a bacille Calmette-Guerin (BCG) vaccination against tuberculosis; three doses of diphtheria, pertussis, and tetanus (DPT) vaccine; at least three doses of polio vaccine; and one dose of measles vaccine; in 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. Substantial progress has been made in achieving full immunization for children globally, however, slightly above 25 million children were either unvaccinated or under-vaccinated in 2021. Most of these unvaccinated children live in Western and Central Africa, with Nigeria accounting for 2.2 million of the 18.2 million zero-dose children

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(United Nations Children's Fund, 2023). To increase the uptake of routine childhood immunization, the Nigerian government has initiated several programmes and campaigns 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), national immunization programme among others.

The Nigerian EPI prescribes that BCG, oral polio vaccine (OPV), DPT, measles vaccine (MV), Yellow fever, and Hepatitis B (HepB) vaccines should be given to every child within the first year of life in five routine contacts in primary health centres. 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 DPT vaccine with the pentavalent vaccine (also known as DPT-HepB-Hib), which contains more antigens – Haemophilus influenzae type B, and hepatitis B. In order to increase children's immunity against types 1 and 3 wild poliovirus (WPV) and reduce the risk of circulating vaccine-derived poliovirus (cVDPV), the inactivated polio vaccine (IPV), which acts as a booster for the oral polio vaccination, was introduced in February 2015. 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 (National Primary Health Care Development Agency, 2012).

Following these initiatives, there has been some improvement in Nigeria in the percentage of children immunized. For instance, the proportion of children aged 12-23 months who received all recommended immunizations rose from 23% in 2008 to 31% in 2018, while the proportion who received none of the recommended vaccinations fell from 29% to 19% between those years (National Population Commission (NPC) [Nigeria] and ICF, 2019). In August 2020, Nigeria was also certified wild polio-free by the Africa Regional Commission for Certification of Polio Eradication (World Health Organization, 2020).

Many previous studies and reports have identified several institutional, contextual, and individual-level factors associated with childhood immunization in Nigeria Gooding et al., 2019; National Primary Health Care Development Agency, 2012; National Primary Health Care and Development Agency, Nigeria, 2012). Some of 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; Olaniyan et al., 2022; Tagbo et al., 2014). Identifying the factors that are associated with childhood immunization is important for program and policy. However, identifying whether the positive change in immunization uptake between 2008 and 2018 is explained by the characteristics of the identified groups or by the effects of those characteristics or the interaction of both, is more important for sustained progress in childhood immunization in the country. Till date, little attention has been paid to this aspect of immunization research in Nigeria. 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 2030 global immunization agenda to halve the number of zero-dose children and 90% coverage (World Health Organization, 2021), and the national target to reduce zero-dose children by 80% by the end of 2028 (World Health Organization, 2023). Therefore, 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 DPT vaccination between 2008 and 2018 in Nigeria. DPT is usually used as a proxy measure in calculating zero-dose and under-immunization (United Nations Children's Fund, 2023). 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 Design

This was a decomposition analysis based on the logit model. This strategy offers a way to compare the outcomes of two different groups. The disparities between two groups may be explained by differences in the endowments or features of the groups, by the consequences of those attributes (coefficients), or by the interaction term, which assesses the combined impact of endowment and coefficient differences. The technique thus discloses the true contribution of each independent variable to the overall difference in characteristics or the effects of characteristics. The decomposition model is derived as follows:

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

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

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 explanatory variables $\ddot{X}$ and the estimated coefficients β. The decomposition technique divides the changes into explained and unexplained portions

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$$\text{Complete DPT3 Vaccination}_{2018} - \text{Complete DPT3 Vaccination}_{2008} = (\ddot{X}^{2018} - \ddot{X}^{2008})'\,\beta_{pooled} + \ddot{X}^{2008'}(\beta_{2008} - \beta_{pooled}) + \ddot{X}^{2018'}(\beta_{pooled} - \beta_{2018})$$

Explained part **unexplained part**

The focus of this paper is on the portion that can be explained, which is the variation in the explanatory variable $\ddot{X}$ mean between 2008 and 2018 multiplied by the corresponding coefficients from the βpooled. The explained part can be further broken down into the sum of the contributions made by each explanatory variable. Following Powers et al. (2011) suggestion to normalize the dummy variable for categorical variables with more than two categories, all categories are included in the decomposition and the contributions are expressed as the deviation from the grand mean.

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, study population and sample size

We analyzed data on children who were aged 12-23 months, using the kids recode in the 2008 and 2018 Nigeria Demographic and Health Survey (NDHS) with a respective weighted sample size of 4,820 and 2,488 children. Thus, the total sample was 7,308 children. 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 DHS is a nationally representative survey that collects information on basic demographic and health topics from women

aged 15-49 and men aged 15-59 in randomly selected households. The information about their vaccination status was collected from mothers. In both surveys, information on vaccination coverage was gathered in two ways: from immunization cards provided to the interviewer and from mothers' verbal reports. The interviewer copied the dates into the form if the immunis ation card was available. If there was no vaccination card or if a vaccine was not noted on the card as provided, the respondent was asked to recollect the immunizations given to her child.

Variables and Measures

The dependent variable is a binary indicator of the immunisation status of a child using DPT as a measure of immunization. The variable captures whether a child had received the three required doses of DPT basic immunization (coded 1 as complete), and if less than three, none or don't know coded 0 as incomplete.

The explanatory variables which were drawn from the literature on immunization in Nigeria and other middle and low-income countries (Bassoum et al., 2020; Debie & Lakew, 2020; Odusanya et al., 2008; O'Leary et al., 2017; Soans et al., 2021; Tagbo et al., 2014) 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. Previous studies suggest that low-weight babies are less likely to receive full and timely immunization (O'Leary et al., 2017; Upadhyay et al., 2017). 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 were permission to seek medical help a problem, and going alone a big problem. Contextual variables were region, and place of residence. All of these variables were utilized to separate the contributions of the changes in child immunization rates between the two time periods caused by changes in population composition from those caused by changes in population behavior.

Statistical Analysis

The contribution of each factor was assessed using both descriptive and multivariable analysis. Descriptive statistics were used to present the characteristics of the respondents in each category for each independent variable in each survey, as well as to demonstrate, in percentage points, the changes between surveys suggesting improvements or otherwise in the sample population's characteristics. The observed difference in DPT uptake in the two survey years was decomposed using a logit model. 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. All statistical analyses were conducted with Stata 14 for windows (STATA Corp, College Station, TX). All the analyses were listwise meaning that missing values in each variable were dropped. Sample weights were applied in all analysis, and the svy command in Stata was used to account for the sample design of the DHS data. The results were considered statistically significant at a p-value <0.05 (95% confidence interval). The manuscript is reported using the STROBE checklist for cross-sectional studies.

Results

Table 1 presents the change over time in the uptake of complete DPT vaccination and the characteristics of the sample population. The results show that during the period under review 2008 and 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 children who were delivered at health facilities increased by 11.9%, and delivery at home reduced by a similar percentage point from 2008 to 2018. The change in proportion by sex of the child 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 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%. Mothers who were resident 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.

Table 1: Characteristics of the study population

Variable	Category	2008 N=4903 n(/%)	2018 N=2453 n(%)	Change (% point)
DPT3	Incomplete	3133(63.9)	1094(44.6)	-19.3
	Complete	1770(36.1)	1359(55.4)	19.3
CHILD'S CHARACTERISTICS				
Birth weight	Underweight	77(1.58)	52(2.1)	0.6
	normal	604(12.3)	539(22.0)	9.7
	Overweight	290(5.9)	221(9.0)	3.1
	Not weighted	3932(80.2)	1641(66.9)	-13.4
Birth Order	1-2	1809(36.9)	934(38.1)	1.2
	3-4	1437(29.3)	711(29.0)	-0.4
	5+	1657(33.8)	808(33.0)	-0.8
Birth Interval	<24 months	1093(22.3)	458(18.7)	-3.6
	24-36 months	2000(40.8)	997(40.6)	-0.2
	37+	1810(36.9)	998(40.7)	3.8
Place of Delivery	Non-Facilities	3197(65.2)	1307(53.3)	-11.9
	Health Facilities	1706(34.8)	1146(46.7)	11.9
Sex of Child	Male	2432(49.6)	1241(50.6)	0.95
	Female	2471(50.4)	1212(49.4)	-0.95
Child age	12 Months	554(11.3)	243(9.9)	-1.3
	13-23 Months	4349(88.8)	2210(90.1)	1.3
MATERNAL CHARACTERISTICS				
Child Wantedness	Wanted then	4302(87.8)	2088(85.2)	-2.61
	Wanted Later	366(7.5)	277(11.3)	3.79
	Wanted no more	235(4.8)	88(3.6)	-1.18
Region	North Central	624(12.7)	337(13.7)	1.01
	North East	784(16.0)	398 (16.2)	0.22
	North West	1524(32.1)	660(26.9)	-4.2
	South East	495(10.1)	328(13.4)	3.28
	South South	661(13.5)	281(11.5)	-2.01
	South West	815(16.6)	449 (18.3)	1.7
Mother Exposure to media	Exposed	1510(30.8)	814(33.2)	2.36
	Not Exposed	3393(69.2)	1639(66.8)	-2.36
Marital Status	Monogamous	3310(67.5)	1741(71.0)	3.41
	Polygamous	1415(28.8)	602(24.6)	-4.24
	Never in Union	178(3.6)	110(4.5)	0.82
Religion	Traditional/Others	77(1.5)	12(0.5)	-0.99
	Christianity	2188(44.6)	1119(45.6)	0.95
	Muslim	2638(53.8)	1322(53.9)	0.05

Table 1 contd.

Variable	**Category**	**2008 N=4903 n(/%)**	**2018 N=2453 n(%)**	**Change (% point)**
Wealth Index	Poorest	1157(23.6)	483(19.7)	-3.98
	Poorer	1093(22.3)	466(19.0)	-3.31
	Middle	927(18.9)	471(19.2)	0.34
	Richer	873(17.8)	515(21.0)	3.2
	Richest	853(17.4)	518(21.1)	3.74
Educational Attainment	No Education	2238(45.6)	927(37.8)	-7.85
	Primary	1098(22.4)	365(14.9)	-7.58
	Secondary	1263(25.7)	910(37.1)	11.36
	Higher	304(6.2)	251(10.3)	4.1
Work Status	Not Working	1706(34.8)	753(30.7)	-4.11
	Working	3197(65.2)	1700(69.3)	4.11
Place of Residence	Urban	1486(30.3)	1106(45.1)	14.86
	Rural	3417(69.7)	1347(54.9)	-14.86
Distance to Facility is a big problem	Yes	1883(38.4)	704(28.7)	-9.7
	No	3020(61.6)	1749(71.3)	9.7
Permission for medical Help a big problem	Yes	755(15.4)	301(12.3)	-3.15
	No	4148(84.6)	2152(87.7)	3.15
Getting Money for treatment a big problem	Yes	2844(58.0)	1192(48.6)	-9.41
	No	2059(42.0)	1261(51.4)	9.41
Going Alone a big problem	Yes	819(16.7)	367(15.0)	-1.74
	No	4084(83.3)	2086(85.0)	1.74
Children Ever Born	1-2	1768(36.1)	913(37.2)	1.14
	3-4	1445(29.5)	723(29.5)	0.04
	5+	1690(34.5)	817(33.3)	-1.19
Current Age	15-19	348(7.1)	109(4.4)	-2.68
	20-24	1022(20.9)	496(20.2	-0.73
	25-29	1487(30.3)	684(27.9)	-2.31
	30-34	1001(20.4)	533(21.7)	1.25
	35-39	639(13)	440(17.9)	4.94
	40-44	279(5.7)	149(6.1)	0.39
	45-49	127(2.6)	42(1.7)	-0.86

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. 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.

Decomposition Analysis

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

Table 2: Change in complete DPT vaccination predicted between 2008 and 2018

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	

DPT3 vaccination uptake increased from 36% in 2008 to 55% in 2018, a percentage point difference of 19%. The proportion of the change in vaccination uptake explained by the coefficient effects of independent variables was higher (54.2% of the total change) than the portion explained by the endowment (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.

The contribution of the explanatory variables to the change in complete DPT vaccination between 2008 and 2018 attributed to endowment and coefficient is presented in Table 3.

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.

Table 3: Contribution of explanatory variables to change in complete DPT vaccination

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*	<0.001	-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*	<0.001	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*	<0.001	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*	<0.001	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

*p<0.05

Table 3 contd.

Variable/Category	Endowment	Sig	(%)	Coefficients	Sig	(%)
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*	<0.001	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

*p<0.05

Table 3 contd.

Variable/Category	Endowment	Sig	(%)	Coefficients	Sig	(%)
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

*p<0.05

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 rise caused by the coefficients was greater than the increase explained by endowments, the contribution of various factors varied greatly between independent variables and according to subcategories within independent variables. The independent variables that make significant positive contributions to the overall increase

attributed to changes in coefficients (54.16%) include 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%).

Discussion

This study identified the relevant explanatory variables that are associated with the change in complete DPT vaccination 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 both the child and mothers' characteristics as well as the effect of the characteristics.

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 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). This result indicates that the misconceptions and fears are changing among the groups that contributed significantly to the coefficient effect. For sustained and more substantial improvement in DPT uptake, Nigeria should invest more in behavior change programmes targeted at the identified categories of children and mothers that contributed positively to the coefficient effect as well as the negative significant contributors.

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 vaccination programmes and initiatives in Nigeria that target vulnerable women and children have been successful given 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). Previous studies suggest that low-weight babies are less likely to receive full and timely immunization (O'Leary et al., 2017; Upadhyay et al., 2017), but in our study, children who were not weighed were a positive contribution to the change. Children who are not weighed are unlikely to have been born in a health facility; many studies in Nigeria show that non-facility birth is prevalent among the less priviledged sub-groups in the country (Babalola & Fatusi, 2009; Dahiru & Oche, 2015; Ntoimo & Odusina, 2019; Ononokpono & Odimegwu, 2014; Ovikuomagbe, 2017).

The effort to reach these categories of women and children with vaccination should be intensified by strengthening the primary health care system. A major service of primary health centres in Nigeria is childhood immunization, and these PHCs are located close to where people reside in the rural and urban areas. However, some previous studies have identified supply and demand factors that limit the utilization of primary health centres for child and maternal health services such as providers' unfriendly attitude, stock-out, inadequate or no providers, poor facilities, among others (Akinyinka et al., 2016; Egbewale & Odu, 2013; Ntoimo et al., 2019; Oyekale, 2017; Udenigwe et al., 2021). It is important to address these barriers for sustainable and substantial improvement in DPT and other vaccination coverage in Nigeria.

On the other hand, negative contributions to the coefficient effect were observed among Muslim women, in the Northcentral and Southwest regions. This result indicates the need to do more among women who are affiliated with the Islamic religion. Religion predicts child health outcomes as shown in many studies (Antai et al., 2009; Defo, 1996; Demir & Yıldırım, 2019; Stroope et al., 2018). Although the coverage of DPT3 in 2018 was 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. However, the results are generalizable to entire Nigeria because the sample is nationally representative.

Conclusion

The increase in DPT immunization between 2008 and 2018 in Nigeria is explained more by coefficients than endowment, and the contribution of the various factors varied greatly between independent variables and within subcategories of the significant independent variables. The factors that contributed significantly and substantially to the change in the proportion of children who received DPT3 between 2008 and 2018 should be given more consideration in Nigerian immunization programmes. This would help the country move closer to meeting the 2028 and 2030 targets of halving zero-dose children and increasing coverage to 80%, as well as SDG 3.2.1, which aims to end preventable deaths among newborns and children under the age of five.

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