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FACULTY OF MEDICINE

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OPTIMISING CHILDHOOD IMMUNISATION IN NIGERIA

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ABSTRACT

In 2016, about 2 million child deaths globally were prevented through routine vaccination; if all children had been immunised fully, a further 1.5 million child deaths could have been prevented. Globally, in 2016, Nigeria had the largest number of eligible infants who did not complete routine Diphtheria, Pertussis and Tetanus vaccinations. Optimal child immunisation coverage has been associated with variables acting at the child, household, community, country, health system and policy levels. This study aims to inform improvement of childhood immunisation programmes in Nigeria through examination of nationally representative survey data on child vaccination in Nigeria by child, household, community and health system factors, with a particular focus on the place of residence. Multilevel logistic regression models were applied for quantitative analyses of Nigeria's 2003, 2008 and 2013 Demographic and Health Surveys (DHS), singly, pooled overall and stratified by rural/urban; these were augmented by qualitative thematic analysis of data collected from two slums in Abuja, Nigeria. Interview with parents, health workers and community leaders in the slums around Abuja solicited their views of the enablers and barriers to child immunisation.

Fully Immunised Child Coverage (FIC, the percentage of children aged 12-23 months who had received all doses of routine infant vaccines) rose from 12.9% in 2003 to 25.3% in 2013, and varied across sociodemographic characteristics including place of residence. In pooled DHS data analysis, overall and stratified, FIC adjusted odds (aOR) were: 1. **Total population**- antenatal care (attendance versus non-attendance, aOR=4.42, 95% CI=2.00-9.76), place of delivery (health facility vs home, aOR=3.86, 95% CI=1.94-7.67), maternal education level (higher vs no education, aOR=6.57, 95% CI=2.32-18.59), Religion (Christian vs Muslim, aOR=2.37, 95% CI=1.82-3.10) and place of residence (urban vs rural, aOR=1.60, 95% CI=0.60-4.24). 2. **Rural and urban stratified: A.Rural** – antenatal care (aOR=8.37, 95% CI=5.34-13.12), place of delivery (aOR=1.47, 95% CI=1.12-1.94), maternal education (aOR=4.99, 95% CI=2.48-10.06), Religion (aOR=2.63, 95% CI=1.79-3.86). B.**Urban**- antenatal care (aOR=5.65, 95% CI=2.73-11.71), place of delivery (aOR=2.79, 95% CI=1.83-4.25), maternal education (aOR=6.04, 95% CI=2.99-12.20), Religion (aOR=2.39, 95% CI=1.53-3.73). 3. **Intra-urban stratified: A**.**Urban formal**- antenatal care (aOR=6.82, 95% CI=2.29-20.34), place of delivery (aOR=2.62, 95% CI=1.43-4.79), maternal education level (aOR=9.18, 95% CI=3.05-27.64), Religion (aOR=1.59, 95% CI=0.89-2.86). B.**Urban slums** - antenatal care (aOR=8.07, 95% CI=2.15-30.25), place of delivery (aOR=5.39, 95% CI=2.18-13.33), maternal education (aOR=5.03, 95% CI=1.52-16.65), Religion (aOR=5.69, 95% CI=2.02-15.45)

The overall stubbornly low FIC rates in Nigeria are of serious global public health concern. Qualitative research suggests that improving vaccine availability and instituting parent-health workers communication channels, would improve FIC in the slums, where 30-40% of Nigerians now reside. Longer term measures to improve FIC for the total population are increasing antenatal attendance and health facility delivery, improved immunisation education and higher education levels among mothers, while in rural areas more health facilities are required, and in urban areas additional targeted development of immunisation education messages specifically aimed at Muslims living in urban slums could be advised. Suggestions to improve childhood immunisation include nationally representative qualitative study on stakeholders views on enablers and barriers of childhood immunisation, strengthening the implementation of relevant government policies and place of residence directed interventions like regular availability of vaccines, session reminder system, active community participation in health facility management, regular supportive supervision, inter personal communication skills development and introduction of date and time appointment for immunisation.

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Research Thesis: Declaration of Authorship

Print name:	Olayinka Aderopo Obanewa

Title of thesis:	Optimising Childhood Immunisation in Nigeria

I declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

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1. This work was done wholly or mainly while in candidature for a research degree at this University;
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3. Where I have consulted the published work of others, this is always clearly attributed;
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Abbreviations

AFP	Acute Flaccid Paralysis
aOR	Adjusted Odds Ratio
BCG	Bacillus Calmette-Guerin
DHS	Demographic and Health Survey
DOR	Drop Out Rate
DPT	Diphtheria-Pertussis-Tetanus
EPI	Expanded Programme on Immunisation
FCT	Federal Capital Territory
FIC	Fully immunised Child
NDHS	Nigeria Demographic and Health Survey
NIDs	National Immunisation Days
NPHCDA	National Primary Health Care Development Agency
NPI	National Programme on Immunisation
OPV	Oral Polio vaccine
OR	Odds Ratio
PHCB	Primary Health Care Board
RI	Routine Immunisation
SIA	Supplemental immunisation activity
U5M	Under-Five Mortality
UN HABITAT	United Nations Human settlements Programme
UNFPA	United Nations Population Fund
UNICEF	United Nations Children Fund
WHO	World Health Organisation

Chapter 1 Optimising childhood vaccination in Nigeria: background to the PhD study

1.1 Introduction

Childhood immunisation is a most successful and cost-effective public health tool (World Health Organisation, 2017); large immunisation programmes resulted in the eradication of small pox, polio and measles in many countries, and have drastically reduced the morbidity and mortality caused by Diphtheria, Poliomyelitis, Pertussis, Tetanus, Measles and, more recently, *Haemophilus influenzae* type b, Streptococcus pneumoniae , Rotavirus, and Hepatitis B (Tao *et al.*, 2013; World Health Organisation, 2017). However, the burden of vaccine-preventable child deaths remains substantial, in 2008 alone thousands of under 5 deaths globally were caused by preventable infections: Measles 118,000, Pertussis - 195,000, Tetanus - 63,000, *Haemophilus influenzae* type b - 199,000, Pneumococcal diseases - 476,000, and Rotavirus - 453,000 (World Health Organisation, 2018).

Immunisation in infancy and childhood remains a key strategy for further reducing infant and child mortality (Sissoko *et al.*, 2014). Immunisation provides protection not only to the individual but also to the community through the prevention and reduction of the spread of the disease (herd immunity) (Stevenson, 2009). In 1974, the World Health Organisation (WHO) launched the Expanded Programme on Immunisation (EPI) targeting six childhood diseases namely Diphtheria, Measles, Pertussis, Polio, Tetanus and Tuberculosis (Tao *et al.*, 2013). Even with 21 vaccines now on the WHO recommended childhood immunisation schedule (World Health Organisation, 2015c), further vaccines are expected to be included as results on their proven effectiveness become available. Immunisation does not just raise the chances that children will resist disease, it virtually guarantees they will (World Health Organisation and United Nations Children's Fund, 2010; World Health Organisation, 2012).

After the launch of Expanded Programme on Immunisation (EPI), global immunisation efforts, including the establishment of the Global Alliance for Vaccine and Immunisation (Bustreo *et al.*, 2015), development of the Global Immunisation Vision and Strategy 2006-2015 (Kamara *et al.*, 2013), and the Global Vaccine Action Plan 2011-2020 endorsed by the World Health Assembly in 2012, are geared towards achieving universal child immunisation coverage. Although the aim of universal coverage has not yet been attained, global childhood immunisation coverage estimates have improved substantially. WHO estimates that, in 2016 alone, two to three million child deaths were prevented by immunisation (World Health Organisation, 2017), and another 1.5 million deaths could have been prevented if global immunisation coverage had been higher (World Health Organisation, 2017). Receipt of the third dose of the DPT vaccine (DPT 3) before the age of one year is a globally accepted and recognised indicator of immunisation system performance and coverage (Murray *et al.*, 2003b; Lim *et al.*, 2008; Ndirangu *et al.*, 2009; World Health Organisation, 2017). In 2016, of the global under one population of 136 million infants eligible for childhood immunisation, 116.5 million received DPT3 vaccines (86% coverage) (Feldstein *et al.*, 2017). In the same year, of the 194 WHO countries, 130 (67%) achieved ≥90% DPT3 coverage, 29 countries had DPT3 coverage between 80-89%, 15 countries between 70-79% and the remaining 20 countries achieved DPT3 coverage < 70% (Feldstein *et al.*, 2017). Overall, an estimated 19.5 million (14%) of the eligible 136 million infants globally missed out on completing the full dose DPT (Diphtheria, Pertusis and Tetanus) immunisations, with ten countries accounting for 61% of these incompletely immunised infants, with Nigeria contributing 18%, or 3.51 million) (Feldstein *et al.*, 2017). Despite enormous success, challenges remain in some settings, with Nigeria being the foremost challenge.

1.2 Nigeria

Nigeria came into existence as a nation-state in 1914 when the British colonial masters amalgamated the northern and southern protectorates (National Population Commission, 2014). It became independent on October 1, 1960 as a federation of three regions (Northern, Western, and Eastern). There are 374 identifiable ethnic groups, with the Hausa, Yoruba, and Igbo being the major groups (National Population Commission, 2014). African traditional religion, Christianity and Islam are the major religions. With an estimated population of 186 million, Nigeria is the most populous nation in Africa and the seventh most populous in the world (The World Bank, 2016). Nigeria is made up of 36 states and a Federal Capital Territory, grouped into six geopolitical zones: North Central, North East, North West, South East, South South, and South West (National Population Commission, 2014). There are 774 constitutionally recognised local government areas (LGAs) in the country (National Population Commission, 2014). Nigeria has an annual urbanisation rate of 4.35% and an annual population growth rate of 2.6% (The World Bank, 2016). About half of the population now live in urban areas, this is projected to rise to 61% by 2030 (United Nations Human Settlement Programme and UN HABITAT, 2014). The UN HABITAT slum almanac 2015/16 reported that just over 42 million Nigerians, which is 50.2% of the Nigerian urban dwellers, resided in slums (UN HABITAT, 2016a). Some Nigerian studies have estimated the proportion of urban dwellers living in slums to be as high as 75% (Bobadoye and Fakere, 1926; Olotuah and Bobadoye, 2009). The growth of the urban population in Nigeria has been rapid, from 7% of the total population in the 1930s, 10% in 1950, 35% in 1990 (Okupe, 2002; Olotuah and Bobadoye, 2009) to the current 50% (UN HABITAT, 2016a).

Nigeria launched its EPI programme in 1979 with the vision to improve the health of Nigerian children by eradicating the identified six major childhood diseases, which are polio, measles, diphtheria, pertussis, tuberculosis, and tetanus (Obioha *et al.*, 2010; Abdulkarim *et al.*, 2011). Following the launch, the nation has made critical efforts to achieve Universal Childhood Immunisation coverage. In 1984, EPI in Nigeria was relaunched after a period of poor management and implementation (Hargreaves, 2002), aiming to immunise at least 80% of all children aged 0-2 years by 1990 and reduce by 50% the morbidity and mortality from the six EPI childhood diseases (Babaniyi, 1990; Ekerete, 2000). EPI was renamed the National Programme on Immunisation (NPI) in July 1995 to emphasise the national responsibility for immunisation (Renne, 2010). In 1996, the then Nigerian First Lady formally launched the NPI as part of her programme (Renne, 2010) and August 1997 saw the promulgation of Decree number 12, which gave legal backing to the NPI project as a self-accounting parastatal in the Nigerian Federal Ministry of Health (National Primary Health Care Development Agency, 2009; Renne, 2010). Following the Federal Government Health Sector Reform, NPI was merged with the National Primary Health Care Development Agency (NPHCDA) in May 2007 (National Primary Health Care Development Agency, 2009). During these years several programme strengthening processes, including the introduction of new vaccines, development of comprehensive EPI multiyear plans, Supplementary Immunisation Activities, Reaching Every Ward strategy, revision of the National policy on immunisation, development of the National Strategic Health Development Plan and National Strategic Routine immunisation Plan were implemented (Federal Ministry of Health and National Primary Health Care Development Agency, 2013).

Immunisation services are provided at fixed (Health facility) and outreach posts in the Nigerian health care system (National Primary Health Care Development Agency, 2009). The outreach service is meant to serve individuals, families and communities in the primary health Care facility catchment area who live 5 (five) to 10 (ten) kilometres from the facility (National Primary Health Care Development Agency, 2009); health workers from the health facilities are expected to visit these further away areas regularly.

Since 1997, childhood immunisation services have been provided free of charge at public health facilities, where bundled vaccines (vaccines, devices and consumables) are expected to be always available (National Primary Health Care Development Agency, 2009). Nigeria adopted the WHO designed immunisation service provision strategy, reaching every district in 2004 but renamed it reaching every ward (REW) (National Primary Health Care Development Agency, 2009; Federal

Ministry of Health and National Primary Health Care Development Agency, 2013). REW has five components namely planning and management of resources, increasing access to immunisation services, supportive supervision, community link activities and use of data for action. The end service provision of vaccine administration is spelt out in the Basic Guide for Routine Immunisation Service Providers book. The childhood routine immunisation target group in Nigeria is composed of children aged less than 12 months (National Primary Health Care Development Agency, 2009), although unimmunised children of ages 12 – 23 months remain eligible for immunisation and should be identified at health care visits. Vaccine stocks are based on the population estimates of children less than one year of age.

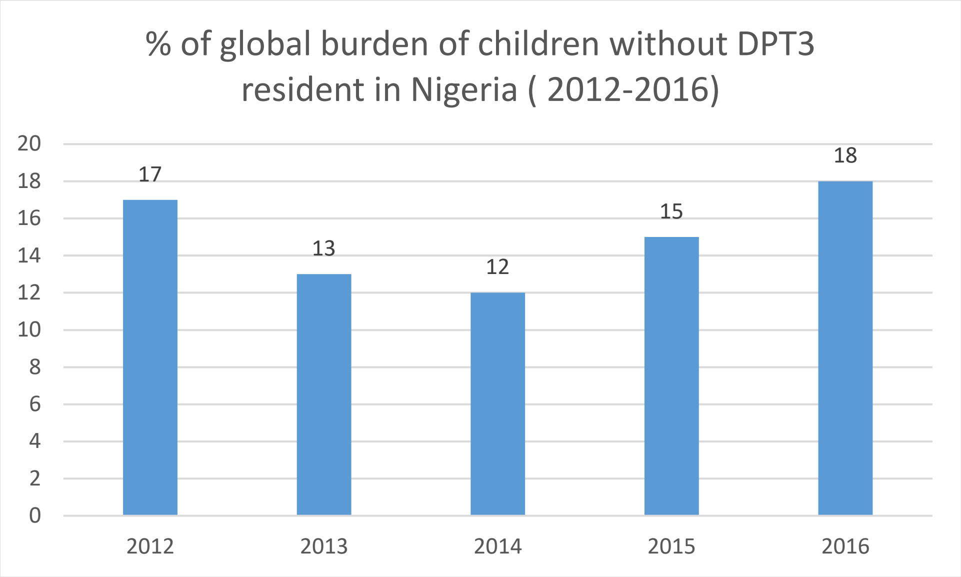
1.3 Child Immunisation performance in Nigeria

Nigeria has Africa's largest under one population but is ranked among the countries with the lowest immunisation coverage globally (The World Bank, 2016; Feldstein *et al.*, 2017).

Nigerians are about 2.4% of the global population of 7.4 billion (Population pyramid.net, 2015), but made up 18% of children with incomplete DPT3 vaccination in 2016 (Feldstein *et al.*, 2017). The burden of child DPT3 non-completion in Nigeria is 7.5 times its share of the world's population.

According to WHO estimates, the number of eligible children (aged less than 12 months) who did not receive the DPT3 globally was 22.6 million in 2012, 21.8 million in 2013, 18.7 million in 2013, 19.4 million in 2015 and 19.5 million in 2016; of these children, 3.8 million (17%) in 2012, 2.8 million (13%) in 2013, 2.2 million (12%) in 2014, 2.9 million (15%) in 2015 and 3.5 million (18%) in 2016 were Nigerians (Centers for Disease Control Prevention *et al.*, 2013; Harris *et al.*, 2014; Subaiya *et al.*, 2015a; Casey, 2016; Feldstein *et al.*, 2017). Figure 1.1 shows Nigeria's contribution to the global number of eligible children who missed the DPT 3 dose, 2012-2016. The Nigerian annual DPT 3 coverage has stagnated at about 64% in the last three years for which data are available (World Health Organisation and United Nations Children Fund, 2017).

Figure 1.1: Nigeria's contribution to the global number of children who did not complete the DPT3 immunisation



The Nigerian fully immunised child (FIC) coverage, which is the percentage of children aged 12-23 months who had received all doses of the basic vaccines (Bacillus Calmette–Guérin, Measles, Oral Polio Vaccine, Diptheria-Pertussis–Tetanus) of all children aged 12-23 months, is much lower than the DPT3 coverage. FIC rates are obtained from nationally representative surveys, with information from child immunisation card or maternally-reported receipt of each immunisation. Demographic and Health Surveys (DHS) are nationally-representative household surveys that provide data for a wide range of monitoring and impact evaluation indicators in the areas of population, health, and nutrition (MEASURE-DHS, 2015). Results from the five Nigeria Demographic and Health Surveys (NDHS) conducted between 1990 and 2013 show that the FIC dropped from 29.6% in 1990 to 25.3% in 2013, with the lowest value of 12.9% recorded in DHS 2003 (Table 1.1) (Federal office of Statistics, 1992; National Population Commission, 2000; National Population Commission, 2004; National Population Commission, 2009; National Population Commission, 2014).

Table 1.1: Nigeria fully immunised child coverage as a percentage of children 12-23 months who had received all vaccines (according to immunisation card or maternal report)

	Fully immunised child coverage in %				
	NDHS 1990	NDHS 1999	NDHS 2003	NDHS 2008	NDHS 2013
NIGERIA	29.6	16.8	12.9	22.7	25.3

Source: NDHS 1990, 1999, 2003, 2008, 2013

Coverage for individual vaccines of the childhood immunisation schedule was higher than the FIC rate, with coverage for the first doses of DPT and OPV higher than the second and third doses. Similar findings were reported from India's National Family Health Surveys (Mathew, 2012).

FIC coverage in the South was above the national average and much higher than those from the North in Nigeria. Lower levels of maternal education and religious inspired concerns in the North have been suggested as reasons for this trend (Chidiebere *et al.*, 2014). Children of birth order 2 and 3 had the highest odds of being fully immunised, with those of birth order 6 or more least likely. In contrast to studies from South East Asia (Griffiths *et al.*, 2002; Borooah, 2004; Mishra *et al.*, 2004), in Nigeria, the sex of the child conferred no immunisation completion advantage. Fewer health facilities in rural areas have been suggested as the reason for the lower immunisation rates in rural than in urban areas in Nigeria (Antai, 2009b; Antai, 2011; Adedokun *et al.*, 2017). Several studies have stated reasons for the poor childhood vaccination in Nigeria and other parts of the world (Agarwal *et al.*, 2005; Babalola and Adewuyi, 2005; Odusanya *et al.*, 2008; Antai, 2009b; Antai, 2010; Antai and Moradi, 2010; Obioha *et al.*, 2010; Abdulkarim *et al.*, 2011; Abdulraheem *et al.*, 2011; Antai, 2011; Mutua *et al.*, 2011; Abebe *et al.*, 2012; Amin *et al.*, 2013; Federal Ministry of Health and National Primary Health Care Development Agency, 2013; Obiajunwa and Olaogun, 2013; Baliga *et al.*, 2014; Chidiebere *et al.*, 2014; Gidado *et al.*, 2014; National Population Commission, 2014; Ophori *et al.*, 2014; Egondi *et al.*, 2015; Johri *et al.*, 2015; Soura *et al.*, 2015). The Nigeria National Routine Immunisation Strategic Plan 2013 – 2015 identified the major causes of poor routine immunisation performance as ineffective supply chain and logistics, poor service delivery and missed opportunities, inadequate human resources, poor data quality, weak demand for routine immunisation (RI) services, lack of funding and financing delays, lack of accountability and unintended consequences of Polio Eradication Initiative (PEI) and poor integration.

1.4 Problem statement and study rationale

Despite the implementation of strategies to improve immunisation coverage and quality of service delivery, including operationalisation and scale up of the WHO reaching every ward strategy (REW), market immunisation outreach, mix of traditional and supportive supervision, between 1990 and 2015 fully immunised child coverage in Nigeria remained below 30%. In 2016, Nigeria overtook India, which has a population of 1.3 billion (about 7 times Nigeria's population), as the country with the largest number of children with incomplete DPT immunisation coverage (The World Bank, 2016;

Feldstein *et al.*, 2017). The global increase in numbers of children not receiving DPT3 from 18.7 million in 2014 to 19.4 million in 2015, then to 19.5 million in 2016 are mostly the consequence of increasing numbers in Nigeria, from 2.2 million in 2014, to 2.9 million in 2015 and 3.5 million in 2016 (Subaiya *et al.*, 2015a; Casey, 2016; Feldstein *et al.*, 2017).

In my capacity as the FCT immunisation programme officer, findings from programme implementation activities revealed that services were reaching more eligible children, but some remained excluded, which was not due to the absence of immunisation services. A review of the three most recent cases of Wild Polio Virus in Abuja that were detected in 2012 (two cases) and 2013 (one case), showed all were resident in urban slums (FCT Primary Health Care Board, 2014b), living less than 300 metres from functional public health facilities that provided regular free immunisation services, and none of the polio victims had received even 50% of the recommended childhood immunisation. The conclusion was that social factors were the most likely reason for their poor routine immunisation status since vaccines were free and available in nearby health facilities (FCT Primary Health Care Board, 2014b). The detection and investigation of children under the age of 15 years with acute/sudden onset of weakness or paralysis of one or more limbs characterised as flaccid (reduced tone) for Poliomyelitis (a national and international notifiable disease) is referred to as Acute Flaccid Paralysis Surveillance, which is one of the main strategies for the Global Polio eradication initiative (Federal Ministry of Health and World Health Organisation, 2007; Bassey *et al.*, 2011).

A desk review of Acute Flaccid Paralysis (AFP) case verification investigations between 2010-2012 in the FCT suggested that rural and slum dwellers may not have access to, or not utilise, routine immunisation services, as AFP cases residing in the urban centres were all fully immunised for age in contrast to slum and rural dwellers who had much lower immunisation status (FCT Primary Health Care Board, 2013a).

Several studies have been published on Nigeria's immunisation coverage and associated factors, with most attention on the child, household and community factors without segregation by place of residence (Antai, 2009b; Adegboye *et al.*, 2014; Ushie *et al.*, 2014; Adedokun *et al.*, 2017). Some looked at the factors in rural locations (Odusanya *et al.*, 2003; Odusanya *et al.*, 2008), few in urban and fewer in the slums, but these latter studies were not rigorous (Dudu and Onokerhoraye, 2018). The childhood immunisation challenges identified in the Nigeria National Routine Immunisation Strategic Plan 2013 – 2015 were mainly health system issues, with individual and setting factors left out. Adegboye et al and Ushie et al conducted multilevel analysis on pooled Nigeria Demographic and Health Survey (NDHS) data (1990 -2008), showing immunisation coverage over time and associated factors but their analysis had two major limitations: the most recent 2013 NDHS was not included and the NDHS 1999 whose quality the Demographic and Health Survey program doubted was one of the datasets used (Demographic and Health Survey Program, 1999). In a multilevel analysis using the DHS 2003, living in the rural area reduced the likelihood of childhood immunisation, with community factors accounting for the significant rural-urban immunisation disparity (Antai, 2011). None of the studies segregated the nationally representative data into the conventional urban and rural before analysis, despite the importance of the place of residence context. The assumption that urban areas, where most Nigerians reside, are homogenous, has ignored findings from studies in other countries, that found lower immunisation rates among slum dwellers compared to other urban dwellers, and possibly even lower than rural dwellers or the national average (Fotso *et al.*, 2007; Mutua *et al.*, 2011; Unger, 2013). Health facilities in slums are usually poorly staffed with little or no equipment and manned by poorly-performing health workers (Feilden Battersby Analysts, 2005; Yahya, 2007; Mathew, 2012; Ophori *et al.*, 2014), and when slum dwellers access health services in urban health facilities they often receive poor service (Pitchforth *et al.*, 2006). Poor treatment then translates into the reluctance to use health services (Bartlett *et al.*, 2005; Hulton *et al.*, 2007). Further, belief and reliance on the traditional system by urban slum dwellers may reduce their utilisation of available modern health facilities (Hossain and Hoque, 2005), and cultural and religious beliefs also play a role in seeking of formal health care (Hossain and Hoque, 2005; Zulu *et al.*, 2011; Mathew, 2012). These slums are set to become the home of most Nigerians in the very near future if the current urbanisation rate continues (Bobadoye and Fakere, 1926).

1.5 Aim, objectives and research questions

This research is to address the issue that free childhood immunisation has not guaranteed equity across all communities in Nigeria. The over-arching aim is to inform improvement of childhood immunisation programmes in Nigeria through the examination of the nationally representative survey and qualitative data on child immunisation uptake in Nigeria by child, household, community and health system factors, with a particular focus on the place of residence. Although there is some evidence on the difference in immunisation coverage by urban-rural place of residence, intra-urban heterogeneity has not yet been explored. The objectives, research questions and data sources of this study are presented in Table 1.2. The first objective of the PhD study is to estimate childhood immunisation coverage, using the most current NDHS (2013) data. The next objective is to quantify the association between child, household and community factors and childhood vaccination coverage overall and by place of residence (rural and urban), using pooled DHS 2003, 2008 and 2013 data.

The third and fourth objectives would provide new understanding of how child, household, community and health system factors are associated with child immunisation in urban areas, with focus on slums. Specifically, the third objective will quantify intra-urban differences in childhood immunisation coverage over time, allowing for health service, child, household and community factors, using urban datasets pooled from all three most recent DHS. The fourth objective adds to the quantitative analyses by investigating the views of parents and health workers in slums near Abuja on childhood immunisation challenges and enabling factors.

Table 1.2: Objectives, Research Questions and Data sources of the study

S/N	OBJECTIVES	RESEARCH QUESTIONS	Data source
1	To estimate childhood vaccination coverage using DHS 2013 data.	What is the childhood immunisation coverage presently? What are the child, household and community-related factors associated with childhood immunisation coverage in Nigeria?	NDHS 2013
2	To quantify, the association between child, household and community factors and childhood vaccination coverage overall, and by rural and urban areas overtime.	What are child, maternal/household and community related factors associated with childhood immunisation coverage in Nigeria and have they changed over time? What is the difference in childhood immunisation coverage between urban and rural areas, and are the associations with child, household and community factors different in rural and urban areas?	Individual and pooled NDHS 2003, 2008 and 2013
3	To explore the intra urban differences in childhood immunisation coverage over time.	In the urban setting, does childhood vaccination coverage vary between urban and slum dwellers and what factors are associated with it?	NDHS 2003, 2008 and 2013 pooled
4	To investigate the view of parents, community leaders and health workers on childhood immunisation challenges and enabling factors.	What are the barriers and enabling factors in the uptake of childhood immunisation? Do health workers practice and attitude affect childhood immunisation in Abuja?	Qualitative slum-area data

Child immunisation coverage depends on several factors, so understanding them will be dependent on scientific evidence obtained from rigorous research. This evidence will be helpful in the formulation of immunisation strategy and implementation of immunisation end-service provision. Relevant literature on child immunisation was reviewed systematically according to an unpublished protocol. Among the results of the review was the identification of independent variables of interest for the PhD quantitative analyses, and the defining of the dichotomous dependent variable as fully immunised child status, and the choice of mixed (qualitative and quantitative) research methods to explore the child, household, community and health system factors associated with childhood immunisation.

The choice of Nigeria Demographic and Health Survey for the quantitative research part was due to it being nationally representative and population-based with adequate and relevant information on three (child, household and community) of the four levels of potentially FIC-associated factors. The use of multilevel logistic regression analysis in Chapters 4, 5 and 6 was to account for the DHS survey design. Overestimation of the significance of some variables and underestimation of the standard errors can be the consequence of analysing survey data without making provision for the survey design (Van Duijn *et al.*, 1999). In Chapter 4, DPT drop-out rates were examined as an indirect measure of health system immunisation performance.

The views of parents, community leaders and health workers on challenges and enablers of childhood immunisation are not collected in NDHS and were investigated in a specific qualitative study. The information from the interviews with parents, community leaders and health workers was analysed with the thematic framework.

1.6 Organisation of Thesis

Chapter 1 – Introduction to the research, setting of aims and objectives and summary of research questions and data sources

Chapter 2 – Review of the literature on routine immunisation in Nigeria, with the use of the preferred reporting items for systematic reviews and meta-analysis (PRISMA) guideline (protocol unpublished). Included in the review are published studies and reports on childhood immunisation focussing on service availability and utilisation. Also, a brief overview of slum development and immunisation is presented. Key immunisation terms were defined and a theoretical conceptual framework developed

Chapter 3 –Methodology applicable to both quantitative and qualitative analyses. This study employed a mixed method approach. The quantitative analysis describes the datasets and analytical methods, statistical models and interpretation of findings. Description, bivariate analysis, univariate logistic regression and multilevel logistic regression were used to analyse 2013, 2008 and 2003 DHS datasets. The STATA version 14 SE statistical software was used in all the quantitative analysis(StataCorp, 2015).

The qualitative study collected data using mother interviews, key informant interviews of health workers and community leaders and health facility assessment that included immunisation inventory and service provision. Thematic analysis was done using the Nvivo 11 software; a computer-assisted qualitative data software (QSR International Pty Ltd, 2015). The analysis was mixed, based on deductive themes from the literature review and inductive themes that emerged from the interviews.

Chapter 4 –Presents results from analysis of the DHS 2013, with descriptions, cross tabulations and chi-square tests, univariate logistic regression and multilevel logistic regression to answer the research questions from the study's first objective.

Chapter 5 – Presents findings from analyses of separate and pooled 2003, 2008 and 2013 DHS datasets to quantify the immunisation coverage over time, and stratified into rural and urban place of residence to quantify the association between child, maternal and community factors with childhood immunisation coverage in each stratum.

Chapter 6 – The pooled DHS 2003, 2008 and 2013 urban dataset was stratified into formal and informal urban settlements, using guidelines from UN-HABITAT, and using cross tabulations, chi-square test and multilevel logistic regression analysis to understand why childhood immunisation coverage varied between these settlements located in the urban residence and identify associated factors.

Chapter 7 –Participant interviews, observation and health facility inventory was conducted in two slum areas in Abuja, Nigeria, to answer the research questions from objective four, which is to investigate the view of parents, community leaders and health workers on childhood immunisation challenges and enabling factors.

Chapter 8 – Concludes the research work. It entails the summary of research rationale, focus of research and key findings, implication of research outcomes for Immunisation programming and lastly, next step research and development work

Chapter 2 Literature Review

2.1 Introduction

Published literature and reports that explored the child immunisation especially the low coverage levels in Nigeria and the factors (child, household, community and health system) that are associated with child immunisation were reviewed. An overview of urbanisation and immunisation in Nigeria that highlighted the implications of slums dwelling on the attainment of the desired child immunisation coverage status was included. These review and overview provides information on the barriers and enablers of child immunisation in Nigeria, the magnitude of the immunisation disparity across sociodemographic characteristics, the challenges of rapid urbanisation on childhood immunisation, in-utero factors that affect the infant's ability to mount optimal immune response to administered vaccines, criticism of the available literature and details of identified gaps in knowledge. Also, the status of childhood immunisation is compared to those of other parts of the globe. Since the introduction of vaccines in the 1790s (Stern and Markel, 2005), immunisation has remained one of the most important public health interventions. Vaccines have saved millions of child lives, especially in low and middle-income countries. However, millions of eligible children remain unimmunised, with some segments of the population and countries like Nigeria having a disproportionate number of these deprived infants. Improving childhood immunisation is dependent on understanding the multiple factors that are associated with it (Antai, 2009b). This Chapter explores relevant literature in order to understand how factors in the child, household, community and health system levels were associated childhood immunisation in Nigeria and presents a conceptual framework to guide the quantitative and qualitative analysis in this PhD study.

This chapter is made up of eight parts. The Introduction is followed by a summary of immunisation terms defined and explained. Part three presents the review of the literature on childhood immunisation, focussing mainly on Nigeria. Part four expands on the role of internal factors in child immune response to vaccines and provides a summary of the relevant publication (Obanewa and Newell 2017). A brief overview of slum development and immunisation made up part five. The sixth part describes the conceptual framework, as it explains how the multilevel interaction of these factors influences the child's immunisation status. The benefits of immunisation are in the seventh part. Finally, the conclusion gives a summary of the findings and the next steps of this research.

2.2 Important immunisation terms

A **vaccine** is a biological preparation that improves immunity to a particular disease, it typically contains an agent that resembles a disease-causing microorganism, mostly made from weakened or killed forms of the microbe, its toxins or one of its surface proteins (World Health Organisation, 2016b). The agent stimulates the body's immune system to recognise the agent as foreign, destroy it, and "remember" it, so that the immune system can more easily and quickly recognise and destroy any of these microorganisms if encountered later (World Health Organisation, 2016b). A vaccine can be administered through needle injections, by mouth, or by aerosol (United States Department for Health and Human Services, 2016), has clearly defined target groups, can be delivered effectively at health facilities and other sites, and does not require any major lifestyle change (World Health Organisation, 2016a).

Vaccination is the injection or any other form of administration of a killed or weakened organism (vaccine) that produces immunity in the body against that organism (United States Department for Health and Human Services, 2016). Vaccination is the physical process of the administration of the vaccine to an individual.

Immunisation is the process whereby a person is made immune or resistant to an infectious disease, typically by the administration of a vaccine (World Health Organisation, 2016a). Immunisation is the process by which a person or animal becomes protected from a disease by the development of immunity against it. This protective immunity can be provided by vaccines and by recovery from the disease. The immunisation programme assumes that once children are vaccinated, they are fully immunised against that particular disease and given that average immunity levels after completing vaccination are about 95% (Immunisation for Public Health, 2016). Multi-dose vaccines such as DPT and OPV are administered more than once to achieve optimal protective levels. Single dose vaccines such as Measles require an additional dose, called booster, after some months or years as the initial protection conferred by the first dose reduces over time. This Measles vaccine booster increases the likelihood that vaccinated children maintain required levels of protective immunity. In a clinical trial, including 318 children who all had measles vaccine administered at nine months of age with some having had a second dose at 18 months, at 24 months of age 314 (99%) had measles antibody protective levels (Martins *et al.*, 2014). Generally, in published and unpublished literature, immunisation can be used for vaccine, vaccination and immunisation.

Herd immunity is the protection of communities from infection by most of the members' immune status (Fine, 1993). Others have referred to it as the immunisation coverage threshold in a population that will lead to the decline in the incidence of the particular infection in that population (Fine *et al.*, 2011). The few children who do not develop immunity after vaccination will be protected by the immunised majority, as long as the vaccination coverage in the community is up to a certain rate, which differs by type of vaccine (Immunisation for Public Health, 2016). The required threshold for different diseases: measles – 95%, DPT – 85% and Mumps – < 80% (Immunisation for Public Health, 2016). The higher the infectivity and transmissibility of a disease the higher its threshold (College of Physicians of Philadephia, 2016). However where vaccination does not confer immunity against infection to all recipients, the level of vaccination required to provide herd immunity increases (Fine *et al.*, 2011). The distribution of immunised and unimmunised in a particular population plays a role in herd immunity. This is evident in populations where there are disparities in the immunisation coverage among constituent groups. The scope of this indirect effect of vaccine-derived immunity depends on how the infection is transmitted, the nature of the immunity induced by the vaccine, the distribution of the immunised persons and level of immunity in the population (Fine *et al.*, 2011).

Childhood immunisation coverage is the proportion or percentage of children in a target age group that received a vaccine dose or doses. It is an individual vaccine coverage if it is for a single vaccine while it is fully immunised coverage when it captures all recommended vaccines and doses for the particular age group. In most developing and developed countries the target age group for routine immunisation are infants, under one year of age (Subaiya *et al.*, 2015b). Coverage is usually estimated by self-reports/reports from mothers/carers, data/information obtained through surveys (DHS, Multi indicator cluster survey, national immunisation survey) and administratively using programme data by simply dividing vaccine doses administered by the estimated number in the target group. WHO and UNICEF derive national coverage estimates through an annual country-by-country review of available data, including administrative and survey-based coverage (Subaiya *et al.*, 2015b). In 2012, the World Health Assembly approved the decade of vaccination, 2011 -2020 (Global Vaccine Action Plan). During the decade, it is planned that access to immunisation will be fair and just across and in-countries, with targets of 90% national coverage for all vaccines and 80% immunisation coverage in all districts by 2015 and these levels maintained till 2020 and beyond (World Health Organisation, 2013).

2.3 Review of literature on childhood immunisation in Nigeria

2.3.1 Literature Review Method

Search process

Articles on factors that influence immunisation status were systematically searched for in Medline, PubMed and Web of Science databases with the use of an unpublished protocol. The manual search for cited references was done using Google scholar. Also included are books, web pages and reports that cover the topic under review. Limiting review searches for health studies to only the Medline database has been found to be adequate (Rollin *et al.*, 2010; van Enst *et al.*, 2014) and achieved about 90% recall ratio of high quality papers in an interventional study of occupational health interventions (Rollin *et al.*, 2010). Hence the search of Medline, PubMed, Web of Science, Google Scholar and others most likely covered the available sources of all relevant literature. The searches were conducted on a quarterly basis from March 2016 to September 2018 and examined appropriate literature published, written or released between January 01, 1990 to September 2018. These cut off dates (January 01, 1990 and September 2018) made the inclusion of the most current literature which is in line with the PhD study aim to optimise the current low levels of childhood immunisation in Nigeria. The first Demographic and Health Survey in Nigeria was conducted in 1990 (Federal office of Statistics, 1992) and it provided nationally representative data for primary and secondary analysis of child vaccination, which made it an appropriate early time limit.

The same combination of key words (Immunisation OR Immunization OR Vaccination OR Vaccine) AND (Child OR Infant) AND Nigeria) were used in the search of the three databases (Medline, PubMed and Web of Science). Google Scholar was used to search the full literature of potentially relevant cited references in the papers identified from the search of the three databases. At the final search in September 2018, 1768 potentially relevant papers had been identified through the use of the three databases and Google Scholar.

Table 2.1: Search terms used in databases searched

Database	Description	Search terms	Limit	Number of papers identified
Medline	Vaccination/ Immunisation	(Immunisation OR Immunization OR Vaccination OR Vaccine) AND (Child OR Infant) AND Nigeria	1990 to September 2018	725
	Child/infant			
	Nigeria			
PubMed	Vaccination/ Immunisation			811
	Child/infant			
	Nigeria			
Web of Science	Vaccination/ Immunisation			112
	Child/infant			
	Nigeria			
Google Scholar and cited references				120
Total				1768

Text Selection/extraction

The preferred reporting items for systematic reviews and meta-analysis (PRISMA) format (Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA), 2009) was used and an appropriate flow diagram developed (Figure 2.1).

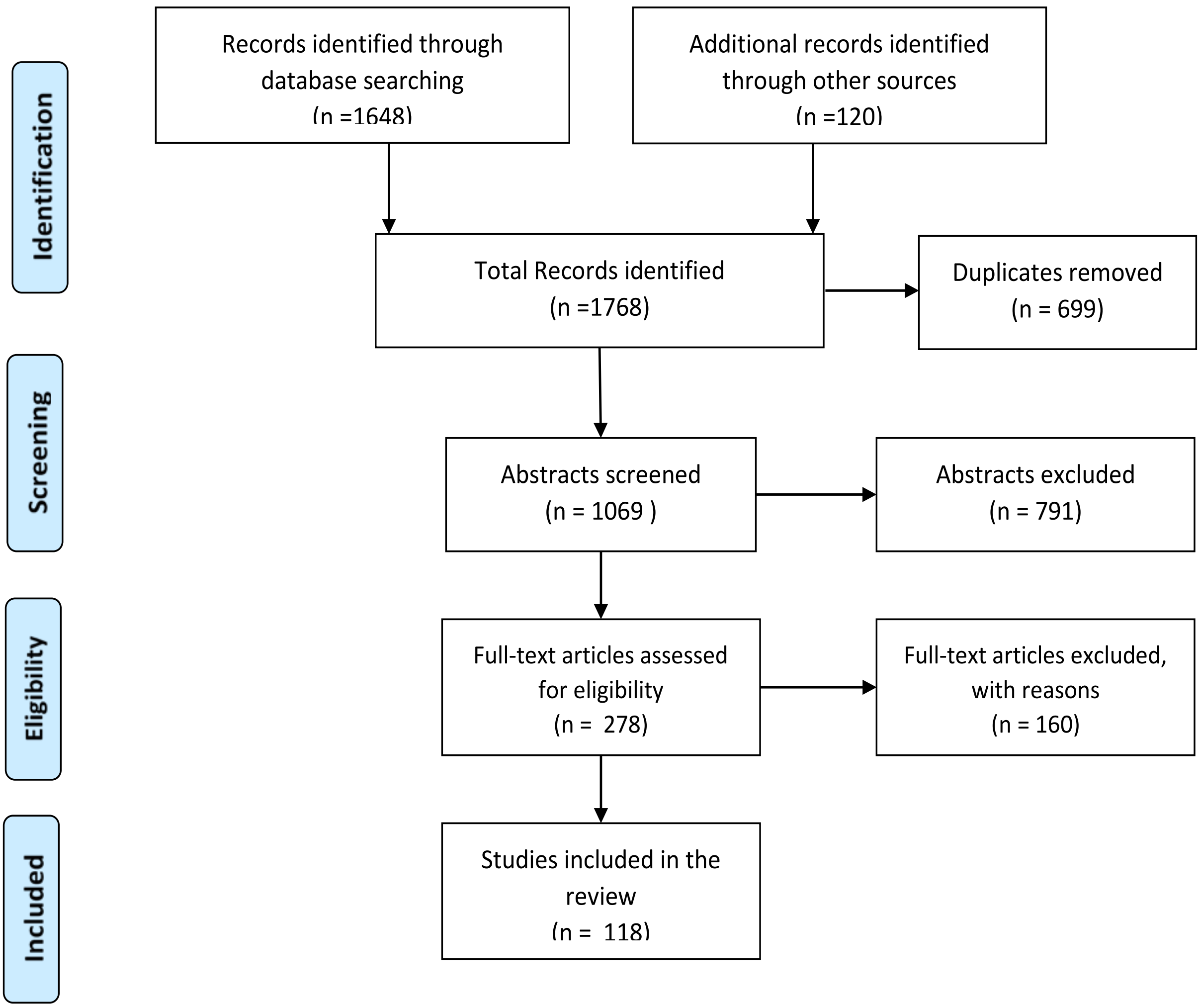
Identification (title) – All papers identified using the search terms from the three databases and references, as described in Table 2.1.

Screening (abstract) – The terms routine immunisation/vaccination, child/maternal health and immunisation/vaccination coverage must refer to routine immunisation and reasons and risk factors related to a child's immunisation or general child health

Eligibility (Text) – Must be about child routine immunisation, explains immunisation coverage challenges and enabling factors, why and how these identified factors affect the access to and utilisation of immunisation services. A total of 278 papers had their full text screened

Exclusion – The exclusion criteria; Adult immunisation studies, clinical and not population-based, animal study, non-relevant immunisation issue like data management, supplemental immunisation like the Polio eradication campaigns, integration with other primary health care (PHC) services etc.

Figure 2.1: Flowchart of screening process



2.3.2 Immunisation coverage

Immunisation coverage levels and trends are used to monitor the performance of immunisation services locally, nationally and internationally, guide strategies for the eradication, elimination and control of vaccine-preventable diseases, identify areas of immunization systems that may require additional resources and focused attention, and assess the need to introduce new vaccines into national and local immunisation systems (Burton A. *et al.*, 2009).

Global childhood immunisation coverage and schedule

The expanded programme on immunisation (EPI) was introduced in 1974 with one of its key aims being equitable access to vaccines. Globally, the coverage of each of the four initially included vaccines (BCG, Measles, DPT and Polio) has risen from less than 5% at EPI's inception to equal or more than 85% in 2014 (Subaiya *et al.*, 2015b).

The number and type of vaccines included in the EPI schedule have increased over the last four decades. As at the end of 2015, there were 27 available vaccines approved for use by the World Health Organisation for children and adults (Table 2.2), with another 19 in the pipeline (in development stages) (World Health Organisation, 2016c). The age at which doses of the recommended vaccines are administered on a child differs slightly across the different regions of the world.

Table 2.2: World Health Organisation recommended Routine Immunisations for Children (World Health Organisation, 2015a)

Summary of WHO Position Papers - Recommended Routine Immunizations for Children (updated 27 February 2015)								
Antigen		Age of 1st Dose	Doses in primary series	Interval Between Doses			Booster dose	Considerations (see footnotes for details)
				1st to 2nd	2nd to 3rd	3rd to 4th		
BCG		As soon as possible after birth	1					Exceptions HIV
Hepatitis B	Option 1	As soon as possible after birth (<24h)	3	4 weeks (min) with DTP1	4 weeks (min) with DTP3			Premature and low birth weight Co-administration and combination vaccine High risk groups
	Option2	As soon as possible after birth (<24h)	4	4 weeks (min) with DTP1	4 weeks (min) with DTP2	4 weeks (min) with DTP3		
Polio	OPV + IPV	6 weeks (see footnote for birth dose)	4 (IPV dose to be given with OPV dose from 14 weeks)	4 weeks (min) with DTP2	4 weeks (min) with DTP3			OPV birth dose Transmission and importation risk criteria
	IPV / OPV Sequential	8 weeks (IPV 1st)	1-2 IPV 2 OPV	4-8 weeks	4-8 weeks	4-8 weeks		
	IPV	8 weeks	3	4-8 weeks	4-8 weeks		(see footnote	IPV booster needed for early schedule (i.e. first dose given <8 weeks)
DTP		6 weeks (min)	3	4 weeks (min) - 8 weeks	4 weeks (min) - 8 weeks		1-6 years of age (see footnote)	Delayed/ interrupted schedule Combination vaccine
Haemophilus influenzae type b	Option 1	6 weeks (min) 59 months (max	3	4 weeks (min) with DTP2	4 weeks (min) with DTP3		(see footnote)	Single dose if >12 months of age Not recommended for children > 5 yrs Delayed/ interrupted schedule Co-administration and combination vaccine
	Option 2		2-3	8 weeks (min) if only 2 doses 4 weeks (min) if 3 doses	4 weeks (min) if 3 doses		At least 6 months (min) after last dose	
Pneumococcal (Conjugate)	Option 1	6 weeks (min)	3	4 weeks (min)	4 weeks		(see footnote)	Vaccine options Initiate before 6 months of age Co-administration HIV+ and preterm neonates booster
	Option 2	6 weeks (min)	2	8 weeks (min)			9-15 months	
Rotavirus	Rotarix	6 weeks (min) with DTP1	2	4 weeks (min) with DTP2				Vaccine options Not recommended if > 24 months old
	Rota Teq	6 weeks (min) with DTP1	3	4 weeks (min) - 10 weeks with DTP2	4 weeks (min) with DTP3			
Measles		9 or 12 months (6 months min, see footnote)	2	4 weeks (min) (see footnote)				Combination vaccine; HIV early vaccination; pregnancy
Rubella		9 or 12 months with measles containing vaccine	1					Achieve and sustain 80% coverage Combination vaccine and Co-administration; Pregnancy
HPV		As soon as possible from 9 years of age (females only)	2	6 months (min 5 months)				Target 9-13 year old girls Pregnancy Older age ≥ 15 years 3 doses HIV and immunocompromised

This table summarises the WHO vaccination recommendations for children. The ages/intervals cited are for the development of country specific schedules and are not for health workers. National schedules should be based on local epidemiologic, programmatic, resource and policy considerations. While vaccines are universally recommended, some children may have contraindications to particular vaccines.

- (min) = minimum

The DPT3 coverage by one year of age remains a key measure of immunisation service delivery, as its administration marks the conclusion of the first part of the basic infant immunisation schedule (Subaiya *et al.*, 2015b). Global DPT3 coverage has remained at around 85% since 2010, reaching 86% in 2016 (116.5 million children) with 19.5million children not reached (Feldstein *et al.*, 2017). In 2016, 130 (67%) of the 194 WHO countries achieved ≥90% national DPT3 coverage, national DPT3 coverage was 80%–89% in 29 countries, 70%–79% in 15 countries, and <70% in 20 countries (Feldstein *et al.*, 2017). The coverage of DPT and other vaccines varies across the different regions of the world (Table 2.3)

Table 2.3: Immunisation coverage by vaccine and World Health Organization (WHO) region — worldwide, 2016(Feldstein *et al.*, 2017)

	Vaccination coverage (%)										
WHO region	BCG	HepB at birth	HepB3	DPT3	Hib3	Polio3	Rota last	PCV3	Rubella	MCV1	MCV2
Global	88	39	84	86	70	85	25	42	47	85	64
Africa	81	10	74	74	74	73	43	65	13	72	24
Americas	95	66	89	91	90	92	74	84	92	92	54
Eastern Mediteranean	87	22	80	80	80	80	23	48	46	77	69
Europe	91	39	81	92	77	94	23	62	93	93	88
South-East Asia	89	34	88	88	80	87	3	9	15	87	75
Western Pacific	95	83	92	97	28	95	2	14	96	96	93

Abbreviations: BCG= Balcille Calmette-Guerin; HepB = hepatitis B vaccine; HepB3= 3 doses of hepatitis B vaccine; DPT3= 3 doses of diphtheria-pertusis-tetanus vaccine; Hib3= 3 doses of Haemophilus influenza type b vaccine; Polio3= 3 doses of poliovirus vaccine; Rota last= last dose of Rotavirus series which is the second dose for Rotarix and third dose for Rota Teq; PCV3= 3 doses of pneumococcal conjugate vaccine; MCV1= first dose of measles-containing vaccine; MCV2= second dose of measles-containing vaccine. *Weighted regional average

Nigeria immunisation schedule and coverage

The routine immunisation schedule in Nigeria offers fewer vaccines than recommended by WHO (Table 2.2). In the first year of life, a child in Nigeria should receive the following vaccines: 1) one dose each of BCG, Hepatitis B and OPV at or shortly after birth, 2) Pentavalent (DPT, Hepatitis B, *Haemophilus influenzae* type B), Pneumococcus conjugate and OPV at 6, 10 and 14 weeks, 3) Inactivated polio vaccine at 14 weeks, 4) one each of Measles and Yellow fever vaccine at 9 months (Olorunsaiye and Degge, 2016; Ophori *et al*., 2014). Vaccines are available in health facilities for the routine childhood vaccination programme, and during supplemental immunisation initiatives such as Integrated measles and polio eradication campaigns.

Nigeria is one of the six countries globally which over the last 19 years has consistently been home to over 50% of the global unvaccinated children (Subaiya *et al.*, 2015b). Nigeria's share of children who did not start or complete DPT vaccination globally was 12% (2.2million) in 2014 (Subaiya *et al.*, 2015b) increasing by 1.3 million to 3.5 million children in 2016 (Feldstein *et al.*, 2017).

Immunisation coverage is reported from administrative, survey and the WHO/UNICEF immunisation coverage sources. Administrative coverage is reported by the national government and is based on immunisation programme implementation data, while the estimates drawn up by WHO/UNICEF are based on reviews of all available data, usually a combination of administrative data from routine immunisation systems and household surveys (DHS, National Immunisation Cluster and Multi-indicator Cluster surveys) (Tao *et al.*, 2013; World Health Organisation and United Nations Children Fund, 2017). As presented in Table 2.4, the administrative DPT3 coverage in Nigeria was 76%, while the WHO/UNICEF estimates was 54% in 2010. This coverage difference widened further from the 22% in 2012 to 31% in 2014, with the WHO/UNICEF estimate always lower. Errors in immunisation data management and the tendency by low- and middle-income countries' immunisation administrators to inflate the third dose of DPT coverage have been cited as reasons for this difference (Murray *et al.*, 2003a; Lim *et al.*, 2008). In addition, the higher values of the administrative coverage as compared to the WHO/UNICEF estimates in Nigeria may be due to under-estimated target population used by the health system/programme staff. Since the population growth is rapid in Nigeria, the current population estimates maybe outdated as it is based on the most recent general census in Nigeria conducted in March 2006.

Table 2.4: Nigeria DPT3 coverage in % by source of estimate and year (World Health Organisation and United Nations Children Fund, 2017)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Estimate (prepared by WHO/UNICEF) A	36	40	42	53	63	54	48	42	63	66	63	66
Administrative (reported by Government) B	49	44	53	74	75	76	63	89	94	97	N.A	N.A

A-based on reports from mothers/carers and administrative data, B-based on health system/programme staff, N.A-Not available

Representative household-based surveys have the advantage of providing individual immunisation and fully immunised coverage estimates based on the sampled population by socio-demographic and regional factors. By early 2018, Nigeria had conducted Demographic Health Surveys (NDHS) in 1990, 1999, 2003, 2008 and 2013. Table 2.5 presents the findings of all NDHS, which showed the immunisation performance was still far off the target of 90% set in the global vaccination action plan (National Population Commission, 2014).

Table 2.5: Nigeria fully Immunised child and DPT3 coverage of children aged 12-23 months (according to an immunisation card or maternal report)

	Fully Immunised Child Coverage (%) and number/denominator	DPT3 coverage (%) and number/denominator
NDHS 1990	29.6 (408/1380)	33.3 (460/1380)
NDHS 1999	16.8 (195/1161)	26.3 (305/1160)
NDHS 2003	12.9 (129/999)	21.4 (214/999)
NDHS 2008	22.7 (1123/4945)	35.4 (1751/4945)
NDHS 2013	25.3 (1493/5900)	38.2 (2254/5900)

Source: NDHS 1990, 1999, 2003, 2008, 2013

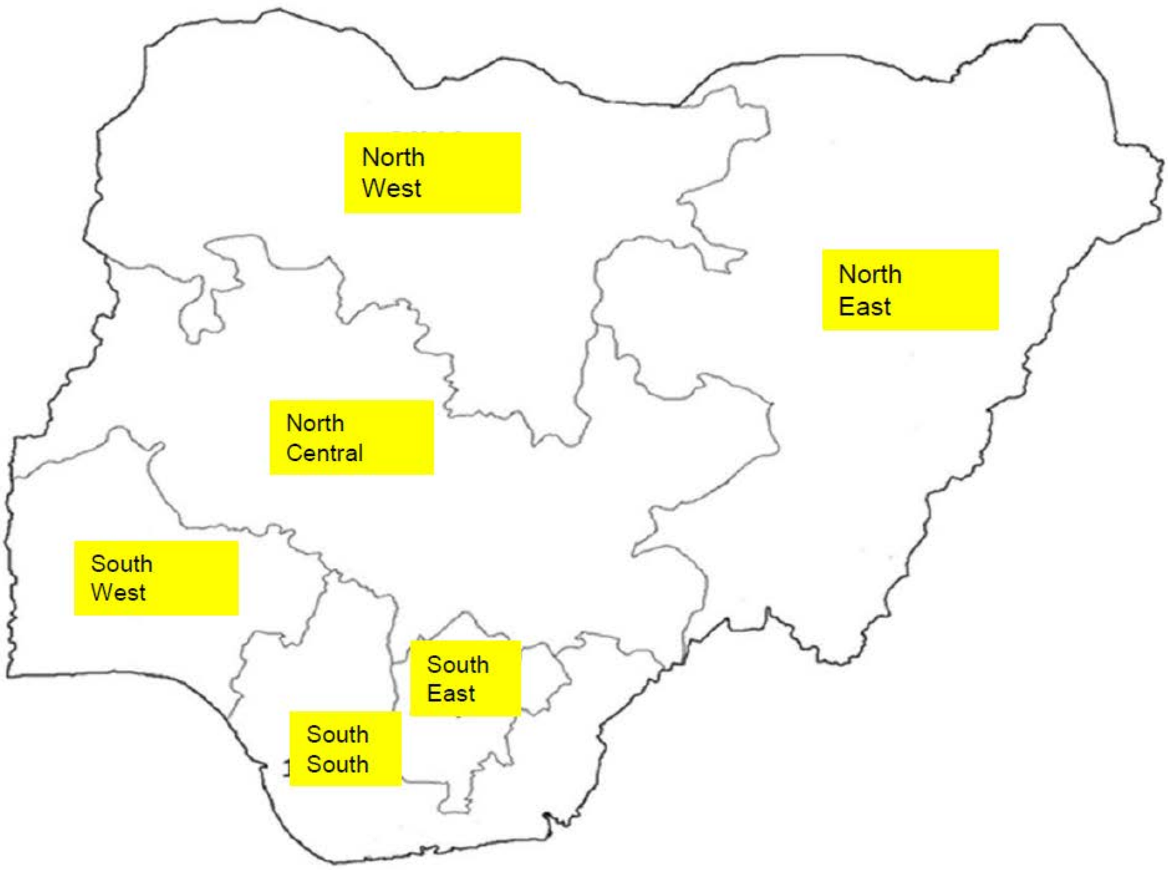
In Nigeria, the WHO/UNICEF immunisation estimates were lower than the administrative levels but higher than the NDHS estimates. In surveys, the sampled population represents the target population, while the administrative child immunisation target population maybe underestimated as it was projected from the last census conducted in 2006. This probably explains why the NDHS estimates are lower than the administrative and WHO/UNICEF estimates. The lower survey coverage compared to the administrative and WHO/UNICEF estimates was not limited to Nigeria as the findings from the comparative study of DHS and WHO DPT3 immunisation estimates from 71 low and middle-income countries from 1986 to 2009 was similar (Tao *et al.*, 2013).

As presented in Table 2.5, in the period covered by NDHS 1990 – 2013, the lowest fully immunised child coverage of children aged 12-23 months was seen in 2003. The NDHS 1990 fully immunised child coverage remained the highest levels attained during the period under review, but there has been an increase over the 2003 values in 2008 and further improvement in 2013. The very low coverage recorded in the 2003 NDHS has been attributed to the political and religious inspired rejection of polio and other vaccines in the early 2000s (Olusanya, 2004; Obadare, 2005; Renne, 2006; Renne, 2010).

Regional immunisation coverage in Nigeria

Several studies and surveys have revealed that immunisation coverage in Nigeria varies between regions (Figure 2.2) (Federal office of Statistics, 1992; National Population Commission, 2000; National Population Commission, 2004; National Population Commission, 2009; National Population Commission, 2014).

Figure 2.2: Map of Nigeria showing the six geopolitical regions



The northern region that was more populated had fully immunised child coverage which was consistently lower than that of the southern regions during the period covered by the 1990 -2013 NDHS (Table 2.6). The most populous region, Northwest had the lowest FIC coverage between 1999 and 2013.

Table 2.6: Nigeria regional fully immunised child coverage in percentage of children 12-23 months who had received all routine infant vaccines (according to immunisation card or maternal report)

		Fully immunised child coverage in %				
		NDHS 1990[1]	NDHS 1999	NDHS 2003	NDHS 2008	NDHS 2013
North	North Central	-	19.6 (44/224)	12.4 (19/149)	25.9 (166/640)	26.9 (218/812)
	North East	15.9 (57/359)	7.5 (18/241)	6 (13/219)	7.6 (59/780)	14.2 (145/1023)
	North West	17.7 (66/373)	4.3 (11/245)	3.7 (13/356)	6 (93/1545)	9.6 (202/2100)
South	South East	43.3 (181/408)	24.9 (48/194)	44.6 (33/74)	42.9 (216/504)	51.7 (284/550)
	South South	-	-	20.8 (25/120)	36 (239/663)	52 (307/591)
	South West	64 (109/240)	28.6 (73/256)	32.5 (26/81)	42.8 (349/814)	40.9 (337/823)
NIGERIA		29.6	16.8	12.9	22.7	25.3

Source: NDHS 1990, 1999, 2003, 2008, 2013

Rural – urban immunisation coverage in Nigeria

Table 2.7 presents the pattern and level of fully immunised child coverage in rural and urban locations of Nigeria as reported in 1990 -2013 NDHS. All NDHS reported higher child immunisation coverage in urban than in rural settings in Nigeria. The urban and rural fully immunised child coverage (FIC) of 52.5% and 23.3% respectively in 1990 NDHS are the highest while the lowest were the 2003 NDHS urban and rural FIC coverage of 25.1% and 7.4% respectively. In all NDHS, the urban

[1] Nigeria had only 4 and 5 regions in 1990 and 1999 respectively

FIC coverage was at least twice that of the rural with the highest disparity reported in NDHS 2003 where the rural FIC was 7.4% and urban had 25.1%. Also, a cross-sectional survey of 550 married couples reporting on their child immunisation coverage rates had much higher coverage in the urban than rural area (Obiajunwa and Olaogun, 2013). Findings of studies in the north (Babalola and Lawan, 2009; Besa *et al.*, 2014) and south regions (Oluwadare, 2009b; Umeh and Ahaneku, 2013) were in line with such urban health advantage. However, Fatiregun et al in south-west Nigeria found no significant difference between rural and urban immunisation coverage; in a cross-sectional study in the south-south region, 11.9% and 10.1% of urban and rural children respectively were fully immunised, while 11.5% children in the rural and 47.0% in the urban area had not received any vaccine with the challenge been more of partial immunisation than non-immunisation in the rural area (Itimi *et al.*, 2012).

Table 2.7: Fully immunised coverage in children 12-23 months by year and place of residence

	Fully immunised child coverage in % and frequency	
	Rural	Urban
DHS 1990	23.3 (253/1086)	52.5 (155/295)
DHS 1999	11.3 (96/850)	31.7 (98/310)
DHS 2003	7.4 (51/687)	25.1 (78/312)
DHS 2008	16.2 (558/3447)	37.5 (562/1498)
DHS 2013	15.8 (598/3787)	42.5 (898/2113)

Source: NDHS 1990, 1999, 2003, 2008, 2013

Intra – urban immunisation coverage

The review was unable to identify any Nigerian-based study that reported on urban immunisation coverage by type of urban setting (informal slums, formal urban). The urban population in Nigeria is expected to increase from the 2011 figure of 49.6% of total population to 60.8% at the end of the sustainable development goals (SDGs) period in 2030 (United Nations Human Settlement Programme and UN HABITAT, 2014), with urban slums accommodating more than half of this urban population (Pepple Ama, 2012). Health outcomes in the urban areas are not homogenous (Hu *et al.*, 2008; More *et al.*, 2009; Zhao *et al.*, 2009; Ziraba *et al.*, 2009; Mutua *et al.*, 2011; Egondi *et al.*, 2015), and the lack of health service may be worse in the urban slums than for rural area residents (Madise and Diamond, 1995; Madise *et al.*, 2003; Fotso *et al.*, 2007). Case studies of Kenya and Zambia (Fotso *et al.*, 2007), using DHS data from the 1980s and 1990s from 22 sub-Saharan African countries including Nigeria, found health disparities between rural and urban areas and between urban and slum areas. In Kenya, children aged 12 – 23 months residing in slums had the lowest fully immunised rates. Immunisation coverage declined in Zambia between 1991 and 2001, with the slum rates declining by 13% and urban by 9% (Fotso *et al.*, 2007). Evidence on immunisation in slums across Nigeria is limited. The study of 7 slums around Warri, a city in Southsouth region estimated that 24.4% of children in the slums were fully immunised (Dudu and Onokerhoraye, 2018), which is much lower than the current national urban FIC coverage of 42.5% (Table 2.7). Reasons provided by parents for the low FIC levels in these slums include parental apathy and bad attitude to immunisation and health care, insufficient health talk given to parents by health workers, immunisation sessions hold at odd times and parents too busy to keep immunisation appointments (Dudu and Onokerhoraye, 2018).

2.3.3 Factors associated with immunisation status

The best approach to provide evidence on childhood immunisation in Nigeria is to undertake a systematic review made up of narrative synthesis and meta-analysis. Most included studies were not compatible as a result of the different age group of the sampled population and non-identical study design made the meta-analysis of data not appropriate (Ryan, 2013). Narrative synthesis, described as the condensation of the present evidence regarding the particular research question (Popay, 2006) was partially carried out, with the risk of selection bias in the literature selection process as it was undertaken by only the PhD candidate. The narrative of the relevant literature on factors that influence child immunisation status has been organised into five groups namely: Child, Household, Community, Health System and Internal factors.

Child level factors

Birth order, sex, place of delivery and maternal antenatal attendance are factors directly linked to immunisation outcomes. These characteristics have been widely studied globally, manifesting differing associations across the social and demographic strata.

Birth Order/Rank- The order of a child within the family has been shown to be associated with the child's level of immunisation. Lower birth orders (1st – 4th) had consistently higher immunisation rates than higher birth orders (5th and above) after adjustment for variables like region, religion, maternal education and wealth (Antai, 2009b; Antai, 2012; Chidiebere *et al.*, 2014). After controlling for maternal, child and community sociodemographic factors that included place of birth, in an analysis of 4242 children aged 12-23 months from a non-nationally representative sample in northern Nigeria in 2009, higher birth orders were shown to have an independent significant reduction in the odds of BCG immunisation, which is given at birth (Babalola and Lawan, 2009). Another Nigerian study showed that a child ranking of 4th or more had a negative influence on the child's full immunisation (Chidiebere *et al.*, 2014). In this latter study, logistic regression analysis of NDHS immunisation data collected from 33,385 households using children of 4th or more birth orders as the reference showed an unadjusted odds ratio of 1.17, 1.27 and 1.11 for the 1st, 2nd and 3rd ranked births respectively (Chidiebere *et al.*, 2014). Similar evidence of decreasing immunisation coverage as child birth order increases was obtained in India (Mathew, 2012).

The reason for the finding is not obvious, but a mother with more children may not have the time, resources and motivation to ensure that her last-born is immunised. It should be noted that BCG is given at birth or soon after, so perhaps higher birth orders infants are less likely to be born in health facilities as a result of competition among older siblings for limited parental care, or even negligence arising from limited resources (Antai, 2012). It has also been suggested that the non-occurrence of vaccine preventable diseases in older children and the community may foster apathy (or worse resistance) towards immunisation (Mathew, 2012).

Evaluating the influence of high birth order on child immunisation deserves more attention in studies that allow for other relevant factors, especially in the face of the high fertility rate of 5.5 per births per woman in Nigeria (National Population Commission, 2014).

Sex of child- Published evidence from Nigeria shows that sex of the child is not significantly associated with likelihood of childhood immunisation (National Population Commission, 2000; National Population Commission, 2004; Antai, 2009b; National Population Commission, 2009; Oladokun *et al.*, 2010; Antai, 2012; Oyo-Ita *et al.*, 2012; Adegboye *et al.*, 2014; National Population Commission, 2014; Ushie *et al.*, 2014), even though Nigeria is a patrilineal society where the inheritance of parental assets are the right of male children. In an analysis that adjusted for socio-demographic characteristics, using data from 24,910 children from the 2008 NDHS, girls had a slightly higher likelihood of being fully immunised than boys (aOR 1.28, 95%CI 1.06 – 1.54) (Antai, 2012). In a short-term evaluation of an immunisation programme in rural Nigeria involving 327 children aged 0 to 2 years, there was no significant difference in the proportion of female (125/156, 80.1%) and male (129/171,75.4%) children who were immunised, though the numbers are limited and the trend is in the girls' favour (Odusanya *et al.*, 2003). All other reviewed papers that used NDHS data reported no significant advantage conferred by the child's sex in being fully immunised

(National Population Commission, 2000; National Population Commission, 2004; Antai, 2009b; National Population Commission, 2009; Oladokun *et al.*, 2010; Antai, 2012; Adegboye *et al.*, 2014; National Population Commission, 2014; Ushie *et al.*, 2014).

The findings from India are in contrast, with boys more likely to have been immunised than girls. Analysis of India's National Family Health Surveys (1991/92, 1998/99 and 2005/06) showed that the disadvantage of the female child worsened over time, with the sex inequality ratio rising from 103.8 in 1992 to 109.4 in 2006 (Singh, 2013). The sex inequality ratio is the percentage of fully immunised males divided by the percentage of fully immunised female multiplied by 100 (Singh, 2013). The persistent sex difference in India has been reported as due to their culture of male preference based on economic, social and religious reasons (Singh, 2013).

Most studies do not report on reasons for the lack of association with the sex of a child and immunisation coverage in Nigeria (Odusanya *et al.*, 2003; Antai, 2009b). Sex equality in Nigeria may be the norm, although further research with qualitative methods would be of interest (Antai, 2012).

Place of Delivery- Delivery of a child in the health facility increases the odds that the child will be immunised, at least for vaccines given at birth or soon after because it suggests engagement with the health system, while a home birth reduces the chances of child immunisation (Fatiregun *et al.*, 2013). In an analysis that controlled for maternal sociodemographic factors such as maternal age, marital status, religion, ethnicity, educational level, employment status and child factors like birth order, place of delivery and sex of data from 1178 mothers of children aged 12 – 23 months of Southwest Nigeria, hospital-delivered children had a 1.8 increased odds of being immunised compared to those delivered at home (Fatiregun *et al.*, 2013). Similar findings were reported from a study using the 1990, 1999, 2003 and 2008 NDHS datasets (Ushie *et al.*, 2014), secondary analysis of Nigeria DHS data findings (Antai, 2009b; Chidiebere *et al.*, 2014; Ushie *et al.*, 2014), a study from northern Nigeria (Babalola, 2009; Babalola and Lawan, 2009) and a study in India (Singh, 2013). Delivery in a health facility is generally safer for both mother and child (Antai, 2010), and also provides the opportunity for the birth dose immunisation (BCG, OPV and Hepatitis B). Between 1990 and 2008 , just a third of children in Nigeria were delivered in health facilities (Ushie *et al.*, 2014); delivery in a health facility significantly increased the odds of the child being fully immunised both in Nigeria (Antai, 2010; Chidiebere *et al.*, 2014; Ushie *et al.*, 2014) and other countries (Nath *et al.*, 2007; Kumar *et al.*, 2010; Etana and Deressa, 2012). This finding may have been at least partially associated with the provision of vaccines at birth, and immunisation messages provided at delivery in the health facility by health workers (Kumar *et al.*, 2010; Etana and Deressa, 2012; Mathew, 2012;

Adedokun *et al.*, 2017). Also, delivery in the hospital could be an indication of the mothers' belief in, and engagement with, formal health care service.

The immediate postnatal package of health care that includes health information on immunisation and nutrition which is available to mothers who deliver in health facilities may explain this relationship (Fatiregun *et al.*, 2013). Non-delivery in a health facility may be suggestive of distrust and lack of confidence in modern medicine and its providers (Ushie *et al.*, 2014). The 2013 NDHS reported that only 36 percent of deliveries in Nigeria were in health facilities (National Population Commission, 2014).

Maternal Antenatal care attendance- Maternal attendance at antenatal care (ANC) has been shown to confer significantly higher probability that the child will be immunised compared to children whose mother did not attend ANC (Babalola and Lawan, 2009; Etana and Deressa, 2012; Adedokun *et al.*, 2017). The antenatal care health package, which includes child immunisation information and Tetanus toxoid immunisation for the pregnant woman, may explain the significantly increased immunisation odds of children whose mother attended ANC compared to those who did not (Adedokun *et al.*, 2017). This result is consistent with previous studies in Nigeria, which used survey datasets to analyse immunisation coverage (Babalola and Lawan, 2009).

Household- level factors

Household characteristics including maternal educational level, wealth, place of residence, marital status, religion, age, ethnic group, mothers' employment status were associated with child immunisation outcome.

Maternal Education- Education plays a key role in the attitude of the mother toward child immunisation. Educational level is associated with maternal employment status and access to child health information. A study of the household structure and childhood immunisation in Niger and Nigeria using DHS data reported that children of educated mothers had 80% higher likelihood of being fully immunised than children of uneducated mothers after controlling for socioeconomic factors (Gage *et al.*, 1997). Findings of a multi-year trend analysis on 46,130 children of 17,380 mothers in 1938 communities from the Nigeria DHS 1990, 1999, 2003 and 2008 showed a 17% reduced likelihood of being immunised for a child of a non-educated mother compared to a child of a primary level education mother (Adegboye *et al.*, 2014). Better educated women often work outside the home, yet several studies have found their children have higher immunisation coverage than those born to mothers with low or no education (Federal office of Statistics, 1992; Gage *et al.*, 1997; National Population Commission, 2000; Bonu *et al.*, 2004; National Population Commission, 2004; Antai, 2009b; Antai, 2009a; Babalola, 2009; National Population Commission, 2009; Antai, 2010; Mushtaq *et al.*, 2010; Babalola, 2011; Antai, 2012; Fatiregun and Okoro, 2012; Fatiregun *et al.*, 2013; Obiajunwa and Olaogun, 2013; Adegboye *et al.*, 2014; Chidiebere *et al.*, 2014; National Population Commission, 2014; Okoronkwo *et al.*, 2014; Ushie *et al.*, 2014; Mukherjee *et al.*, 2015).

The positive effect of maternal education is global, with several reasons postulated (Mathew, 2012; Wiysonge *et al.*, 2012; Singh, 2013); the effect of education goes beyond just literacy, educated women are more open to immunisation advice, health seeking behaviour and education.

Household wealth- Childhood immunisation is provided free of charge in all public health facilities in Nigeria. However, cross-sectional studies in northern (Babalola, 2009; Babalola, 2011) and southwest Nigeria (Fatiregun *et al.*, 2013) showed that higher economic status positively influenced the completion of immunisation. The wealthier the household, the higher the immunisation status of the children (Federal office of Statistics, 1992; National Population Commission, 2000; National Population Commission, 2004; Antai, 2009b; Antai, 2009a; National Population Commission, 2009; Antai, 2010; Antai, 2012; Adegboye *et al.*, 2014; National Population Commission, 2014; Ushie *et al.*, 2014).

Although immunisation coverage was higher in the lower wealth class than higher wealth category in a study in the Southeast region of Nigeria, based on 4,873 households from two of Nigeria's 36 states, study findings should be interpreted with caution due to the regional study sample and non-rigorous statistical analyses, which did not adjust for other factors associated with immunisation coverage (Onwujekwe *et al.*, 2012).

National Immunisation Days (NIDs), a supplemental immunisation activity, have had varying country-specific effects on routine immunisation coverage (Bonu *et al.*, 2004). Using DHS datasets of 15 south Asian and African countries including Nigeria, the study, which among other objectives assessed how NIDs affected relative coverage as per the wealthiest versus poorest population, found a strong association between wealth and increased immunisation coverage, with only Zimbabwe's results contrary (Bonu *et al.*, 2004). The Zimbabwean child from the poorest wealth quintile had a 6% higher likelihood of receiving the third dose of OPV than those from the richest quintile.

Free service provision may not always ensure equity. There are several costs like transportation to the health facility and loss of income when attending the health facility (for example petty trader, artisans etc.) which can determine the utilisation of immunisation services. In the face of limited resources, the poor may spend their funds on curative health than preventive health care like immunisation (Merten *et al.*, 2015).

Religion- Religion is very important to Nigerians and has influenced several spheres of their lives, including child immunisation. In 2003, northern Nigeria leaders brought the nation's Polio Eradication efforts to a halt (Renne, 2006). They alleged that vaccines were contaminated with HIV and anti-fertility substances by developed western countries in order to reduce their (Muslim) population. About 90% of Nigerians are either Christians or Muslim (Antai, 2009a). In the 2008 NDHS, 5% of the reasons for the refusal to immunise children was reportedly due to religious beliefs (Chidiebere *et al.*, 2014). An analysis that adjusted for household and community factors, using data from 3935 children aged 12 – 59 months in Nigeria, showed that children from Muslim mothers had a significantly increased likelihood of not being immunised compared to Christians and other religions (Antai, 2009a). A systematic review of 54 papers on immunisation inequities in India showed similar results, with lower immunisation rates in Muslim (45.5%) than Hindu (55.4%), Sikh (81.9%) and Christian (67.3%) children (Mathew, 2012).

In Nigeria, reluctance to utilise immunisation services is not limited to Muslims. Adherents of the Christ Apostolic Church, a Christian sect, believe in the use of prayers for disease prevention and cure and avoid immunisations (Oluwadare, 2009b). In the very early 2000s, Nigeria immunisation coverage reached an all-time low, with the North as the most affected due to the religion-inspired rejection of vaccine administration (Renne, 2006). In the 2003 NDHS, fully immunised child coverage for Nigeria was 12.9% but only 6% and 3.7% in the Northeast and Northwest regions, which are predominantly Muslim (Antai, 2009a; National Population Commission, 2014). In the 2008 NDHS, appreciable progress had been made in allaying these religious concerns with coverage for Nigeria, Northeast and Northwest regions rising to 22.7%, 7.6% and 6% respectively (National Population Commission, 2009), with just 5% of women giving religious belief as the reason for not having their child immunised (Chidiebere *et al.*, 2014).

The hypothesis that refusal to accept immunisation services is due to the specific doctrines, beliefs and values associated with religion (Islam) (Antai, 2009a) may not fully explain the situation in Nigeria. Muslims in the South had lower immunisation levels than their Christian peers but their educational attainment, social economic status and knowledge of immunisation was much lower too (Oluwadare, 2009a). It remains unclear whether religion was an independent variable. Ignorance due to lack of education has made these mothers believe myths like vaccines will cause infertility, HIV or cancer (Renne, 2006; Yahya, 2007).

Ethnicity- Ethnicity and religion are closely related in Nigeria. Cultural practices like the home restriction of the mother until 40 days post-delivery can affect utilisation of routine early infant immunisation (Adegboye *et al.*, 2014). Nigeria has three major ethnic groups: Hausa/Fulani, Ibo and Yoruba. The likelihood of an Ibo or Yoruba child being fully immunised was much higher than that of a Hausa/Fulani/Kanuri child with the adjusted odds being 1.7 and 1.9 respectively, allowing for other variables known to be associated with full immunisation coverage (Antai, 2009b). Analysing these Hausa and Fulani as individual tribes even though they are religiously and culturally alike, as proposed for the PhD, may provide a new insight since Fulanis are nomadic while the Hausas are farmers. Also, in other countries ethnicity was found to be associated with immunisation uptake (Mathew, 2012). Chidiebere et al's analysis of the 2008 NDHS showed that the Yoruba and Ibo tribes from the South of Nigeria, who are mostly Christian, had an immunisation coverage of 46.8% and 44.5% respectively, while the Hausa, Fulani and Kanuri groups of the north, who are mostly Muslim, had rates of 7.8%, 14.5% and 6.2% respectively. The association between ethnoreligious complex and immunisation coverage has also been reported in India (Mathew, 2012).

Tribal resistance to immunisation may be an explanation for the low coverage among particular ethnic groups (Nwogu *et al.*, 2008). Many authors have expressed low levels of western education among the women of the north of Nigeria as the main reason for this under-performance (Antai, 2009a; Chidiebere *et al.*, 2014). The loss of political power by the North in 1999 may have precipitated the boycott of immunisation services (Renne, 2010). From independence in October 1960 until May 1999, Northerners have headed the Nigerian government except for about four years, hence the suggestion that the northern boycott of child immunisation services was more political than religious with the rejection of vaccine being a ploy to destabilise the government (Renne, 2010).

Marital Status- The association between maternal marital status and child immunisation has been explored in a limited number of studies from Nigeria. Findings from the secondary analysis of 2003 Nigeria DHS that adjusted for individual, household and community variables showed that children of single and divorced women were more likely to be fully immunised than those whose mothers are married (Antai, 2009b). In an analysis that adjusted for sociodemographic factors, which used the 2007 Malawi Welfare Monitoring Survey datasets with 18,251 children aged 10-60 months, findings were similar, with children of single and divorced mothers having higher fully immunised coverage than children whose mothers were married or separated (Abebe *et al.*, 2012). However, this study did not indicate if the divorce came before or after immunisation, but as reports relate to children up to the age of five years while immunisation would have occurred in the first year of life, it is more likely that the divorce came later.

A study in rural south-south Nigeria that included 339 mother/child pairs, children of married mothers had a higher full immunisation coverage than children of single/divorced mothers (Odusanya *et al.*, 2008), although the 7% difference in immunisation coverage was not statistically significant (Odusanya *et al.*, 2008). However, the study sample was small and not representative regionally or nationally (Odusanya *et al.*, 2008).

The authors who reported that children of single mothers had a higher likelihood of completing immunisation (Antai, 2009b; Abebe *et al.*, 2012) and those that had a contrary finding (Odusanya *et al.*, 2008) did not suggest an explanation. The Nigerian belief that children from still married parents should have the better immunisation status because the mother and father's resources work in synergy to improve the overall health status of a child is contrary to the findings of the secondary analysis of the 2003 NDHS (Antai, 2009b). Further research is warranted to explore such associations, with allowance for other variables possibly associated with full immunisation coverage.

Maternal employment/occupation status- Employed mothers may spend less time with their children than mothers not working outside the home, with the children of employed mothers expected to have a lower chance of full immunisation. Unemployed mothers may have more time for their children and would not miss immunisation appointments in contrast to employed mothers who may default due to employment commitments (Fatiregun and Okoro, 2012). Keeping these appointments depends not only on the availability of time, but on factors like the belief that immunisation is good, and having transport funds to go to the health facility (Abdulraheem *et al.*, 2011). In cases where transport cost to access services is a challenge, the employed mother's child may be at an advantage.

Children of unemployed mothers (mainly housewives) were found to be more likely to have been fully immunised, with an adjusted odds ratio of 1.71, as compared to children of employed mothers, based on data from mothers of 525 children of ages 12 – 23 months in south-east Nigeria (Fatiregun and Okoro, 2012). This study was set in one of the six regions of Nigeria, and sociodemographic factors such as maternal age, maternal employment status and maternal parity were adjusted for in the analysis.

In contrast, two studies using NDHS data found independently increased immunisation odds for children of employed mothers (Antai, 2009b; Adegboye *et al.*, 2014). Children of employed mothers achieved higher immunisation coverages than those whose mothers were not employed in an analysis that adjusted for several variables which included child place of delivery, maternal education level, sex of household head and household wealth that used data from 46,130 children (Adegboye *et al.*, 2014). In an analysis that allowed for sociodemographic factors, maternal occupation was grouped into four, with the least being not working and highest being in managerial/professional employment, children of managerial mothers had a significantly increased adjusted odds of being fully immunised than children of mothers in the three lower occupational levels in the (Antai, 2009b). Based on the integrity of the DHS datasets and the quality of the secondary analysis, it can be concluded that an employed mother independently increases the immunisation completion chance of her child.

Maternal Age- The age of the mother plays a role in the health of the child. The association between maternal age and childhood immunisation status has been explored in several Nigerian studies. Chidiebere et al, adjusting for maternal sociodemographic factors, found that children of mothers less than 35 years of age were more likely to be fully immunised than children of mothers aged 35 – 45 years (Chidiebere *et al.*, 2014). Higher full immunisation coverage was reported in children with older parents in a research involving parents of 800 schoolgirls (Mukherjee *et al.*, 2015). In this cross-sectional study, retrospective immunisation history was obtained from parents whose daughters were then aged 11 – 15 years schooling in Mysore, India (Mukherjee *et al.*, 2015). The authors identified recall bias as a severe limitation

In rural Nigeria, children of mothers aged 30 years and above were reported to have higher immunisation completion status than those of younger mothers (Odusanya *et al.*, 2008). Also, data from the two Urban Health and Demographic Surveillance Systems in Africa (Nairobi and Ouagadougou) revealed that children of mothers less than 20 years of age were more likely to be unimmunised than their peers who have older mothers (Soura *et al.*, 2015). Similar evidence was provided from a Nigerian study which showed that children with mothers aged 15-24 years were more likely to be unimmunised than children with mothers older than 24 years (Adedokun *et al.*, 2017).

Findings from these studies are at variance as are the reasons postulated. The grouping of the ages are not identical and sometimes the age range is too wide. This may have contributed to the inability to establish a link. The age of the mother at the time of delivery rather than maternal age during the survey may provide better understanding of the influence of maternal age over childhood immunisation.

Chapter 2

Community level factors

Many characteristics in a community may play a positive or negative role in childhood immunisation status of their very young. Place of residence, region, customs and traditions, community immunisation awareness and distance to the health facility have all been suggested to be associated with immunisation status.

Place of Residence- Where the child resides in Nigeria played a role in wellbeing and health (Federal office of Statistics, 1992; National Population Commission, 2000; National Population Commission, 2004; National Population Commission, 2009; Adegboye *et al.*, 2014; National Population Commission, 2014). Access to health services, water and sanitation, wealth, maternal awareness and health education, maternal health care (especially ante- and postnatal care) and quality of health service provision can vary by place of residence. Presumably, the benefits of immunisation are the same across Nigeria, but access may vary between urban areas and rural communities (Antai, 2009b; Antai, 2011). These health benefits are neither limited to immunisation nor occur only in Nigeria. Globally, it has been termed "urban advantage", said to be common in low- and middle-income nations as a result of improved access to health facilities, commodities and qualified personnel in urban areas compared to their lack or absence in rural areas (Hu *et al.*, 2008; More *et al.*, 2009). All Nigeria DHS reports showed a considerable urban advantage regarding higher immunisation coverage (Federal office of Statistics, 1992; National Population Commission, 2000; National Population Commission, 2004; National Population Commission, 2009; National Population Commission, 2014). Results from a multilevel logistic regression analysis of 2003 NDHS data, showed that a rural child's unadjusted odds of being fully immunised was lower than that of an urban child. After controlling for child, maternal and community variables, the urban child still had a full immunisation odds which was significant and 39% higher than the rural child (Antai, 2011).

However, results from a multilevel logistic regression analysis of DHS data for 27,094 children aged 12–23 months, nested within 8,546 communities from 24 countries (Nigeria included) in sub-Saharan Africa showed that allowing for sociodemographic variables, children from urban areas were less likely to be immunised than those from rural areas (Wiysonge *et al.*, 2012). Although the authors acknowledged that their results were contrary to expectation, they did not proffer any reason for their finding. This may be explained by the increased proportion of urban dwellers that reside in slums, which are said to have worse health outcomes than rural residents (Fotso *et al.*, 2007). A cross-sectional study in Southwest Nigeria in 2012 involving mothers with children aged 12 - 23 months aimed to identify factors associated with achievement of a complete child immunisation status in rural and urban locations, found similar coverage in urban and rural areas, at 40.2% and

41.3% respectively (Fatiregun *et al.*, 2013). This study was not nationally representative and study areas were chosen based on their very poor immunisation performance within the region, as such findings should be interpreted with caution.

The Nigerian population has grown from an estimated 123 million in 2000 to 182 million in 2015, and is expected to grow to 263 million by 2030 (World Bank, 2015b). The urbanisation rate in Nigeria is alarming, with the urban population expected to increase from the 2011 figure of 49.6% of the total population to 60.8% by (United Nations Human Settlement Programme and UN HABITAT, 2014). One of the reasons for rural-urban migration is the desire to have better access to health services and other social amenities (Okhankhuele and Opafunso, 2013). A widening disparity will further fuel migration to urban areas, increase the slum population and worsen the lot of the urban poor(Okhankhuele and Opafunso, 2013). The young and educated may drive this rural to urban migration, leaving the older, poorer and less educated behind. Results from all five, nationally-representative, Nigeria DHS provided further evidence of an urban immunisation advantage. This urban advantage needs to be further analysed, as it is important to ascertain if this disparity has increased over time, the influence of other socio-demographic factors on childhood immunisation varied with place of residence and all urban residents have similar odds of full child immunisation. With more Nigerians living in the urban slums, the present low child immunisation coverage in Nigeria cannot be improved without confirming if intra –urban disparity exist.

Region- In Nigeria, the uptake of immunisation was influenced by the child's geographical region. The child in the best performing region was several times more likely to be fully immunised than the child from the least performing region (Federal office of Statistics, 1992; National Population Commission, 2000; National Population Commission, 2004; National Population Commission, 2009; National Population Commission, 2014). Children from the three Southern regions had a much higher likelihood to be fully immunised than their Northern peers (National Population Commission, 2004; National Population Commission, 2009; National Primary Health Care Development Agency, 2009; National Population Commission, 2014). The three Northern regions are not homogenous, the Northcentral region, populated by tribes who are neither Hausa, Fulani nor Kanuri and has borders with the south, achieved immunisation rates much higher than the Northeast and Northwest that are populated by the Hausa/Fulani/Kanuri tribes (National Population Commission, 2014). Regional immunisation disparities are common in developing nations (Mathew, 2012; Singh, 2013). Ghana and Nigeria are former colonies of the United Kingdom, with multi-ethnic societies, that are characterised by a significantly less developed Sahelian and Muslim North, and a Christian-dominated coastal South (Mancini, 2009). The high inequalities in education and child mortality in

Nigeria are along regional and ethnic/religion lines. In Nigeria, about 25 per cent of people living in the North are Christians and 15 per cent of southerners are Muslims, similar to Ghana's profile, but in Ghana, education, mortality and wealth inequalities between Christians and Muslims are significantly lower than in Nigeria (Mancini, 2009).

The region of the child's place of residence was a major factor associated with immunisation status in Malawi that changed over time (Munthali, 2007). Unadjusted analysis of nationally representative datasets collected in the 1990s and 2000s in Malawi showed that the South region had the highest childhood immunisation coverage in the 1990s, while in the DHS conducted in 2000 and 2004, the North had the highest coverage. The Central region had the lowest coverages in all the four surveys analysed (Munthali, 2007).

The huge disparity between the North and South in Nigeria is not only due to religious beliefs, but also to fear and confusion due to inadequate information and lack of trust and confidence in child immunisation (Ophori *et al.*, 2014). The fact that mothers from the northern part of Nigeria are generally less educated and less economically empowered than their southern counterparts may be one of the reasons for this (Mancini, 2009). In addition, the loss of political power by the northern political elite was the key reason that led to their boycott of immunisation services in 2002/ 2003 and this had more effect than maternal lack of education, less economic power and other sociodemographic variables (Renne, 2010).

Customs and Traditions- Customs and traditions are strongly linked to ethnicity and religious beliefs. In Nigeria, most members of a tribe profess a particular religion. Their association with immunisation is as discussed above under the region factors. The gaps in knowledge on how these beliefs influence child immunisation or are dependent on where the communities are located in their regions would be filled by the exploration of views of relevant stakeholders in a qualitative study.

Community Immunisation Awareness- Community immunisation awareness is a composite variable including community maternal education level, antenatal attendance, utilisation of health facilities and access to mass media. Common to all of these variables is immunisation information. These are the formal ways to be educated about immunisation, its importance and availability.

The percentage of educated mothers in a community played a role in the proportion of their children that were fully immunised. The higher the percentage of educated women, the greater the chances of increased childhood immunisation coverage at the community level (Antai, 2009b). The proportion of literate females in the community is associated with the child's complete immunisation status at the community level (Parashar, 2005). The hypothesis that a significant and positive relationship exists between the average female literacy rate in a district and a child's probability of being completely immunised within that district was tested in rural India (Parashar, 2005). Statistical analysis showed that independent of maternal education, the adjusted odds of a child being fully immunised increased significantly by a factor of 1.27 when the percentage of literate women increased by 16% in the district (Parashar, 2005). The relationship between women's education and child health in an area can be explained by the fact that even children of uneducated mothers benefit from the expansive effect conferred by the other women's education (Parashar, 2005). Just like immunisation, education may have a "herd" effect.

The wellbeing and health of a child can be determined as early as before conception. However, antenatal care provides the opportunities for the mother to be educated on the importance and need for childhood vaccines, the immunisation benefit of hospital delivery (BCG, OPV and HBV given at birth) and opportunities to ask questions on fears and doubts about vaccines. Increased use of antenatal care in the community was positively associated with full immunisation child coverage (Antai, 2009b).

Proximity to Health Facilities- The Nigerian Primary Health Care strategy, which has immunisation as a component, recognised the importance of proximity to service provision. As such, in addition to service provision in the health facility, outreach services are meant to serve clients/patients residing further away. Walking a long distance to the health facility was the reason given by 17.5% of mothers of partially immunised children as the reason for not completing their child's immunisations (Abdulraheem *et al.*, 2011). Children of mothers who felt it was a big problem to access the nearest health facility when seeking health care had lower fully immunised child coverage compared to peers whose mothers did not see it as a big problem (National Population Commission, 2004; National Population Commission, 2009; National Population Commission, 2014).

Mohan studied the association between distance from the health facility and immunisation uptake in 2365 children (< 5 years old) presenting in 12 Primary Health Centres in one district in India (Mohan, 2005). The study reported a fully immunised child coverage of 55% for households less than one kilometre away, 47% for distance one to two kilometres, 32% for distance two to seven kilometres and 30% for more than seven kilometres from health centres (Mohan, 2005). Also, there was strong evidence that poorer families lived further away from functional primary health facilities than better-off families (Mohan, 2005).

Chapter 2

Health system level factors

The need to ensure the potency of vaccine from the manufacturing line to the point of administration is key if the high immunisation rates can be taken as high immunity levels in the community. A well-functioning system should be made up of an adequate number of health workers who should be well trained and mannered, delivering quality and timely services, be devoid of avoidable adverse events following vaccine administration and having drugs to treat vaccine side effects (National Primary Health Care Development Agency, 2007; National Primary Health Care Development Agency, 2007; Federal Ministry of Health and National Primary Health Care Development Agency, 2013). . How close the communities are to the health facility and how health facilities provide services to their catchment communities far away are health system issues. Regular and adequate availability of potent vaccines at immunisation sessions are important systematic factors. Transcending several levels of the health system is ensuring that at the point of administration of the vaccine, it can induce immunity in the recipient. Several qualitative studies in Nigeria have suggested the negative role the health system may play in immunisation coverage (Abdulkarim *et al.*, 2011; Oyo-Ita *et al.*, 2012; Federal Ministry of Health and National Primary Health Care Development Agency, 2013).

Abdulkarim et al.'s review of Nigeria's immunisation system reported the health system weaknesses as poor transport and storage, weak logistics such as cold chain, inadequate and poorly motivated health care workers, poor health financing and lack of sustainable partnerships (Abdulkarim *et al.*, 2011). In Central Nigeria, direct health system failures include the unavailability of vaccines, long waiting times for services at the clinic, absence of health workers on the facility scheduled vaccination day, and mothers not given next appointments, made up 27% of the reasons for incomplete vaccination (Abdulraheem *et al.*, 2011). In the 2008 DHS, health system issues accounted for 25% of the reasons given by mothers for not immunising their children (Chidiebere *et al.*, 2014). Health system weaknesses have also been reported to affect immunisation service delivery in several low and middle-income countries (Cassell *et al.*, 2006; Abebe *et al.*, 2012; Mathew, 2012). An interventional study that explored clients' satisfaction with immunisation services received in north central Nigeria with a study population of 300 women had pre-intervention average waiting times of 82.7 minutes and 90.4 minutes for study and control groups respectively (Goodman *et al.*, 2013). After providing immunisation service improvement sensitisation to only the health workers who provided services to the study group, the study and control groups had waiting times of 48.0 minutes and 88.4 minutes respectively at post implementation(Goodman *et al.*, 2013). Of the 685 mothers with children aged 0-11 months sampled, 15.2% of the mothers felt the long waiting time in the immunisation clinic was a barrier to completing the child routine immunisation schedule in Nigeria (Abdulraheem *et al.*, 2011).

In these studies, the analysis of the health system mainly focussed on the perspective of the community and their members (Cassell *et al.*, 2006; Abebe *et al.*, 2012; Chidiebere *et al.*, 2014); the service delivery practice and views of the health workers are important factors that if studied can provide vital information to improve childhood immunisation.

Summary of key factors associated with childhood immunisation

In Table 2.8, the association between child immunisation and sociodemographic status was synthesised directly from the results presented of the included papers. The strength of the association was assessed with the use of the critical appraisal skills programme (CASP) qualitative checklist (Critical Appraisal Skills Programme, 2018) that evaluates the value, importance and practicality of the research evidence (Akobeng, 2005; Yost *et al.*, 2014). Only six of the ten questions of the CASP checklist applicable to studies such as reviews and quantitative studies was used for evaluation here. The six questions: was there a clear research aim, was the research design appropriate, was the data collected in the way that addressed the research issue, were ethical issues taken into consideration, was the data analysis sufficiently rigorous, was there a clear statement of findings, were each assigned one (1) point. An overall score of 0-2 was then indicated by one star (*), 3-4 two stars (**) and 5-6 three stars (***).The scoring of these six questions was anchored largely on each study's methodology. For example, the quantitative studies were assessed by criteria such as good data quality and national representative statistical analysis. The data quality was judged as good if it was nationally representative, which is indicated when the study data was representative of the country, and statistical analysis that adjusted for relevant independent variables was seen as rigorous. Qualitative studies were assessed by having a well-defined sample, ethical approval and peer reviewed coding process, and the presence of a conceptual framework.

Table 2.8: Summary of key factors associated with childhood immunisation

Variable	Direction of Association	Strength of Evidence
Birth order		
Low	+	**
high	-	**
Place of delivery		
Health facility	+	***
Home	-	**
Maternal Antenatal attendance		
Yes	+	***
No	-	**
Maternal Education level		
No education	-	***
Education	+	***
Household Wealth		
Poor	-	**
Moderate	+	**
Rich	+	***
Religion		
Muslim	-	***
Christian	+	**
Ethnicity		
Hausa/Fulani/Kanuri	-	***
Igbo/Yoruba	+	**
Marital status		
Not married	+	*
Married	-	*
Mothers' employment status		
Employed	+	*
Not employed	-	*
Maternal age		
<20 years	-	**
≥ 20 years	+	**
Place of residence		
Rural	-	**
Urban formal	+	***
Urban slum	-	*
Distance to Health facility		
Far	-	**
Near	+	**
Vaccine availability		
Yes	+	***
No	-	***

- = reduce immunisation status; + =increase immunisation status; *= weak association: **= moderate association; strong association.

2.4 Internal factors

Within the child are unseen and internal factors which may include, HIV status, nutritional status and maternal nutritional state from the child's conception to birth that have been reported to significantly affect translation of vaccination into immunisation which is protection of child against disease (Obanewa and Newell, 2017; Falconer *et al.*, 2018). It will not be effective to achieve the required immunisation coverage that should normally confer herd immunity, if a child's vaccine immune response was low due to such internal factors.

Unseen though very important internal child level factors have not been studied as relating to childhood immunisation in Nigeria. An observational analysis that applied multivariable regression methods to data from 771 pregnant women and their offspring in a randomised controlled trial of treatments of helminths in pregnancy showed that factors associated with reduced measles specific antibody levels in infancy included maternal malaria infection, infant malaria, infant HIV and infant wasting (Kizito *et al.*, 2013). Only 75% of these infants had measles specific antibody protective levels even though they had all been immunised (Kizito *et al.*, 2013). This is alarming when a protective level of 99% is achievable (Martins *et al.*, 2014). In utero exposure to HIV can lead to altered cellular and humoral immune response of the infant to immunisation and other antigens (Falconer *et al.*, 2018)

The Joint United Nation's programme on HIV/AIDS 2014 gap report said that 22% (51, 000 infants) of the world's new HIV infected children were born in Nigeria, with only 12% of them accessing ART (Joint United Nations Programme on HIV/AIDS (UNAIDS), 2014). The 2014 Nigeria HIV country progress report showed a national adult HIV prevalence of 3.1%, the age group 35-39 year had the highest prevalence and age group 20-24 year had the highest rate of new infection with females more affected in all cases (National Agency for the Control of AIDs (NACA), 2014). In the 2013 NDHS, of all under 5 year of age children sampled, 37 percent were stunted, 18 percent wasted and 29 percent underweight, while for the women of reproductive age (15-49 years), 11 percent were underweight, 17 percent overweight and 8 percent obese (National Population Commission, 2014). Among pregnant women globally, Africa has the highest prevalence of underweight, night blindness (9.4%) and iron deficiency anaemia (20.3%) (Black *et al.*, 2013).

2.4.1 Maternal nutritional status during pregnancy and infant immune response to routine childhood vaccinations (Obanewa and Newell, 2017)

Related to but beyond the scope of this study, the high prevalence of nutrition deficiency among Nigerian women of reproductive age justified an exploration of the role of maternal nutrition during pregnancy in infant immune response to childhood vaccination.[2] (Appendix 1).

The study was composed of two reviews of relevant literature. First, an overview that of maternal nutrition during pregnancy, fetal immune system and vaccines and possible relationships, and the latter, a systematic review of literature on maternal nutritional status and infant vaccine response.

The overview provided a background of the role of specific maternal nutrients during different periods and trimesters of pregnancy in the development of the fetal immune system. The maternal nutrients are made up of macronutrients like carbohydrates, lipids and proteins, and micronutrients such as zinc, selenium, copper, iodine and iron, and vitamins like vitamin A, C, D, E and folate. The study found that irreversible impairment of the fetal system such as the immune system, leading to future adverse effects on vaccine immune response, health and increased risk of chronic diseases in line with the developmental origin of diseases could result from maternal malnutrition during pregnancy (Palmer, 2011; Obanewa and Newell, 2017). Also, the various aspects of the human immune system responsible for the immune response to each childhood vaccine were identified.

With guidance from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, the systematic review search was conducted using these search terms: Maternal nutrition AND (child OR infant) AND (vaccine OR immune response) in CINAHL, Medline, Popline, Scopus and Web of Science databases. From the initial 1439 papers identified, only 9 met the inclusion criteria. The quality of these selected papers was adjudged as average, using the critical appraisal skills program (CASP), which appraised the validity, importance and practicality of the study finding. The maternal nutritional status was obtained either directly (by measurement of nutrient level) or indirect (as measured by season of birth, supplementation, micronutrient deficiency, birth outcome in the form of Intra Uterine Growth Restriction (IUGR) and low birth weight (LBW)). It was inferred that IUGR and LBW were most likely due to maternal malnutrition, maternal micronutrient supplementation in pregnancy may have corrected pre-existing intrauterine

[2] The findings have been published - Obanewa O, Newell M-L. Maternal nutritional status during pregnancy and infant immune response to routine childhood vaccinations. Future Virology. 2017; 12:525-36

nutrient deficit and the rainy season in Africa is the period of hunger with more cases of intrauterine malnutrition.

The study found some proof of the complex relationship between maternal nutritional status, measured by season of birth of the infant, supplementation, micronutrient deficiency, birth outcome in the form of IUGR, or LBW, and infant immune response to administered vaccines. Evidence on the effect of availability, deficiency or total absence of key macro and micronutrients nutrients in fetal life on the infant's response to routine vaccines was limited, and associations could not be quantified. The conclusion of the synthesized findings in the review was that the ability of infants to respond to childhood vaccinations was impaired by restricted fetal growth and development that resulted from maternal lack of adequate levels of macro- and micronutrients during pregnancy (Obanewa and Newell, 2017). Subsequent nutrient supplementation during infancy did not correct the immune impairment during infancy and later years (Obanewa and Newell, 2017). Probably, an estimated up to a third of children who experienced intrauterine malnutrition may be unable to mount protect level immune response to vaccines, and they would need other health attention.

The review concluded that government policy makers, civil servants, community leaders and other immunisation stakeholder, must look beyond mere immunisation coverage, if the protection of the child from vaccine diseases is the goal of the child vaccination programme (Obanewa and Newell, 2017). The United Nation's 2010–2020 decade of vaccine child immunization coverage target may be reached although without ensuring the protection of the child from the vaccine preventable diseases and thus without the desired effect. Further, a child's parent, caregivers and communities may lose faith in childhood vaccination if the fully immunised child comes down with one or more of the vaccine preventable diseases, due to its failure to mount an appropriate immune response to vaccination.

2.5 Slum development and immunisation coverage in Nigeria

Currently, more than half of the world's population live in urban areas (Fink *et al.*, 2014). The global population rose from 2.5 billion in 1950 to 6.9 billion in 2010, with 63% of this increase residing in the urban areas (UN HABITAT, 2010). Developing countries account for most of the increase, with an approximately seven-fold increase in the urban population in just six decades (UN HABITAT, 2010). New arrivals in these urban centres need shelter, employment and other social services, which are not available for all in the planned areas of the urban settlements. Hence, the development of informal urban communities, slums, that are overcrowded, with poor housing, and lacking in water and sanitation services (Fink *et al.*, 2014). The increased population of the urban areas was not the only reason for the slum development in the developing countries, lack of capacity and political will by responsible governments and institutional (public and private) failures that deny slum dwellers life chances are also reasons for the permanence and expansion of slums (UN HABITAT, 2010).

The definition and measurement of slums remains a challenge. Slums are complex (with multiple characteristics), relative (a slum in a region/country may be accepted as a planned area in another country/region), dynamic (can evolve very quickly) and spatial in nature (defined as "a heavily populated urban area characterised by sub-standard housing and squalor"(UN HABITAT, 2010). In 2002, UN-HABITAT defined slum as "a contiguous settlement where the inhabitants are characterised as having inadequate housing and basic services". Further revision of the slum definition made it more operational, with the proportion of urban slum dwellers being the proportion of the urban dwellers residing in slum households, defined as a household lacking one or more of improved water, improved sanitation, sufficient living area, durable housing and secure tenure (UN HABITAT, 2010). "Slums are rarely acknowledged and planned for as an integral or equal part of the urban area by the government" (UN HABITAT, 2010).

Outbreaks of vaccine preventable diseases like measles, pertussis and diphtheria are more prevalent in communities with low immunisation coverage (Unger, 2013), in addition, the diseases cluster in a slum-like environment, where there is household overcrowding, high density population and poor nutrition (Siegel *et al.*, 1997; Lodha *et al.*, 2000; Fotso *et al.*, 2007). Studies in Asia and the near East (Fry *et al.*, 2002), India (Agarwal *et al.*, 2005) and Kenya (Mutua *et al.*, 2011) consistently reported lower rates of immunisation coverage in slums than in formal urban areas.

In 2001, sub-Saharan Africa had the lowest number of urban areas, but the fastest urbanisation rate globally (Tostensen *et al.*, 2001). At unparalleled rates, in the 35 years prior to 2007, the sub-Saharan Africa urban population increased by 600 percent, while its developmental indices have worsened (Caraël and Glynn, 2007). This rapid urban population growth occurred at lower gross domestic product compared to other developing countries, leading to a lack of necessary basic urban infrastructure (Lall *et al.*, 2017). Hence, the proliferated slum being the home to most urban dwellers. The United Nations Population Funds (UNFPA) stated in 2007 that urban growth was closely associated with slums in sub-Saharan Africa, with 72% of the urban population resident of slums (United Nations Population Fund (UNFPA), 2007). In addition, in just 15 years the slum population of sub-Saharan Africa doubled and reached about 200 million in 2005 (United Nations Population Fund (UNFPA), 2007). Between 2010 and 2014, the population of the sub-Saharan slums increased by 17.5 million (UN HABITAT, 2016b).

A UN estimate relating to 2010 suggests that the proportion of urban population living in slums in sub-Saharan Africa had reached 62%, much higher than the average for developing countries (33%) (UN HABITAT, 2010). The issue of slums in sub-Saharan Africa is alarming: with just 13% of the urban population of developing regions, it accommodates 24% of its slum population (UN HABITAT, 2010).

A major dividend of slum residency is the marked negative health disparity, including immunisation coverage, compared to non-slum dwellers. In Niger, immunisation coverage among slum dwellers was 35%, while non-slum dwellers had a rate of 85% (UN HABITAT, 2006). Immunisation coverage reduced generally between 1992 and 2001 in Zambia, but was more in slums (-13%) than the total urban population (-9%) (Fotso *et al.*, 2007). Immunisation coverage also declined in Kenya between 1993 and 2003, with the rate among all urban children dropping from 76% to 48%, and from 71 to 43% in the slums (Fotso *et al.*, 2007). According to the Kenya 2008/9 Demographic and Health Survey, child immunisation coverage increased, to a national rate of 77%, an urban rate of 81% (Nairobi and its slums -73%), and a rural rate of 76% (Mutua *et al.*, 2011), with evidence from a separate study conducted during the same period reported the Nairobi slum immunisation rate of only 58% (Mutua *et al.*, 2011).

Poverty, lack of information, absence of health services, poor quality of available health services, low maternal education, poor health seeking behaviour, violence/threat of violence, lack of family supervision/support have all been suggested as barriers to uptake of health services, including immunisation, in the slums (Fotso *et al.*, 2007; Mutua *et al.*, 2011; Crocker-Buque *et al.*, 2017). Multi-faceted interventions aimed at the numerous barriers to child immunisation have been shown to be effective in improving low coverage in slums (Crocker-Buque *et al.*, 2017). A very important component is understanding the particular slums context through the involvement of the slum community (Crocker-Buque *et al.*, 2017), as even slums located in the same city can be very different (UN HABITAT, 2010).

2.5.1 Slum development and immunisation coverage in Nigeria

Nigeria is the most populous country in Africa with an annual urbanisation rate of 4.35 and a 2.6% annual population growth rate (The World Bank, 2016). About half of the population now live in urban areas, this is projected to rise to 61% by 2030 (United Nations Human Settlement Programme and UN HABITAT, 2014).

The UN-HABITAT slum almanac 2015/16 reported that 42,067,000 million Nigerians, which is 50.2% of the Nigerian urban dwellers, resided in slums (UN HABITAT, 2016a), although some Nigerian studies estimate the proportion of urban dwellers living in slums to be as high as 75% (Bobadoye and

Fakere, 1926; Olotuah and Bobadoye, 2009). The growth of the urban population in Nigeria has been rapid, from 7% of the total population in the 1930s, 10% in 1950, 35% in 1990 (Okupe, 2002; Olotuah and Bobadoye, 2009) to the current 50% or more. This rapid urbanisation is largely due to high population growth and rural-urban migration for economic opportunities (Olotuah and Bobadoye, 2009), which overwhelmed the aged and deteriorated physical and social infrastructure in the urban centres, and led to informal settlements in and around urban centres with poorly built houses, densely populated, poorly laid out houses with little or no road between them, no provision for drainage, proper ventilation, sanitary waste disposal and clean water supply (Olotuah and Bobadoye, 2009). In addition, the Boko Haram insurgency in Nigeria's North East has displaced millions of people with some settling in the cities (Mbanaso and Ozden,2017).

Nigerian cities rank among the fastest growing in Africa, with its largest city, Lagos expected to become Africa's largest urban agglomeration in 2015 (United Nations Human Settlement Programme and UN HABITAT, 2014). Two of every three residents of Lagos reside in a slum (Lall *et al.*, 2017), which made a reporter ask " if the extravagant ugliness of the cityscape is a sign of vigour or one of disease – a life force or an impending apocalypse" (Packer, 2006). Of the fourteen (14) Nigerian cities with a population of 750,000 or more persons, 10 (ten) had higher average growth rates than Lagos (4.7%) (United Nations Human Settlement Programme and UN HABITAT, 2014). As such, these 10 (ten) cities may develop greater slum problems than Lagos.

Abuja, the federal capital city, had the highest annual growth rate, 6.4%, in 2014 in Nigeria (United Nations Human Settlement Programme and UN HABITAT, 2014). In 2004, 26 slums covering over 2000 hectares were identified in and around Abuja (Obia, 2016). A household enumeration survey conducted in Abuja in 2013, revealed that most inhabitants of the Abuja were slum dwellers (FCT Primary Health Care Board, 2013b).

The potential benefits of high urbanisation may elude Nigeria because of the absence of adequate infrastructure (Lall *et al.*, 2017), that has left most urban inhabitants living in slums or slum-like conditions, made up of mostly the poor with the increased risk of exposure to disease, violence, insecurity and less life opportunities (World Bank, 2015a). In Nigeria, the health and health indices of slum dwellers are worse than that of other urban inhabitants, including high levels of malnourished children (Abidoye and Ihebuzor, 2001), high prevalence of tuberculosis (Ogbudebe *et al.*, 2015), high seroprevalence of Toxocariasis (zoonotic infection) (Gyang *et al.*, 2015), high prevalence of high blood pressure (Ezeala-Adikaibe *et al.*, 2016), high levels of self-medication and drug non-adherence (Kehinde and Ogunnowo, 2013), higher rates of malaria, Typhoid and HIV infection compared to other urban dwellers (Badaru *et al.*, 2015), high childhood morbidity and mortality (Ojinnaka *et al.*, 2014), high prevalence of cholera prevalence of meningitis (Kagu *et al.*), and low immunisation coverage (Dudu and Onokerhoraye, 2018).

The detection of the last three cases of wild polio virus confirmed in Abuja in two of its slums, (FCT Primary Health Care Board, 2013a), may suggest that residing in Abuja slums comes with health disadvantages such as higher incidence of vaccine preventable diseases, resulting from lower immunisation coverage rates compared to non- slum urban dwelling.

2.6 Conceptual framework

Child immunisation status is a product of multiple factors acting directly and indirectly at the child, mother, community and health system level. Due to these multi-factorial complexities, conceptual frameworks inform/facilitate understanding of how the multilevel interaction of these factors may influence the immunisation status in different sociodemographic and geographic settings. Individual child's characteristics, maternal/household factors, community characteristics, service delivery factors and the policy environment were concepts used in a study in northern Nigeria to understand the determinants of BCG immunisation status (Babalola and Lawan, 2009). Government immunisation policy has been strategic in improving full immunisation outcome (Al Sheikh *et al.*, 1999). Strategies to improve immunisation outcome are of two types (Johri *et al.*, 2015): demand creation that focuses on changing maternal and community behaviour, and supply side which is service availability and improving health workers attitude. The critical aim of immunisation programmes is to achieve full/complete immunisation status for all children in the prescribed age group, by increasing utilisation of immunisation services, but this cannot be achieved without good quality service delivery and product availability which are necessary for this behaviour change (Cohen and Chehimi, 2007). Several researchers have adopted the multilevel analysis as the best approach to study the dynamics of immunisation status (Antai, 2009b; Antai, 2011; Wiysonge *et al.*, 2012; Chidiebere *et al.*, 2014).

A modified social ecological model can be used to explain the association between child immunisation status and sociodemographic characteristics acting at child, mother, community level (Glanz, 2015), and incorporates environmental and policy influences (Glanz, 2015). The adopted social ecological model has as core principles: 1. Diverse structure of human environments, 2. multiple levels of analyses as the basis for understanding complex associations. 3. Concepts and assumptions from system theory, which suggest that the elasticity of particular settings and wellbeing of people are dependent on the several interactions between the physical and social environment and 4. Improving understanding and performance of people focussed systems will rely on broad and multidisciplinary research where different cultural knowledge, lay and professional perspectives are incorporated and explored. (Stokols *et al.*, 2013).

Building on the reviews presented in this chapter with key findings summarised in Table 2.8, the conceptual framework (Figure 2.3) developed for this study illustrates which, and how, socio-demographic characteristics are associated with access to, and utilisation of, immunisation services in Nigeria. The framework operates at three levels: the non-individual level at the top, the individual level is next and lastly, the outcome, child immunisation status. This conceptual framework informs understanding of how these factors could interact at the implementation level but does not consider government policy. The non-individual level, made up of the health system and community factors, usually do not directly influence the immunisation status, while the individual factors, which are made up of child and household characteristics, act directly.

Non-individual factors include community (urban/rural residence, urban formal/slum residence, region, proximity to a health facility) and health system (adequate staff, staff attitude, physical infrastructure, vaccine availability, planned immunisation sessions conducted, potency of vaccines). They interact within and between groups. The issue of where one lives plays a role across all the factors and is important in a child's immunisation outcome. Several studies in Nigeria have shown wide disparities between rural and urban residence and across regions with the urban residence and southern regions consistently achieving higher immunisation status than the northern ones (Antai, 2009b; Ushie *et al.*, 2014). The urban area is the fastest growing place of residence in Nigeria, with most of the new urban arrivals residing in the slums (Bobadoye and Fakere, 1926; Olotuah and Bobadoye, 2009), and understanding the relationship between childhood immunisation and socio-demographic variables in the intra-urban settlements, separate from the usual rural-urban residence has the potentials to optimise childhood immunisation. The relationship between child immunisation and sociodemographic characteristics may vary from one place of residence to another. Health system factors such as distance to the nearest health facility and availability of vaccines may be linked to the type of community

Household and child characteristics, grouped as individual factors, are mostly directly associated with the outcome. Household's characteristics include maternal education level, maternal employment status, religion, ethnic group, marital status, maternal age at child's birth and wealth. These characteristics can be termed direct based on practicality because they ensure the child is at the health facility. Child factors include place of birth, sex, birth order, place of delivery and maternal antenatal care attendance. The interplay of these direct level factors singly, in their groups and across the direct level, translates to the degree of optimal Immunisation service utilisation and demand available.

It must be noted that non-individual and individual factors might be interrelated, also not all the sociodemographic factors have been listed in the conceptual framework, but all the relevant factors will be explained in subsequent chapters. Individuals (household and children) have to utilise immunisation services provided by the health system, the quality of which may vary according to the health facility location (community). The adequacy of vaccines, regular and appropriate timing of immunisation sessions, skilled and friendly immunisation service providers, short waiting time and close proximity of health facilities play a role in immunisation service availability (Federal Ministry of Health and National Primary Health Care Development Agency, 2013; Ophori *et al.*, 2014).

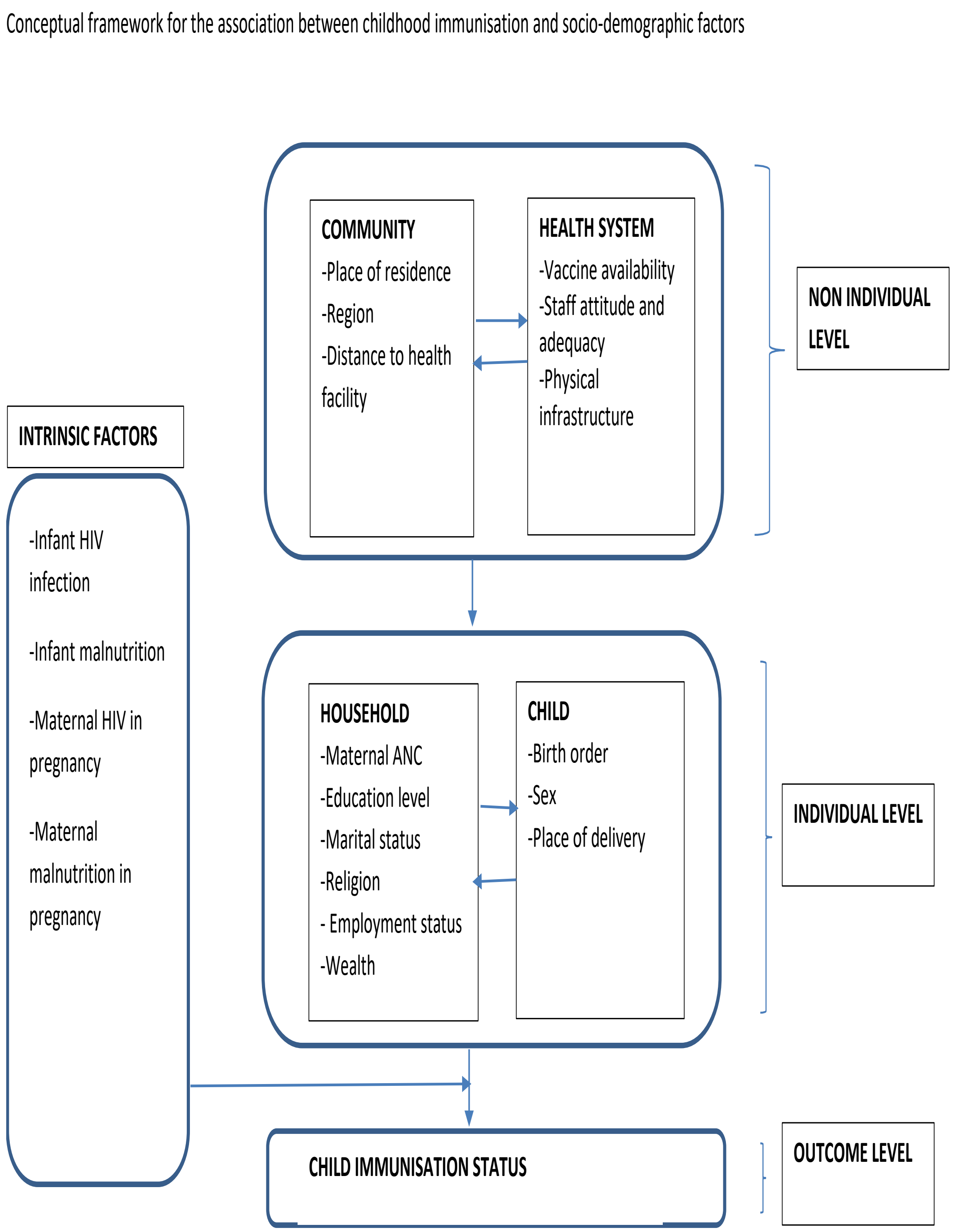
Internal factors recognise the influence of host/genetic characteristics in individuals. For the global assumption of the vaccination coverage being equal to immunisation coverage to hold, the role of internal factors in individuals must be studied. These factors such as infant nutrition and HIV status, maternal HIV and nutrition status during pregnancy have been reported to reduce the level of immunity/protection that vaccines should confer (Kizito *et al.*, 2013; Kampmann and Jones, 2015), with reductions as high as 25% reported (Kizito *et al.*, 2013). Findings of the systematic review of the association between maternal nutrition and infant vaccine immune response provided evidence that malnutrition during pregnancy reduced the infant’s response to recommended vaccines (Obanewa and Newell, 2017). However, although these internal factors are acknowledged, they are not further explored in this thesis.

The outcome, immunisation status which can be full, moderate or low, is the result of the health system and society (child, mother and community factors) interaction in immunisation services delivery. Each vaccine contributes to the collation of the outcome. Vaccines administered at the same time sometimes have different contribution due to a particular vaccine stock out(Federal Ministry of Health and National Primary Health Care Development Agency, 2013), decision of health worker not to open a new vial of vaccine for the few infants present at the time because of envisaged wastage (FCT Primary Health Care Board, 2013d; FCT Primary Health Care Board, 2013c) or parental preference for only oral vaccine or injectable vaccine (FCT Primary Health Care Board, 2013a; FCT Primary Health Care Board, 2015). Immunisation status along sociodemographic lines including sex, wealth, birth order, place of residence and maternal education, show wide disparities (Federal office of Statistics, 1992; National Population Commission, 2000; National Population Commission, 2004; Antai, 2009b; National Population Commission, 2009; National Population Commission, 2014; Ushie *et al.*, 2014).

This PhD conceptual framework is a simplified representation of the complex interactions that exist between sociodemographic variables at the child, household, community and health system level. For example, at the household level, maternal education is likely to be associated with her employment status and with household wealth. The more educated the mother, the higher the chance she is to be employed and the wealthier the household will be. Also, wealthier households will more likely get their children educated to a higher level than poorer households, and marriage will likely occur within the same social strata, with wealthier households showing a later age at marriage and childbearing than poorer households. Further, maternal education will likely be associated with child level variables such as antenatal care attendance and health facility delivery, with educated mothers more knowledgeable of associated health benefits. At the same time, household wealth will facilitate expenses such as transport fee and service user fees. A combination of intertwined and difficult to tease apart interactions thus exist within and between levels of influence and sociodemographic variables in their association with childhood immunisation. Nevertheless, the proposed conceptual framework in this PhD, although simplified, provides a useful tool as it broadly captures the associations between child immunisation status and sociodemographic variables within and between the child, household, community and health system level.

The arrows indicate the probable direction of the relationship between the factors. The conceptual framework will be operationalised all through this study using the methods explained in Chapter 3.

Figure 2.3: Conceptual framework for the association between childhood immunisation and sociodemographic factors



2.7 Benefits of Immunisation.

In 1977, the last naturally occurring small pox infected person was seen in Somalia (Stern and Markel, 2005). The eradication of small pox was the result of the mass vaccination programme implemented under the leadership of WHO in the 1960s and 1970s (Stern and Markel, 2005). Many have claimed that vaccines have contributed most to the relief of human misery, and the reduced mortality at the start of life has contributed to the spectacular increase in life expectancy in the last two centuries Vaccinology has been reported as the only branch of science that has eradicated an infectious disease, smallpox, which caused 8–20% of all deaths in several European countries in the 18th century (André, 2003).

Immunisation coverage rates have been stable over the last few years and have saved an estimated 2 to 3 million child lives annually. Improvement in child health care, including immunisation, has led to a reduction in the annual under five years of age child mortality (U5M), from an estimated 9.6 million in 2000 to 7.6 million in 2010 globally, despite an increase in the number of children born each year (World Health Organisation, 2013). The number of deaths caused by the basic vaccine preventable diseases (diphtheria, measles, neonatal tetanus, pertussis and poliomyelitis) has fallen from an estimated 0.9 million (10% of U5M) in 2000 to 0.4 million (5% of U5M) in 2010 (World Health Organisation, 2013).

Before the advent of mass measles vaccination campaigns, in 1980 approximately 2.6 million deaths were caused by measles(World Health Organisation, 2015b). Though vaccine preventable, measles virus causes a highly virulent, contagious and deadly disease with an estimated 114,900 deaths in 2014 alone (World Health Organisation, 2015b). WHO estimated that measles vaccination saved 17.1 million lives between 2000 and 2014, making measles vaccine one of the best health interventions (World Health Organisation, 2015b).

In 1988, when the global polio eradication initiative started, more than 1000 children were paralysed daily across 125 countries globally (Global Polio Eradication Initiative, 2016). A 99% reduction in the incidence of this incurable disease, which leaves most of its victims with one or more limbs physically disabled, has been achieved (Global Polio Eradication Initiative, 2016).

In addition to lives saved and diseases prevented, immunisation has societal benefits in saving the deprived from being much poorer. Loss of income from work absence due to the care of the sick child, transport cost of seeking care in health facility, medical care bills and most importantly the emotional distress of having a disabled child, losing a child or a loved one are the undeniable great societal benefits of vaccines.

2.8 Conclusion

This review of the literature has explained the concept of childhood immunisation, its enabling factors and challenges. The critical role played by various social, demographic and internal characteristics acting at the child, maternal, community and health system levels in ensuring optimal child immunisation was explored. The benefit of optimal immunisation coverage usually extends beyond the vaccinated child to include the remaining few unvaccinated in the community. The reduction in funds expended on childhood diseases are the early benefits and ultimately, child deaths due to vaccine preventable diseases are prevented leading to a reduction in child mortality rates. The influence of some characteristics like education, wealth, place of residence and region to immunisation coverage were consistently reported in the literature, but the association of maternal age and maternal employment and immunisation coverage varied. As presented in Table 2.8, there were variations in the strength of association between child immunisation status and sociodemographic variables.

Relevant studies in Nigeria expressed the place of residence as either rural or urban, with the belief that urban settings are homogeneous. However, studies from urban slums in Nairobi and Ouagadougou have shown the heterogeneous nature of urban health access and utilisation. Individual factors such as place of delivery, birth order, maternal education, wealth, religion and ethnicity broadly influenced immunisation status. However, the reviewed studies did not explain how these factors influenced immunisation coverage in similar socio-demographic groups living in a different place of residence.

Internal factors like in-utero malnutrition may prevent a child from optimally mounting an optimal immune response to the administered vaccine. Though beyond the scope of the PhD study, the high prevalence of internal factors in Nigeria is a threat to child immunisation in Nigeria.

Table 2.9: Summarises the findings of the reviewed literature, highlights the gaps and outlines how the PhD research sets out to answer these gaps and add to the body of knowledge

Level of Associated Factors	Literature review findings	Gaps in literature	What and how PhD research will add to the body of knowledge
Child	Hospital delivery and low birth order were positively associated with		* Estimation of childhood vaccination coverage in Nigeria, using the DHS 2003,

<table>
<tr>
<td></td>
<td>coverage/likelihood; sex of the child was not significantly associated in Nigeria. A child’s internal make- up has a role to play in being fully immunised and protected against the specific disease.</td>
<td rowspan="4">* No recent review of the Nigerian immunisation coverage (after DHS 2008).

* No current comprehensive study of immunisation coverage in Nigeria over a longer period.

* No study on the association between child, maternal and community factors and childhood vaccination coverages stratified by rural and urban area using nationally representative data

* No literature on whether immunisation utilisation varies within the urban area (urban formal centre and informal slum)

* No current literature on the role of place of residence on the association of each sociodemographic variable with immunisation uptake.

* Absence of immunisation specific study on views of mothers, and of health workers on enabling factors and challenges of immunisation service delivery and observation/inventory of service provision.</td>
<td rowspan="4">2008 and 2013 data, and quantification of the association between child, maternal and community factors with childhood immunisation coverage using bivariate analysis and simple and multilevel logistic regression.

* Quantify with the use of pooled DHS data (2003, 2008 and 2013), the association between child, maternal and community factors and childhood vaccination coverages overall and by rural and urban areas using bivariate analysis and simple and multilevel logistic regression.

* Exploration of the intra-urban differences in childhood immunisation coverage over time by using bivariate analysis and simple and multilevel logistic regression in pooled 2013, 2008 and 2003 DHS.

* Investigate the view of parents and health workers on childhood immunisation challenges and enabling factors.</td>
</tr>
<tr>
<td>Maternal</td>
<td>The strongest positive links were maternal education and wealth class. Findings on association with mothers’ age, employment and marital status contrasted in different studies.</td>
</tr>
<tr>
<td>Community</td>
<td>Place of residence was a very significant determinant in Nigeria. The Region of residence also had a big influence. Other community characteristics like community immunisation awareness and proximity to the health facility were influential.</td>
</tr>
<tr>
<td>Health system</td>
<td>Inadequate health workers and availability of vaccines have played a negative role. Lack of proper education on immunisation has contributed to the low coverage in Nigeria.</td>
</tr>
</table>

Chapter 3 Methods

3.1 Introduction

This chapter operationalises the conceptual framework, linking to the research questions and objectives presented in Chapter 1, with the description of data and methods used to answer this mixed method study's research questions. Quantitative methods were used to answer the first five research questions, while the last two questions were answered with qualitative methods.

The Nigeria Demographic and Health Survey (NDHS) data sets of 2003, 2008 and 2013 are the data sources for the quantitative study (Chapters 4, 5 and 6). First, the analysis of the NDHS 2013 provides levels of child immunisation coverage in Nigeria across sociodemographic variables and magnitude of immunisation drop-out rates and level of non-immunised children. The outcome of interest chosen was the fully immunised child coverage, which is the percentage of children aged 12-23 months who had received all doses of the routine vaccines out of all children aged 12-23 months and the exploratory sociodemographic variables selected were based on the reviewed literature, conceptual framework and PhD candidate's practical experience. In Chapter 5, the three NDHS datasets were made use of in two different ways: 1. Separate analyses of each NDHS dataset to identify whether patterns of association between the immunisation coverage and associated factors in NDHS 2003 to 2013 had changed over time. 2. In order to provide more understanding of the association between immunisation and selected sociodemographic factors by place of residence, the datasets of the three NDHS were pooled with analyses done on the total dataset, stratified into rural and urban place of residence. Lastly, in Chapter 6, the pooled NDHS dataset of the urban area was used to explore the factors associated with childhood immunisation intra-urban disparities.

The NDHS lacks adequate information on the state of the health system and views of parents/caregivers, health workers and community leaders on immunisation service provision, hence the need for a qualitative study to collect relevant information to complement the quantitative analyses based on NDHS data in Chapter 7. The conduct of interviews that examined the views of parents, health workers and community leaders on the challenges and enabling factors of childhood immunisation and the health facility assessment which included observations of immunisation sessions in Abuja's informal urban settlements provided relevant information on the state of the health system and the other levels of influence such as community, household and child.

Table 3.1: Research questions and Analyses summary

<table>
<tr><th>S/N</th><th>RESEARCH QUESTIONS</th><th>Analyses Summary</th></tr>
<tr><td>1</td><td>What is the current childhood immunisation coverage?</td><td>DHS 2013 description, cross tabulations and chi-square test, univariate logistic regression and multilevel logistic regression</td></tr>
<tr><td>2</td><td>What are child, maternal/household and community related factors associated with childhood immunisation coverage in Nigeria and have they changed over time?</td><td rowspan="2">A separate analysis of DHS 2003, 2008 and 2013 and analysis of pooled datasets of all three DHS. Immunisation coverage overtime is quantified followed by stratified rural-urban analysis. Statistical methods used included descriptions, cross tabulations and chi-square test, univariate logistic regression and multilevel logistic regression</td></tr>
<tr><td>3</td><td>What is the difference in childhood immunisation coverage between urban and rural areas, and are the associations with child, household and community factors different in rural and urban areas?</td></tr>
<tr><td>4</td><td>In the urban setting, does childhood immunisation coverage vary between urban and slum dwellers and what factors are associated with it?</td><td>Analysis of pooled DHS 2003, 2008 and 2013 urban datasets, stratified into formal and informal urban settlements using UN-HABITAT guidelines. The analysis included descriptions, cross tabulations, chi-test, and multilevel logistic regression</td></tr>
<tr><td>5</td><td>What are the barriers and enabling factors in the uptake of childhood immunisation?
Do health workers practice and attitude affect childhood immunisation in Abuja?</td><td>Thematic analysis of the transcripts obtained from interviews of parents, health workers and community leaders on enablers and barriers to child immunisation in the slums, obtained with the use of semi-structured interview guides. In addition, a modified version of the Nigerian Routine Immunisation supportive supervisory checklist was used to assess immunisation sessions and conduct the inventory of immunisation equipment and consumables.</td></tr>
</table>

3.2 Quantitative Study

3.2.1 Demographic and Health Survey (DHS)

Demographic and Health Surveys (DHS) are nationally representative household-based studies conducted in low- and medium income countries, usually every five years, by the respective national population/statistics bodies with major technical and financial support from USAID (Tao *et al.*, 2013). DHS surveys are designed to produce reliable estimates for critical demographic, fertility and health indicators, representative at the national level, urban and rural areas, geopolitical zones (regions), and, in Nigeria, the 36 states and the Federal Capital Territory (FCT) (National Population Commission, 2000; National Population Commission, 2004; National Population Commission, 2009; National Population Commission, 2014). The DHS is known for the quality and relevance of collected information as a result of the survey's rigorous design, systematic data collecting process and standardised methods of data processing , hence, the current role of DHS as one of the primary sources of globally acceptable data on demographic, fertility and health in low- and middle-income countries (Cleland, 1996). Weighting, a crucial part of the complex DHS design was first used to correct for probable non-proportional sampling from different states, FCT, urban and rural areas and deployed to account for the expected differences in response rates during the survey, thus ensuring that the survey data is most representative of the population (National Population Commission, 2014). All Nigeria DHS oversampled from urban areas and some states to take into account smaller population size (Federal office of Statistics, 1992; National Population Commission, 2000; National Population Commission, 2004; National Population Commission, 2009; National Population Commission, 2014).

The NDHS samples are independently selected in a three-stage probability sampling process that aimed to reach the targeted number of households which was calculated based on Nigeria's population census results (National Population Commission, 2004; National Population Commission, 2009; National Population Commission, 2014). In stage one, communities called clusters were chosen from all communities in the 36 states and Federal Capital Territory of Nigeria, which have been stratified into urban and rural areas. These communities were selected independently from each stratum using proportional probability sampling. Each cluster has more than one segment known as enumeration area. In most clusters, one enumeration area was selected at random during the second stage. Before the commencement of the survey data collection period, the line listing of all households in the selected enumeration areas was carried out. In stage three, a fixed number of households were selected in urban and rural cluster enumeration areas through equal probability systematic sampling from the household line list developed in stage two.

The main objective of the DHS is to provide reliable information on fertility and fertility preferences, knowledge and use of family planning methods, maternal and child health including immunisation, childhood and adult mortality levels, knowledge of, and attitudes towards, HIV and other sexually transmitted infections (STIs), women's empowerment and domestic violence, and knowledge about other illnesses (National Population Commission, 2004; National Population Commission, 2009; National Population Commission, 2014). This information was obtained with the use of three questionnaires: 1. Household- This is filled first, with most information from the household head and line listed all household members and collected information on basic characteristics of those listed. 2. Women- collected comprehensive reproductive, demographic and health information on the woman and her children. 3. Men- Similar to the women questionnaire but not as expansive as it seeks limited reproductive history and no question on maternal and child health or nutrition (National Population Commission, 2004; National Population Commission, 2009; National Population Commission, 2014). In line with the national requirement, the Nigeria government and partners modified the questionnaire questions from model questions previously developed by DHS MEASURE (National Population Commission, 2004; National Population Commission, 2009; National Population Commission, 2014). During the survey, all women age 15-49 who are either usual members of the selected households or household guests present in these selected households on the night before the survey were eligible for individual interviews(National Population Commission, 2014). All men age 15-49 who are either usual members of the selected households or guest present in the household the night before the survey were interviewed in a third or half the selected households depending on the DHS year (National Population Commission, 2009; National Population Commission, 2014). Thus the female sample is more than the males as men are sampled in a third or half of the selected households.

Nigeria conducted DHS in 1990, 1999, 2003, 2008 and 2013, of which the NDHS 2003, 2008 and 2013 are the most comparable in terms of variables, regions and state, and are included in this PhD study. The female response rates were higher than the males in 2003, 2008 and 2013 NDHS that will be analysed. Also, in these NDHS, the households had higher response rates than female and male interviews because few of the eligible members of the line listed households could not be interviewed. Further information on the DHS protocol, questionnaires and methodology is available at https://www.dhsprogram.com/ . All DHS reports are available online on an open access basis, applications to obtain specific DHS datasets should include the study outline and analysis plan and be submitted to DHS MEASURE (https://www.dhsprogram.com/). The DHS datasets used in this PhD thesis were thus made available once DHS MEASURE approved my application, with DHS MEASURE providing a password to be used to access and download the Nigeria DHS data STATA files.

3.2.2 Nigeria DHS 2013

For the 2013 NDHS, 904 clusters of 372 urban and 532 rural areas were randomly selected, on the basis of the 2006 national census. Each cluster, termed the primary sampling unit, consisted of one or more enumeration areas from the 2006 general national census, which was the last census before the 2013 NDHS. The population numbers were thus projected from the 2006 general census, and the time lag may have affected the representativeness of the population included given the fast changing population structure in Nigeria. Approximately 45 households were selected from each cluster through equal probability systematic sampling based on the household listing of 40,320 households. From these selected households, 38,904 were occupied with 38,522 household interviews conducted (Table 3.2). Of the 39,902 eligible women aged 15 – 49 years seen, 97.6% were interviewed (National Population Commission, 2014). The response rate among the sampled males aged 15-49 was 2.4% lower than the female sample.

Table 3.2: Number of households, number of interviews, and response rates, by place of residence (unweighted), Nigeria 2013

Results	Residence		
	Urban	Rural	Total
Household			
Household selected	16, 695	23, 625	40, 320
Household occupied	16, 070	22, 834	38, 904
Households interviewed	15, 859	22, 663	38, 522
Household response rate	98.7%	99.3%	99.0%
Women			
Eligible women	15, 972	23, 930	39, 902
Eligible women interviewed	15, 545	23, 403	38, 948
Response rate	97.3%	97.8%	97.6%
Men			
Eligible men	7, 553	10, 676	18, 229
Eligible men interviewed	7, 144	10, 215	17, 359
Response rate	94.6%	95.7%	95.2%

3.2.3 Nigeria DHS 2008

Similarly, the 2008 NDHS sample was selected using a stratified two-stage cluster design, with an average of 41 households selected in each of 888 clusters, 286 clusters in urban areas and 602 clusters in rural areas. These clusters were derived from the enumeration areas used in the 2006 general census, and the population used was projected from the 2006 general census.A 98.3% household response rate was obtained with 33,385 women aged 15 – 49 years interviewed out of the total eligible women number of 34, 596 (Table 3.3) (National Population Commission, 2009). Only 92.6% of the 16,722 eligible men were interviewed.

Table 3.3: Number of households, number of interviews, and response rates, by place of residence (unweighted), Nigeria 2008

Results	Residence		
	Urban	Rural	Total
Household			
Household selected	11, 418	24,880	36, 298
Household occupied	10, 958	23,686	34, 644
Households interviewed	10, 724	23, 346	34, 070
Household response rate	97.9%	98.6%	98.3%
Women			
Eligible women	10, 868	23, 728	34, 596
Eligible women interviewed	10, 489	22, 896	33, 385
Response rate	96.5%	96.5%	96.5%
Men			
Eligible men	5, 597	11, 125	16, 722
Eligible men interviewed	5, 133	10, 353	15, 486
Response rate	91.7%	93.1%	92.6%

3.2.4 Nigeria DHS 2003

The 2003 NDHS sample was similarly selected using a stratified, two-stage cluster design. Nigeria was divided into 37 strata (36 states and FCT), each stratum was stratified further into rural and urban areas. The sample frame for the 2003 NDHS was the list of 212,080 enumeration areas (EAs) developed for the 1991 Population Census. A minimum of 50 households per cluster was required for a cluster; in case of fewer than 50 households, a contiguous EA was added. In Nigeria, a majority of the population reside in rural areas, so the number of clusters allocated to the urban areas in five out of the six zones was increased in order to obtain reasonable urban estimates (National Population Commission, 2004). A total of 365 clusters were selected, 165 in urban and 200 in rural areas. Of the 7,864 households selected, 7,327 were occupied with 7,225 household interviews conducted. A response rate of 95.4% was obtained for eligible women interviewed (Table 3.4) (National Population Commission, 2004).

Table 3.4: Number of households, number of interviews, and response rates, by place of residence (unweighted), Nigeria 2003

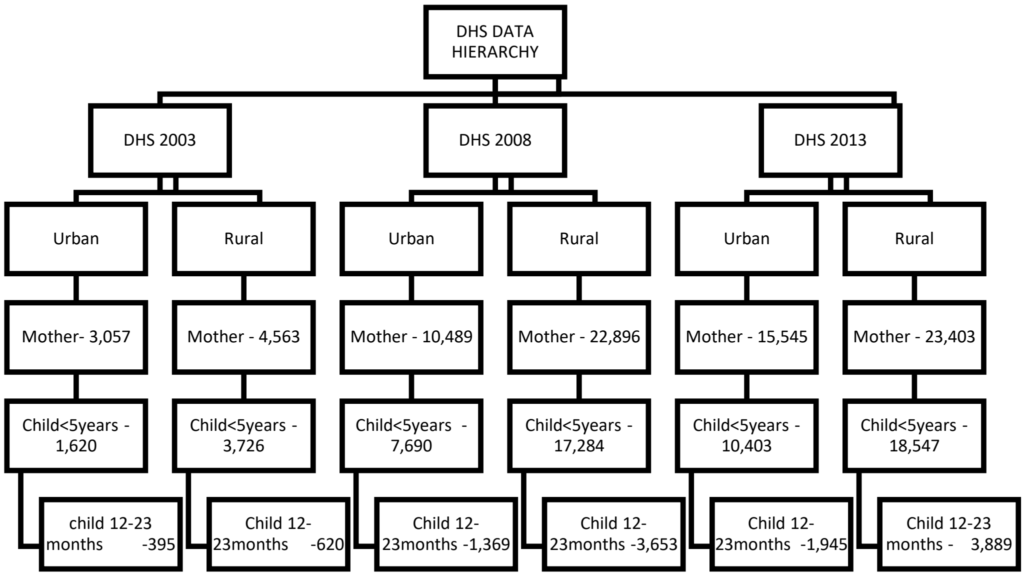
Results	Residence		
	Urban	Rural	Total
Household			
Household selected	3,163	4,701	7,864
Household occupied	2,979	4,348	7,327
Households interviewed	2,931	4,294	7,225
Household response rate	98.4%	98.8%	98.6%
Women			
Eligible women	3,181	4,804	7,985
Eligible women interviewed	3,057	4,563	7,620
Response rate	96.1%	95.0%	95.4%
Men			
Eligible men	1,073	1,499	2,572
Eligible men interviewed	986	1,360	2,346
Response rate	91.9%	90.7%	91.2%

3.2.5 Nigeria Demographic and Health Survey Data

In all three NDHS, childhood immunisation information was collected from the child's immunisation card if available, or from the mother's recall of the immunisation uptake on children aged 0-5 years. The information included the type of vaccine received and age at which the child received them. For the child without an immunisation card, the mother reported based on her understanding of the vaccine and its site of administration. The limitation of the mother's report is the likelihood of recall bias, especially given that children would be aged 0-5 years at the time of the survey.

The information required on immunisation were similar in the three NDHS (2003, 2008 and 2013). The NDHS data collection was hierarchical from the cluster, household/mothers and child. As described in Figure 3.1, more mothers were sampled in the rural than urban areas. Similarly, information was provided on more children from the rural than urban areas; the quantitative analyses on immunisation coverage relate to reports on children aged between 12 and 23 months, who are those who should have received the routine infant immunisations within their first year of life.

Figure 3.1: Hierarchy of Nigeria Demographic and Health Survey data[3] .



3.2.6 Dependent variable

Children are expected to have received all doses of the six basic recommended childhood vaccines, namely BCG, HBV, OPV 1, 2, 3, DPT 1, 2,3 and measles within the first year of life as captured in Table 2.3. The outcome for each vaccine is binary being either a “yes” if received or “no” if not received. The immunisation status can be for the receipt of all the recommended vaccines (Fully Immunised), one vaccine (Individual Vaccine), at least one vaccine not received (Partially Immunised) and no vaccine received (non-/un-immunised). Current levels of all the different immunisation status were calculated in Chapter 4. A brief analysis of the individual vaccine, partially immunised and unimmunised child status was conducted to understand where the gaps are, as it may help in developing appropriate interventions.

Most of the subsequent analyses focused on fully immunised child (FIC) coverage, the main dependent variable for the PhD study, which is the percentage of children aged 12-23 months

[3] Data was retrieved from 2003, 2008 and 2013 NDHS reports.

who had received all doses of the routine vaccines out of all children aged 12-23 months. The outcome was 'yes' If the child received all recommended vaccines in all doses (fully immunised) or 'no' when the child missed one or more of the vaccines. The choice of the FIC as the dependent variable was because it incorporated all the basic vaccines, as such provided a broader view of the child's immunisation status. The FIC coverage was calculated from the NDHS data which had the number of children aged 12-23 months who received each of the recommended childhood vaccines out of all the children aged 12-23 months sampled in the NDHS. Thereafter, the FIC coverage was computed as the percentage of these children who received all the basic vaccines.

3.2.7 Independent variables

The selection of the included explanatory variables from the available ones in the NDHS was based on their relevance in answering the research questions in line with the conceptual framework (Chapter 2). As such they are grouped into the child, household and community levels as shown in Table 3.5. The choice of independent variables in Chapter 4 was based on the findings of the review of the literature, while for Chapters 5 and 6, their availability in all the three DHS datasets was an additional inclusion criterion.

Table 3.5: Independent variables from NDHS source

INDEPENDENT VARIABLES		
Child level	Maternal/household	Community
Place of birth Sex Birth order/rank	Antenatal care attendance Maternal education level Maternal religion Maternal ethnic group Maternal marital status Maternal employment status Maternal age at child's birth Attitude of health workers – maternal view Media exposure Spender of mothers income Household wealth Sex of household head	Place of residence – rural/urban, urban formal/informal Region Maternal getting medical help: distance from health facility

The categories of some of the chosen variables were recoded; in a few cases two or more variables from the NDHS datasets were used to develop the desired independent variable and in others, the components used in deriving the variable was recalculated to make it more location appropriate. Variables such as child sex, maternal education level and rural/urban place of residence were used as captured in the NDHS without modifying the variable categories. Some NDHS variables like the place of birth, birth order, maternal ethnic group and employment status with several categories had the categories reduced by merging similar categories with few observations to avoid situations of very wide confidence intervals with limited cell sample size. The NDHS variables, access to television, access to radio and access to newspaper were combined and became the media exposure variable. The DHS household wealth variable was recalculated separately for urban and rural areas with the use of principal component analysis (Kolenikov and Angeles, 2009). During the variable modification process, missing data and don't know categories with fewer than 50 observations were incorporated in a group that was least likely to be reported on, except for maternal attendance of antenatal care that the number of don't know response and missing were far above the 50 observation cut off.

Child level factors

The initial child order variable had more than ten categories, this was recoded accordingly into four categories: first, second and third, fourth and fifth, and sixth or more. Female and male were the categories in the child sex variable. The child's place of delivery was recoded to either home or health facility; delivery in the health facility related to deliveries in private and public owned health establishment while home delivery included children whose birth took place in the house, other locations apart from home and health facility and missing data. The maternal antenatal care attendance variable was grouped into No, Yes and Don't know/Missing.

Household level factors

Household factors included maternal education level (no education/primary/secondary/higher) and sex of household head (female/male) are as categorised in the NDHS, while religion (Christianity/Islam/traditionalist and others), maternal employment status (no/yes), maternal age at the child's birth (14-19/20-29/30-39/40-49), maternal marital status (never married/married/no longer married), Decision maker on maternal income (mother alone/mother and spouse/spouse alone/no income mother), Media exposure (no/yes) and urban/rural-specific Household wealth (poor/middle/rich) were recoded.

Maternal age at the index child's birth was built from two variables (child's age and mother's age at the time of survey) in the NDHS by subtracting the child's age from the mother's age.

As noted earlier in this section3.2.7, the media exposure household level variable combined three individual media exposure variables that were captured in the NDHS.

The NDHS Household wealth was developed with principal component analysis by measurement of the possession of household assets like cow, bull, car, television, refrigerator, and housing materials/facilities such water supply, material of roof/walls/floors, toilet type, and has been found to be a good proxy for household wealth (Filmer and Pritchett, 1999; Filmer and Pritchett, 2001). This NDHS derivation of household wealth did not take cognisance of assets that the urban rich must possess, which may not be useful to the rich rural dweller. Hence the decision to recalculate the wealth variable separately for urban and rural households. Also, the wealth variable was grouped into three categories: Poor, Middle and Rich, which is the wealth grouping that policy makers and programme managers who are expected to make use of the findings of this study are used to.

Community level factors

Community level factors included: Place of residence with two categories, urban and rural as provided in the NDHS, while disaggregation of urban area into formal and informal (Slum) households was guided by the UN-HABITAT guidelines (UN HABITAT, 2010). In Chapter 6, the comprehensive process of the urban disaggregation is explained.

The regions are defined by Northcentral, Northeast, Northwest, Southeast, Southsouth and Southwest. For the variable on distance to the nearest health facility to seek care, categories used in the 2003 NDHS were: no problem, small problem and big problem, while in the 2008 and 2013 NDHS this variable was grouped as big problem and not a big problem; therefore for the 2003 DHS the data were recoded into big problem and no/not a big problem. In addition, in Chapter 5, interaction terms were developed as appropriate to understand variables that may increase or reduce the influence of the child's place of residence.

3.2.8 Quantitative data analysis

The choice of the type of statistical methods for the analysis of the NDHS data was made in line with the conceptual framework, research questions and the hierarchical nature of the DHS datasets. Descriptions, bivariate analysis with the chi-square test, simple regression and multilevel logistic regression models were the statistical methods employed. For ease of understanding and clarity, the in-depth explanation of certain statistical methods are presented in the appropriate result chapter. This section is a general introduction to the quantitative analytical process of the PhD study.

The NDHS datasets sample weights which ensured that it represented the country and controlled for non-response was used in most analyses. All data analysis was done with the STATA statistical Software for Windows version Stata/SE v14 College Station,Texas, USA (StataCorp, 2015).

Preliminary Analysis

A descriptive analysis presents numbers, frequency and percentages of the independent variables, and association with the dependent variable, showing the sample size, the different categories of each sociodemographic characteristics with the category number and as the percentage of the sociodemographic variable and their immunisation status expressed in percentages. In Chapter 4, the DPT drop out rate (DOR) was used to indirectly assess the health system performance, with the WHO guidelines stating that a DOR of more than 10% is suggestive of the health system being a barrier to immunisation access (World Health Organization and UNICEF, 2002; Nwokeukwu *et al.*, 2015). The DPT drop-out rate that is the most commonly used, as it combines three immunisation sessions and three pathogens, is calculated by subtracting the DTP3 number (or percentage coverage) from the DTP1 number (or percentage coverage) divided by the DPT1 number (or percentage coverage) all multiplied by 100% [(DPT1- DPT3)/DPT1 x 100] (Nwokeukwu *et al.*, 2015).

The chi-square test was used to test if the difference in the immunisation coverage between the categories of the sociodemographic variable was statistically significant at 95% confidence interval. Only independent variables that showed significant association with the dependent variable in the chi-square test analysis were introduced into the regression models.

Logistic regression

The dependent variable, FIC was dichotomous, with a “Yes” or “No” outcome, hence the choice of the logistic regression, which fits a model showing the likelihood of the child being fully immunised. The logistic regression was used to investigate the strength of the relationship between the dependent variable and one (simple) or more (multivariable) independent variable(s). The estimated effects were fixed and random. The measures of fixed effect were expressed in this study as the odds ratio, 95% confidence interval and the associated p-value. Variance and Intraclass correlation showed the extent of the random effects. The odds ratio compared the odds of being fully immunised of a category with another category (reference) of the same sociodemographic variable and can range from 0 (zero) to infinity. An odds ratio of one indicated that both likelihoods of full immunisation are the same, the odds ratio of more than one indicated that that children in the category had higher full immunisation likelihood than the reference category. An odds ratio of less than one showed that the category reduced the likelihood of being fully immunised compared to the reference category. And the p-value that expressed the significance of the association between the dependent variable and each independent variable was separately examined with the simple logistic regression model (Bagley *et al.*, 2001), showing whether FIC coverage was significantly likely to be increased or reduced with the presence of that sociodemographic variable. The quantified association was expressed as an odds ratio. Simple regression analysis on each NDHS datasets (Chapter 4 and 5) and the pooled NDHS dataset (Chapter 5 and 6) found variations in the unadjusted relationship between FIC coverage and relevant sociodemographic variables.

After identifying variables that were individually associated with FIC status, multivariable logistic regression analysis was carried out, to quantify the independent association between selected variables and FIC coverage in the presence of other key factors (Kawamoto *et al.*, 2005). Three-level multilevel logistic regression models, a type of multivariable logistic regression that accounts for the hierarchical collection of data (Merlo *et al.*, 2005) such as in the NDHS, where children (level 1), nested within households (level 2), who were then nested within communities (level 3) was used. The choice of multilevel models for the investigation of the association of FIC with sociodemographic variables using NDHS datasets was made as the regular logistic regression has the assumption of independent observation. The NDHS design of cluster sampling, where villages or towns are used in the sampling process may lead to lack of independence of the independent variables as unobservable or unrecorded characteristics such as culture and tradition can be influential (Kazembe *et al.*, 2007). Overestimation of the significance of some variables and underestimation of the standard errors can be the consequence of analysing survey data without making provision for the survey design (Van Duijn *et al.*, 1999). Further explanations on the procedure for fitting the multilevel models are discussed in Chapters 4, 5 and 6. The analyses were done with STATA 14 (StataCorp, 2015).

Variables that were not statistically significantly associated with the outcome of being fully immunised at 95% significant level in the preliminary analysis or which displayed multicollinearity using the variance inflation factor (VIF) were not included in order to achieve a good fit for the regression models. Also, in the analysis of pooled data, relevant NDHS variables that were absent in at least one NDHS were dropped.

The fixed effect part of the model measured the association between the dependent and independent variables as odds ratios with 95% confidence interval. Interaction terms were used to assess the relationship between two independent variables as they influence the dependent variable. These variables, maternal education level, household wealth, Maternal ANC attendance, place of child delivery and mothers birth age had significant influence on childhood immunisation. As such in Chapter 5, the interaction between the place of residence and each of these variables was tested to determine if the influence of place of residence on childhood immunisation was reduced or increased by these variables.

The random effects (measures of variation) used were variance and intraclass correlation (ICC). The ICC measures the variability of the fixed effect (odds ratio) that was due to difference within the level, community or household.

The goodness of fit was assessed with the Akaike Information Criterion (AIC), which provides an estimate of the predictive accuracy of study hypothesis, which is the performance of the Model after the addition of new data (Forster, 2002; Sober, 2002).

3.2.9 Ethical consideration

This study conducted secondary analysis of anonymised data previously collected for the Demographic and Health Surveys conducted in Nigeria in 2003, 2008 and 2013 by the Monitoring and Evaluation to Assess and Use Results Demographic and Health Surveys (MEASURE DHS) project (www.measuredhs.com), in conjunction with the National Population Commission of Nigeria. The surveys were carried out in line with the best ethical practice with two ethical review approvals: 1. Institutional Review Board of Macro International in Calverton in the United States of America and 2. National Ethical Review Committees in Nigeria. During the NDHS, information was collected confidentially after written informed consent for participation had been obtained from all the participants. Access to and approval for the use of the NDHS dataset was given by DHS MEASURE following an application by the PhD candidate. In addition, the Ethics Committee of the Faculty of Medicine, University of Southampton through ERGO (Ethics Review and Governance Online) system approved the PhD research design.

3.3 Qualitative study

The views of the parents, community leaders and health workers on childhood immunisation challenges and enabling factors in two informal (slum) setting located in Abuja of the Federal Capital Territory (FCT) in Nigeria were explored in a qualitative study. After obtaining ethical approval from the two relevant institutions, this qualitative study involved the collection of qualitative information in two informal urban settlements in Abuja, FCT. These slums (names withheld to protect the anonymity of the participants) were chosen because they had specific immunisation system challenges identified by the FCT Primary Health Care Board(only these two settlements have had this issue since 2005 in Abuja). Data were collected via interviews with twenty parents, two community leaders and two immunisation service providers, service provision observation and inventory taking after obtaining written informed consent. All interviews were audio recorded. Further details are provided in Chapter 7.

3.3.1 Geographical setting

The Federal Capital Territory of Nigeria is made up of Abuja, Nigeria's capital city and satellite towns. The Federal Capital Territory of Nigeria was established in 1976 to replace the then capital, Lagos, which was congested, had limited land space, was dominated by a particular ethnic group, and prone to flooding. The territory was made up of land carved out of four States (Kaduna, Kwara, Niger and Plateau). The seat of the Nigerian government moved to FCT in December 1991. The FCT is centrally located in Nigeria and covers about 8000 square kilometres. During the last general population census in March 2006, the FCT had a population of 1,405,201 with an annual growth rate of 9.3%, almost triple the national rate of 3.2% (National Population Commission, 2007). The FCT is divided into six Area councils (Abaji, Abuja Municipal, Bwari, Gwagwalada, Kuje and Kwali) which are further divided into 62 political wards.

The Abuja Municipal Area Council (AMAC) including Abuja, had 58% of the FCT population in the 2006 census. AMAC has 12 political wards. Abuja was planned to be developed in four phases with 68 districts and housing 3.2 million people spread across a 250 square kilometres area (Abubakar, 2014). The native settlements within this 250 square kilometres were to be relocated. Abuja phase 1 with 5 districts was to house 140,000 people, phase 2 with 15 districts will be home to 500,000, the 19 districts of phase 3 would have 1 million residents and 1.6 million inhabitants will live in the 29 districts of phase 4. As at 2013/2014, Abuja had a population of 3 million with day time population reaching 7 million with phase 1 fully developed, 5 of the 15 districts of phase 2 fully developed, 2 of the 19 phase 3 districts developed and none of phase 4 districts developed (Abubakar, 2014)

3.3.2 Study Community

Slums are pre-existing native (Gbagyi tribes) settlements within the 250 square kilometres Abuja landmass that was planned to be cleared of all previous communities. The settlements have expanded several folds over the original size. The communities lack drainage, tarred roads, planned layout, and proper waste disposal. The inability of the government to compensate the native inhabitants has delayed the planned demolition of the settlements to pave the way for modern development. However, the government has restricted further development of the slum beyond boundaries agreed with the communities. Most inhabitants of these slums are migrants from other parts of Nigeria, who have been drawn to the opportunities available in Abuja, Nigeria's capital city. To ensure anonymity, the sampled slums are referred to as Slum A and Slum B.

Further expansion of Slum A has been halted by the planned development of the surrounding district. It is located in Gwarinpa ward of AMAC, in the western part of Abuja, and about 5 kilometres from the city centre. The slum has almost been encircled by the planned nearby district. The government infrastructure in the slum include a primary school, primary health care centre and electricity power supply.

One of the largest Abuja slums, Slum B is located about 15 kilometres from Abuja City centre (Phase 1 districts), along the ten lane express road leading to the only airport in Abuja. It is located in the Kabusa political ward of AMAC, which is in the southern part of Abuja.

3.3.3 Study Participants

The summary of the number and make up of study participants, and sampling method are described in Table 3.6. Twenty participants were interviewed, made up of ten mothers/fathers of fully immunised and ten of non-fully immunised children in two health facilities serving urban slums. In each facility, ten participants were interviewed with five from each group. The term participant represents either the mother alone, father alone or both parents of a child (or children) aged nine months to less than two years. This age group was selected for these reasons: 1) Fully immunised child coverage can only be determined after nine months of age as the last routine child vaccine, Measles is recommended to be administered at nine months of age.,2) It will represent more recent immunisation attitude of parents and reduce recall bias, 3) Comparable to the NDHS sampling of children aged 12-23 months. The fully immunised group participants were selected from parents who brought their children to immunisation clinics to be administered the measles vaccine and who had received all earlier immunisations; the other group were parents whose children attended the paediatric out-patient clinic and had missed at least one of the recommended immunisation. The child's Road to Health card/Immunisation card/hospital record was used to select participants for the groups. A purposive sampling technique enabled the collection of information from different socio-demographic groups in line with the quantitative data analysis findings. The duration of each interview was between 25 and 40 minutes.

In each of the locations, an in-depth interview with one community leader explored their understanding of the enabling factors and challenges facing the availability and utilisation of childhood immunisation services in their locality.

The Health Facility Assessment conducted in the Health facility serving the selected location consisted of observation of an immunisation service provision session, interview of the immunisation provision health worker and inventory taking of immunisation equipment and consumables.

Table 3.6: Summary of Qualitative study sample size, participants and sampling method

Activity/ number of activity	Sampling Method	Participant(s)/number of participants
Immunisation service provider interview/ 2	Purposive	2
Parent interview/ 20	Purposive	Parents/ minimum of 20
Slum community leader interview/ 2	Purposive	Community leader/ 2

Sample size determination in qualitative study have no set rules and specific formula for its calculation (Patton, 2002). The principle of saturation, in which collection of more data does not yield new information to understand the subject being studied was suggested as the guide for qualitative sample size determination(Glaser and Strauss, 1971). Twenty parents (mother alone, father alone or father and mother pair) was deemed adequate to explore the parents' view of barriers and enablers of childhood immunisation, since the interview guide was well designed from findings of the reviewed literature and quantitative analysis of NDHS data. Half of these parents were full child immunisation compliant and the others were not. Two community leaders, one from each slum community were interviewed, and one immunisation service provider from each facility.

3.3.4 Qualitative study process

My employer, the FCT Primary Health Care Board (FCT PHCB): the statutory body charged with the provision of Primary Health Care services in the FCT who are supportive of the study, were briefed on arrival to commence the study. Thereafter a selection process was conducted for the selection of a staff from FCT Primary Health Care Board as the research assistant.

Prior to the trip, letters had been sent to the two selected health facilities heads and two community leaders, who as gatekeepers were needed to secure access to the participants.

Despite securing prior consent from these gatekeepers, in the company of the research assistant, the PhD candidate visited them and jointly agreed on the schedule for the participants' interviews before the commencement of the qualitative data collection.

The immunisation clinic and paediatric outpatient sessions are run in a similar way, with parents/caregivers required to have their children in the clinic at or before 9 am, when service provision commences with a health talk by the health worker. Only emergency cases are exempted. During this study, as part of the health talk, one of the facility health workers introduced the study and invited the researcher, who explained the reason for the study, interview process, protection of participants' rights measure in place, and benefits of the possible research findings. The participants were assured there would be no negative consequence if they declined to participate, or withdrew their consent during the interview or refused to answer some questions. Thereafter, the information sheet (Appendix 2A) was given to potential participants (parent), before the child was immunised or received treatment. After the child had been treated or immunised, the research assistant purposively selected the sample from amongst the parents who agreed to participate and signed the informed consent form (Appendix 3A). The research assistant confidential screening was done by going through the child's road-to-health card/ immunisation card/hospital records and/or asking the parents the child immunisation status to determine the child's immunisation group and age, which was electronically done without any hard copy. The response to the screening questions confirmed the child's immunisation status and provided key sociodemographic information. In the immunisation clinic only parents whose children had been fully immunised were selected, while in the paediatric outpatient clinic, parents of the not-fully or unimmunised children were selected. Failure to participate or withdrawal of consent during the interview or refusal to answer some questions did not affect the child's right to further vaccinations or treatment. In addition, the parent with a partially or unimmunised child who after the interview wanted the child to be immunised was linked to the immunisation clinic, and had the child immunised at the next immunisation service provision date. Mothers aged less than 18 years old not accompanied by a spouse, or with a spouse less than 18 years, and parents of very ill children (emergency) were excluded.

A community leader and the most senior immunisation service provider in each slum were interviewed after they read the community leader's information sheet (Appendix 2C) and Immunisation service providers information sheet (Appendix 2B), and signed the community leader's informed consent form (Appendix 3C) and Immunisation service providers consent form (Appendix 3B) respectively.

All the interviews were done in comfortable and private rooms in the clinics. The audio recording of all the interviews were of high quality. Though informed consent that covered audiotaping had been collected, the PhD candidate secured verbal permission before commencement. All interviews were conducted by the PhD candidate. The research assistant was involved in only the screening and selection of the twenty parent participants.

The plan to ensure gender balance among the participants was not realised, as the 24 participants were made up of 22 females (20 mothers and 2 health workers) and 2 males (2 community leaders). During the study, only mothers came to the immunisation clinic, while the few men who were seen in the paediatric clinic were parents of very sick children. Also, all the immunisation service providers were female while the community leaders were males. During the recruitment process, the participants were not promised any reward for participation, but lunch was provided for all participants at the completion of the interviews.

3.3.5 Qualitative Data

Data collection tools used were separate informed consent forms, interview guides (Appendices 4A, 4B and 4C) and participant information sheet for parents, community leaders and health workers, and health assessment tool (Appendix 5). Data were collected with the use of interviews and health facility assessment tool that covered the child, household, community and health system levels. The choice of interview was due to the need to protect the participants as sensitive information was sought for. The semi-structured interview guide for each category of participant, parent (Appendix 4A), Immunisation service provider (4B) and Community leader (Appendix 4C) was developed in line with findings from reviewed literature and result of the study's quantitative analysis. The non-participant observation of immunisation service provision was done with the health assessment tool that was an abridged version of the 2008 Nigerian routine immunisation supervisory checklist.

In regards to the Data collection plan, the community leaders preferred to be interviewed in the health facility rather than their homes, to avoid interruptions and provide the opportunity to give undivided attention during the interview. The data collection was held between January 24 and April 23, 2017. The first week was for briefing/training of the FCT Primary Health Care Board officers, visit to the gatekeepers (community leaders and head of the health facilities), recruitment of research assistant and preparation for the study. All the interviews were conducted in secure and comfortable rooms within the health facilities.

Data was of the highest quality at all stages of the qualitative study. As the data tools were used for the first time without pre-testing, the PhD candidate ensured that the semi-structured questions were appropriate and responses to them would provide adequate information to answer the research questions. As part of the selection process of the research assistant, mock interviews and role plays at the child and household levels (mother), community (Community leader) and health system (immunisation service provider) were conducted in English language and pidgin English. Though the respondents were employees of the FCT Primary Health Care Board, they had similar sociodemographic and experience as the study participants. This pre-field activity improved the quality of the interviews by the clarity of the questions, consistency and timing, with no risk of contamination as the study questions could not be leaked to the study population. In addition, the decision to have the interviews transcribed on an ongoing basis provided the avenue to follow up on newly emerged themes such as the parent's desire to have a reliable communication channel with the health workers, in subsequent interviews. Also, efforts were put in to ensure that the participants' views were solely investigated without being biased by the PhD's candidate's views and beliefs. This led to the collection of quality and objective data (Creswell *et al.*, 2007; Creswell, 2009).

The PhD candidate conducted and transcribed all the interviews, which ensured quality and consistency. The simultaneous transcription process provided evidence of saturation before the target sample size was reached.

3.3.6 Response rate

The 20 parent (mother, father or both mother and father) sample size for data collection at the child and household levels was achieved. Despite the inability to interview a male parent, about 400 mothers agreed to participate in the study, from this pool the 20 mothers were purposively selected. The most senior immunisation provider and the leading community leader were interviewed in both slums. The reason for the met interview targets may be due to the early interaction with the community and health facility gate keepers, availability of unabridged information on the study, good inter personal communication skills of the research team and joint planning of the data collection schedule with the communities and health facilities. All participants completed the interviews and answered all questions.

3.3.7 Research Ethics

Two ethical approvals were obtained for the study. The University of Southampton Faculty of Medicine Ethics Committee approved the ethics application (Ethics ID: 23986) submitted through the Ethics and Research Governance Online portal (Appendix 7). Another approval was received from the Federal Capital Territory Health Research Ethics Committee after the submission and defence of the study plans, objectives, ethics application and expected outcomes (Appendix 6)

3.3.8 Informed Consent

Voluntary informed consent was obtained. First, a verbal explanation of the study's aim, interview process and protection of participants' rights such as the right to decline participation, opt out after initial acceptance to participate and refusal to answer some questions if they wish, then a written information sheet (Appendix 1) was made available. The information sheet had the study aims, study methods including participants' selection, non harmful nature of the study, participants rights, ethics approval, study benefits, right to ask questions and feedback process that was independent of the researcher (phone number and e-mail contacts of the main supervisor). Thereafter, the participant who voluntarily accepted to participate signed the informed consent form which was in English (Appendix 2). For the non-literate and visually impaired participants, the information sheet was read out very slowly in order to ensure that they understood the study and their role if they chose to participate. A health worker working in the health facility who was not connected to the research attested to the fact that the researcher read out all the information contained in the information sheet and explained the content of the informed consent form thoroughly. This health worker called a literate independent witness sat in during the recruitment process until the signing/attestation of the consent, which the literate independent witness also signed. A thumb print was accepted as the signature for this category of participants. After signing, the informed consent forms were locked up in a briefcase which only the PhD candidate had access to.

The same process was followed for the health workers and community leaders, verbal explanation of the study and participants right, followed by the reading of the information sheet and the signing of the informed consent form.

Even though the information sheet stated that all interviews will be audiotaped, verbal permission was obtained from the participants to be audiotaped before the interview commenced.

3.3.9 Confidentiality/Anonymity

During the recruitment process, all potential participants were informed of measures put in place to keep their responses confidential and anonymous. The data obtained had the participant, health facility and community identity removed. The communities' choice for the study was due to an immunisation challenge that occurred in only these communities of the Abuja Municipal Area Council since 2005.

Only the researcher and participant were present in the interview which was held in a convenient room. Privacy, anonymity and confidentiality were strictly maintained not only during the interviews but in all other aspects of the study such as securing audiotapes before completing transcription. All transcription was done by the researcher, stored in a password protected laptop whose password was known by only the researcher. The destruction of audiotapes was carried out after transcription and analysis were completed.

Paper records were minimal and kept locked up when not in use. Only the informed consent form had the participant's name which was linked to the interview by a code (linked anonymity). Immediately after the analysis, paper records were scanned and the papers destroyed. The papers were shredded, then placed in the internal paper recycling bins available in the university. On submission of the final thesis, all electronic records will be retained and stored securely in the University of Southampton's repository for 15 years in line with the Faculty of Medicine's research conduct guidelines.

3.3.10 Qualitative data analysis

The thematic analysis develops themes by identifying relevant patterns in the data and utilise these themes in understanding the research questions (Braun *et al.*, 2014). Thematic analysis was carried out with the use of the Nvivo 11 software, a computer assisted qualitative data software (QSR International Pty Ltd, 2015) and manual interpretation and understanding of the identified themes. The analysis was mixed, based on deductive themes from the literature review and inductive themes that emerged from the interviews. The key mistake of thematic analysis of the adaptation of the interview questions as themes (Braun and Clarke, 2013) was avoided by the strict adherence to the Braun & Clarke's (2006) 6-step framework of thematic analysis, described in Table 3.7 (Braun and Clarke, 2006).

Table 3.7: Braun & Clarke's six-phase framework for doing a thematic analysis

S/N	Braun & Clarke's Steps	Analysis
1	Step 1: Become familiar with the data	Manual
2	Step 2: Generate initial codes	Nvivo
3	Step 3: Search for themes	Nvivo
4	Step 4: Review themes	Nvivo
5	Step 5: Define themes	Nvivo
6	Step 6: Write-up	Manual

Step 1: Become familiar with the data- The entire transcript was read several times as this made the PhD candidate very familiar with the qualitative data. During this process, mental notes were taken and preliminary impressions formed.

Step 2: Generate initial codes- The transcript is loaded into the Nvivo software. The data was organised into much smaller meaningful segments called codes, in this step. The first systematic identification was based on the theoretic basis from the literature review and quantitative analysis. As the coding process was reviewed, new codes (emerging) were identified and in a few cases, the initial codes were modified.

Step 3: Search for themes- The codes were organised along subjects that are related to the research question. In most cases, several codes were related to a specific aspect of the research objective, called themes. But in a few cases, codes fitted one or more themes

Step 4: Review themes- The initial themes developed in Step 3 were modified, reviewed and refined. The themes became more distinct and objective. The codes organised the themes was studied to confirm if the data supported the theme. Also, the search continued for the development of new themes.

Step 5: Define themes- The last review of the themes were undertaken. The patterns the theme represented were fully identified, with the relationship with other themes and sub themes understood.

Step 6: Write-up- The findings and what the result meant are reported in Chapter 7.

3.3.11 Qualitative Study Limitations

The study design took cognisance of the challenges of funds and time available to complete the study process that included travel to Nigeria, recruitment, interviews, transcription, translation, analysis and write up. Repeated assurance of confidentiality and how the information provided would be used to improve immunisation programme during the interviews was done to reduce the risk of courtesy bias, where the participants especially the mothers may provide information on the positive and not the negative aspects of the immunisation programme. A further limitation relates to the PhD candidate being the only person who transcribed and coded the material, given that normally in qualitative research there are two independent coders/transcribers. However, given the PhD's candidate knowledge of the health care and childhood immunisation system, the local language, and the nature of the interviews it is unlikely that this would have substantially impaired the interpretation of the findings. Though there should be a cautious generalisation of findings as a result of the study limitations and sample size, the study design and implementation were of the highest quality. The study aim to explore the views of parents, health workers and community leaders on childhood immunisation was achieved.

Chapter 4 Level of childhood immunisation and associated factors, Nigeria 2013 DHS

4.1 Introduction

Using the most recent, 2013, Nigeria Demographic and Health Survey (NDHS), national childhood immunisation coverage was estimated, the association between child-, household- and community-related factors with childhood immunisation coverage quantified, and childhood immunisation drop-out rates calculated. In the NDHS, mothers are interviewed relating to their children delivered in the five years preceding the interview; immunisation coverage relates to children between the ages of 12 and 23 months, who should have received all infant routine immunisation, and the data used in these analyses are from the 2013 NDHS, thus relates to children born between 2011-2012 (National Population Commission, 2014). Analyses provide answers to the research questions relating to the first PhD objective, to estimate the current childhood immunisation coverage in Nigeria.

All analyses in this chapter are in line with the conceptual framework, which identified four levels (child, household, community and health system) of variables that may be associated with child immunisation coverage (as presented in Chapter 2). The role of three (child, household and community) of these four levels were directly examined and quantified, while the fourth level, health system, was indirectly explored in this chapter by quantifying immunisation drop-out rates.

First, coverage of all basic routine childhood vaccines (Bacillus Calmette–Guérin, Oral Polio Vaccine, Diphtheria-Pertussis –Tetanus, Measles) as derived from the 2013 NDHS is presented. The Bacillus Calmette–Guérin (BCG) and Measles are single dose vaccines, Oral Polio Vaccine (OPV) and Diphtheria-Pertussis –Tetanus (DPT) are given thrice. BCG is given at birth, OPV and DPT are given at 6, 10 and 14 weeks of age and the administration of the Measles vaccine at 9 months completes the immunisation schedule for the basic vaccines (Federal Ministry of Health and National Primary Health Care Development Agency, 2013). The coverage of the third DPT immunisation at 14 weeks (DPT3) is taken to indicate short-term engagement with the health system; fully child immunisation coverage (FIC) relates to the administration of all vaccines as per schedule (Kazungu and Adetifa, 2017). After the quantification of basic vaccines coverage, the bivariate analysis that used cross-tabulations and chi-test to assess the relationship between three dependent variables (BCG, DPT3 and FIC) with independent variables was conducted. The initial selection of independent variables was guided by the reviewed literature and field experience of the PhD candidate. Due to the similarities of the three dependent variables, only the FIC was taken forward into univariable and multilevel regression analyses; independent variables found to be significant at the 95% confidence level in bivariate analyses were included. Multilevel logistic model regression accounts for the hierarchical structure of the NDHS data (children nested within women, women within households and households within communities).

In Chapter 3, Methods, the definition of the independent variables included in the analyses was presented. Child level factors included birth order, sex, antenatal attendance by mother and place of delivery, household factors were maternal level of education, sex of household head, religion, mother employment status, maternal age at the child's birth, marital status, ethnicity, decision-maker on spending of mother's income, attitude of health staff, media exposure and household wealth. Place of residence, region and distance to the health facility were defined as variables denoting community factors.

In the second part of the Chapter, and because of the lack of immunisation specific health system data in the NDHS, DPT drop-out rates were calculated from DPT1 and DPT3 immunisation coverage to provide an indirect assessment of the performance of the health system (Kazungu and Adetifa, 2017).

4.2 Childhood immunisation uptake in Nigeria

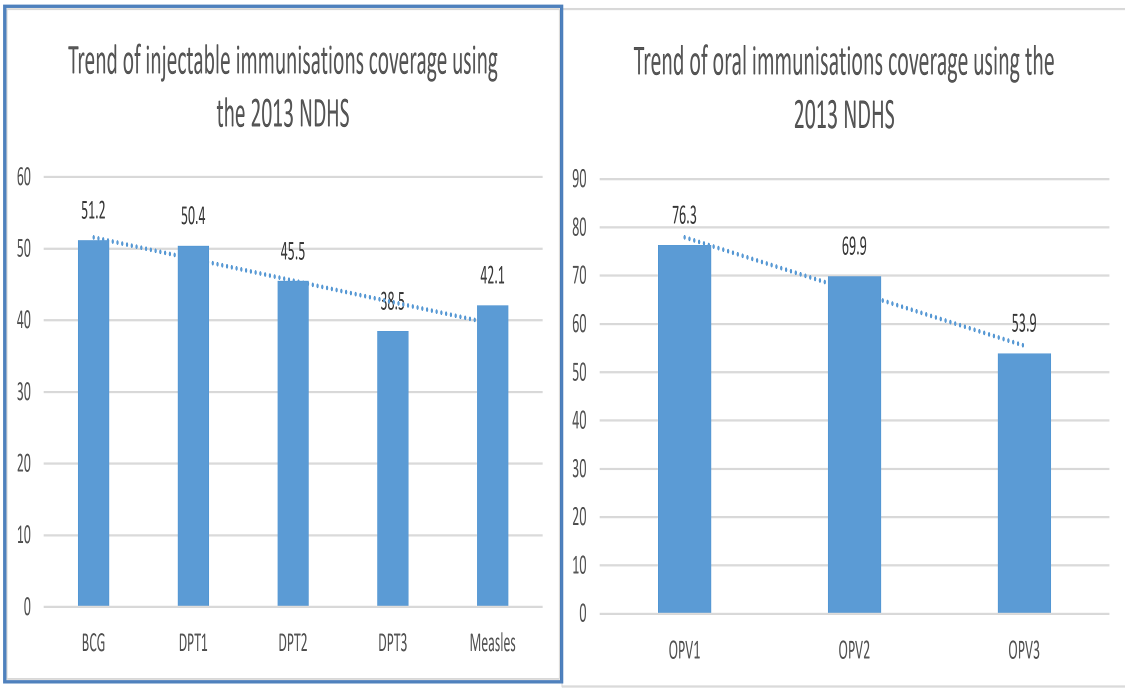
The utilisation of immunisation services differed by each vaccine as shown in Table 4.1, which reports immunisation coverage as the percentage of receipt of a specific immunisation among children aged 12-23 months using the 2013 NDHS weighted data. Immunisation given at birth or soon after had higher coverage than those administered later; oral vaccine (OPV) coverage was higher than that of injectable vaccines (DPT) even though the oral and injectable vaccines should be administered during the same visit. The coverage of the first dose of oral Polio vaccine and injectable DPT vaccine scheduled to be administered at 6 weeks was 50.4 and 76.3% respectively; coverage of the third dose of oral polio vaccine was 53.9% and DPT3 was 38.5%. The national stock outs of DPT immunisation in 2012 and reluctance of health workers to reconstitute injectable immunisation until an adequate number of children are available may explain this finding (FCT Primary Health Care Board, 2013a; Federal Ministry of Health and National Primary Health Care Development Agency, 2013). The lowest oral immunisation coverage, OPV3 (53.9%) was higher than the highest injectable immunisation coverage, BCG (51.2%). The trend is for coverage of all vaccines to decline over time but to be lowest for injectable vaccines at each time (Figure 4.1). The only exception was Measles coverage of 42.1%, which was higher than the DPT3 coverage of 38.5%. One of the reasons may be the availability of access to measles immunisation outside the usual routine immunisation setting like supplemental immunisation activities (Salako and Sholeye, 2015). For the oral immunisations, the largest point difference between subsequent immunisation sessions, 16.0, was between OPV2 and OPV3 (Figure 4.1). While for the injectable ones, the largest point difference of 7.0% was between DPT2 and DPT3 (Figure 4.1).

Table 4.1: Proportion of children aged 12-23 months by receipt of routine childhood vaccines, Nigeria (weighted 2013 NDHS- sample – N=5900)

VACCINES	HAD RECEIVED		DID NOT RECEIVE	
	NUMBER	%	NUMBER	%
BCG	3018	51.2	2882	48.8
DPT1	2972	50.4	2929	49.6
OPV1	4500	76.3	1401	23.7
DPT2	2684	45.5	3216	54.5
OPV2	4122	69.9	1779	30.1
DPT3	2272	38.5	3628	61.5
OPV3	3181	53.9	2719	46.1
Measles	2483	42.1	3418	57.9
FIC	1494	25.3	4406	74.7

Chapter 4

Figure 4.1: Trend of immunisation coverage using 2013 NDHS



The fully immunised (FIC) coverage, which is the percentage of children aged 12-23 months who received all doses of the basic immunisations (Bacillus Calmette–Guérin, Oral Polio Vaccine, Diptheria-Pertussis –Tetanus, Measles) was only 25.3% (1494 of 5900). Of the remaining 4406 (74.7%) children who were not fully immunised, 1221 (20.7% of the total and 27.7% of those who were not fully immunised) did not receive any vaccine, and 3185 (54.0% of the total, 72.3% of those not fully immunised) had had at least one, but fewer than eight vaccine doses.

The BCG, DPT3 and FIC coverage association with the selected sociodemographic factors were investigated in the next section. The BCG as the first immunisation on the routine immunisation schedule was chosen as the proxy for the initial level of access, while DPT3 is the most widely accepted indicator for the level of childhood immunisation in the absence of the FIC coverage and had the lowest immunisation coverage among all the basic immunisations in 2013 NDHS.

4.3 Childhood Immunisation coverage and associated factors in the 2013 Nigeria DHS

Table 4.2 presents BCG, DPT3 and FIC coverage by sociodemographic characteristics; coverage for all three was low, much lower than the 90% national target (World Health Organisation, 2013) and varied across categories within socio-demographic variables. Generally, BCG coverage was higher than that for DPT3, and DPT3 coverage was higher than FIC, which suggest a gradual drop-off with age in children returning for immunisation sessions. Coverage varied by sociodemographic characteristics, but not for sex of the child in DPT3 and FIC coverage.

Table 4.2 shows that child level factors (child's birth order, mother's antenatal care (ANC) attendance and delivery in a health facility) are associated with immunisation coverage. Vaccine coverage decreased with increasing child's birth order; for the three vaccines, boys had slightly higher coverage than girls. Immunisation coverage was also related to delivery in a health facility, with those delivered at home (62% of the sample) having lower coverage than health facility delivered children. Coverage was higher in children whose mother attended antenatal care than in those who had not.

Coverage increased with higher maternal education level. Children whose mothers had received no formal education had the lowest coverage but contributed most to the sampled population. Coverage was generally higher in female- (10% of those interviewed) than male-headed households (90% of those interviewed). Religion was found to be associated with immunisation coverages, with Muslims having the lowest coverage. Mothers' employment status was also associated with immunisation coverage; coverage was lowest among children of the youngest (14-19 years) mothers. Mothers' current marital status was another household characteristic that was related to immunisation coverage. For coverage of all three immunisations, Ibos had the highest values while Fulanis had the lowest. Who decided the spending of maternal income was also associated with BCG, DPT3 and FIC coverage. Children of mothers who reported the health staff attitude as a big problem had lower BCG, DPT3 and FIC coverage than children of mothers that regarded health staff attitude as not a big problem. Most respondents were exposed to the media and their children had higher immunisation coverage. The poorer the family, the lower the immunisation coverage despite the free provision of immunisation services.

At the community level, coverage was related to place of residence and regions, with the categories of these variables that made up the majority of the sample having the lowest coverage. Immunisation coverage was lower in rural than in urban communities, with most of the sampled population living in rural areas. Similarly, the two regions, Northeast and Northwest, with the lowest coverages contributed more (53%) to the sample population than the other four regions. Distance from home to the health facility to access health care was associated with the vaccine coverage, although most mothers (69%) did not see the distance to the health facility to access care as a big problem, and their children had higher coverage than children whose mother saw the distance to the health facility as a big problem when accessing health care.

Overall, associations between BCG, DPT3 and FIC coverage with the independent variables were similar, and further investigation of the relationship between vaccine coverage and sociodemographic variables focussed on FIC coverage only.

Table 4.2: Socio-demographic characteristics and their association with BCG, DPT3 and FIC coverage (DHS 2013, weighted data, total sample 5900)

Variable	Sample size per category	BCG	DPT3	FIC
		% that received/ (p-value)	% that received/ (p-value)	% that received/ (p-value)
Child level				
Birth order		(0.001)	(0.001)	(0.001)
1	1,173	61.6	49.6	34.1
2-3	1,851	55.4	42.3	27.7
4-5	1,444	50.8	36.8	25.0
>=6	1,433	37.5	26.3	15.7
Sex		(0.017)	(0.120)	(0.529)
Male	3,066	52.9	39.7	25.7
Female	2,834	49.3	37.3	24.9
Place of delivery		(0.001)	(0.001)	(0.001)
Home	3,652	30.0	19.4	12.4
Health facility	2,248	85.6	69.6	46.3
Antenatal attendance		(0.001)	(0.001)	(0.001)
No	1,907	12.4	6.9	4.5
Yes	3,580	70.1	54.0	35.6
Don'tknow/ missing	414	66.3	50.3	32.5
Household level				
Maternal education level		(0.001)	(0.001)	(0.001)
No education	2,807	20.7	12.2	6.9
Primary	1,062	63.2	40.4	26.3
Secondary	1,608	84.3	70.3	46.6
Higher	423	96.9	87.4	64.1
Sex of Household head		(0.001)	(0.001)	(0.001)
Male	5,304	48.7	36.0	23.7
Female	596	72.7	60.5	39.6
Religion		(0.001)	(0.001)	(0.001)
Christian	2,238	82.9	68.1	46.4
Islam	3,568	31.3	20.2	12.4
Traditionalist/ others	94	48.5	27.4	15.0

Mother employment status		(0.001)	(0.001)	(0.001)
No	1,705	40.1	30.4	20.0
Yes	4,196	55.7	41.8	27.5
Maternal age at the child's birth		(0.001)	(0.001)	(0.001)
14-19	841	32.7	21.4	13.3
20-29	3,123	53.3	40.32	26.7
30-39	1,658	56.4	43.7	28.9
40-49	277	51.3	38.62	25.0
Current marital status		(0.001)	(0.001)	(0.001)
Never married	114	85.4	64.0	46.2
Married/partner	5,637	50.2	37.8	24.7
No longer together	150	60.1	47.8	32.8
Maternal ethnicity		(0.001)	(0.001)	(0.001)
Fulani	447	16.9	9.2	6.1
Hausa	1,995	20.7	12.3	7.7
Ibo/Igbo	700	90.6	81.7	52.8
Yoruba	667	89.1	70.2	43.2
Others	2,091	62.3	45.3	31.3
Decision maker on spending of mothers income		(0.001)	(0.001)	(0.001)
Mother alone	2,658	48.1	35.8	23.0
mother & spouse	677	75.4	58.2	40.0
spouse alone	383	62.5	43.7	29.9
No income mother /missing	2,183	45.3	34.8	22.8
Attitude of health staff		(0.001)	(0.001)	(0.001)
Big problem	936	39.7	29.4	18.4
No/Not a big problem	4,964	53.3	40.2	26.6
Media exposure		(0.001)	(0.001)	(0.001)
No	2,030	25.7	16.8	9.6
Yes	3,871	64.5	49.9	33.6
Household wealth		(0.001)	(0.001)	(0.001)
Poor	2889	46.0	33.1	21.8
Moderate	2732	55.2	42.6	28.2
Rich	280	65.1	53.9	33.7
Community level				
Place of residence		(0.001)	(0.001)	(0.001)
Urban	2,113	76.3	62.4	42.5
Rural	3,787	37.1	25.2	15.8
Region		(0.001)	(0.001)	(0.001)
Northcentral	812	62.7	44.1	26.8
Northeast	1,023	35.1	21.4	14.2
Northwest	2,100	21.8	14.0	9.6
Southeast	550	90.4	80.9	51.7
Southsouth	591	84.7	70.0	52.0
Southwest	823	84.5	65.8	40.9

Distance to nearest Health Facility		(0.001)	(0.001)	(0.001)
Big problem	1,823	32.2	22.5	14.9
No/Not a big problem	4,077	59.6	45.7	30.0

The chi square p-value showed the statistical significance of the difference of the within-variable difference between the categories. Also the household wealth was calculated separately for rural and urban households.

Table 4.3: Association between socio-demographic factors and Full immunisation coverage (assessed at 12-23 months of age) in Nigeria, univariable and multivariable logistic regression analysis (DHS 2013 data)

Variable	Univariable regression		Multivariable regression					
			Model 1 -Child		Model 2 -Maternal/household		Model 3 - full model Community	
	Unadj Odds ratio (p-value)	95% CI	Adj Odds ratio(p-value)	95% CI	Adj Odds ratio (p-value)	95% CI	Adj Odds ratio (p-value)	95% CI
Child								
Birth order								
>=6	1.0		1.0		1.0		1.0	
1	2.5 (0.001)	2.1,3.0	1.6 (0.001)	1.3,2.0	1.6(0.009)	1.1,2.2	1.5(0.013)	1.1,2.1
2-3	2.0(0.001)	1.7,2.4	1.4(0.003)	1.1,1.7	1.2(0.226)	0.9,1.6	1.2(0.243)	0.9,1.6
4-5	1.5(0.001)	1.2,1.8	1.1(0.730)	0.8,1.3	1.0(0.679)	0.7,1.2	0.9(0.531)	0.7,1.2
Place of delivery								
Home	1.0		1.0		1.0		1.0	
Health facility	5.0(0.001)	4.4,5.7	2.4(0.001)	2.0,2.9	1.4(0.001)	1.1,1.7	1.2(0.011)	1.1,1.6
Antenatal attendance								
No	1.0		1.0		1.0		1.0	
Yes	9.8(0.001)	8.8,12.1	5.5(0.001)	4.2,7.2	3.8(0.001)	2.9,5.1	3.7(0.001)	2.8,4.9
Don't know/ missing	9.1(0.001)	6.9, 12.2	4.2(0.001)	2.9,6.0	2.8(0.001)	1.9,4.0	2.6(0.001)	1.8,3.7
Maternal/Household								
Maternal education level								
None	1.0				1.0		1.0	
Primary	4.9(0.001)	4.0,5.9			1.8(0.001)	1.4,2.3	1.6(0.001)	1.3,2.1
Secondary	10.8(0.001)	9.1, 12.9			2.7(0.001)	2.0,3.5	2.3(0.001)	1.7,3.0
Higher	20.6(0.001)	16.2,26.3			4.0(0.001)	2.7,5.8	3.2(0.001)	2.2,4.7
Sex of Household head								
Male	1.0				1.0		1.0	
Female	2.1(0.001)	1.8,2.5			1.2(0.209)	0.9,1.5	1.1(0.299)	0.9,1.4
Religion								
Islam	1.0				1.0		1.0	
Christianity	5.7(0.001)	5.0,6.5			1.8(0.001)	1.4,2.4	1.8(0.001)	1.6,4.2
Traditionalist/other	1.1(0.863)	0.6,2.0			1.1(0.876)	0.5,2.4	1.0(0.884)	0.4,2.2

Mother employment status								
No	1.0				1.0		1.0	
Yes	1.5(0.001)	1.3,1.7			1.0(0.982)	0.7,1.3	1.0(0.877)	0.8,1.4
Maternal age at birth of child								
14-19	1.0				1.0		1.0	
20-29	2.0(0.001)	1.7,2.5			1.8(0.001)	1.3,2.4	1.6(0.001)	1.2,2.2
30-39	2.3(0.001)	1.9,2.9			2.1(0.001)	1.5,3.0	1.9(0.001)	1.4,2.8
40-49	1.8(0.001)	1.3,2.5			1.9(0.012)	1.2,3.2	1.9(0.019)	1.1,3.1
Current marital status								
Never married	1.0				1.0		1.0	
Married/partner	0.4(0.001)	0.3,0.6			0.8(0.260)	0.5,1.2	0.9(0.695)	0.6,1.5
No longer together	0.6(0.019)	0.4,.9			1.0(0.912)	0.6,1.9	1.1(0.693)	0.6,2.1
Mothers ethnicity								
Fulani	1.0				1.0		1.0	
Hausa	1.1(0.783)	0.7,1.6			0.8(0.260)	0.5,1.2	0.8(0.440)	0.5,1.4
Ibo/Igbo	13.5(0.001)	9.2,19.8			1.9(0.021)	1.1,3.3	1.9(0.050)	1.0,3.7
Yoruba	10.6(0.001)	7.2,15.6			1.6(0.073)	1.0,2.8	1.8(0.054)	1.0,3.3
Others	5.7(0.001)	4.0,8.2			1.7(0.033)	1.0,2.7	1.5(0.110)	0.9,2.5
Decision maker on spending of mothers income								
No income mother	1.0				1.0		1.0	
mother	1.1(0.342)	0.9,1.2			1.2(0.210)	0.9,1.6	1.2(0.285)	0.9,1.6
mother & spouse	2.2(0.001)	1.8,2.6			1.1(0.478)	0.8,1.6	1.1(0.599)	0.8,1.5
spouse	1.5(0.001)	1.2,1.9			1.0(0.915)	0.7,1.5	1.0(0.908)	0.7,1.5
Attitude of health staff								
Big problem	1.00				1.0		1.0	
No/Not a big problem	1.3(0.005)	1.1,1.5			0.9(0.244)	0.7,1.1	0.8(0.069)	0.6,1.0
Media exposure								
No	1.00				1.0		1.0	
Yes	4.4(0.001)	3.8,5.1			1.6(0.001)	1.3,2.0	1.5(0.001)	1.2,1.8
Household wealth								
Poor	1.0				1.0		1.0	
Moderate	1.5(0.001)	1.3,1.7			1.2(0.041)	1.0,1.4	1.2(0.066)	1.0,1.4
Rich	1.8(0.001)	1.4,2.3			1.2(0.288)	0.9,1.7	1.2(0.265)	0.9,1.7

Community								
Place of residence								
Rural	1.00						1.0	
Urban	3.5(0.001)	3.1,3.9					1.7(0.001)	1.4,2.3
Region								
Northcentral	1.00						1.0	
Northeast	0.4(0.001)	0.3,0.5					1.0(0.851)	0.7,1.4
Northwest	0.2(0.001)	0.2,0.3					0.8(0.259)	0.5,1.2
Southeast	2.3(0.001)	1.8,2.8					0.9(0.657)	0.5,1.5
Southsouth	2.1(0.001)	1.7,2.6					1.8(0.001)	1.3,2.6
Southwest	1.6(0.001)	1.3,2.0					0.6(0.037)	0.4,1.0
Distance to nearest Health Facility								
Big problem	1.00						1.0	
No/ not a big problem	2.1(0.001)	1.9,2.5					1.4(0.006)	1.1,1.7
Random Effects								
Household variance (SE)			1.9(0.12)		0.13(0.17)		0.16(0.18)	
Household ICC			0.32		0.22		0.18	
Community variance (SE)			1.5(0.17)*		0.78(0.12)		0.74(0.11)*	
Community ICC			0.32		0.19		0.21	
AIC			5461		5105		5058	

Unadj. =Unadjusted, Adj. = adjusted, CI= confidence interval, SE= standard error, AIC = Akaike information criterion, 95% significance level, ICC=Intraclass correlation, *=p-value<0.05

4.4 Simple and multilevel logistic regression analysis of full childhood immunisation and association with sociodemographic variables

The dependent variable, Fully Immunised Child (FIC) is dichotomous (yes or no), and thus logistic regression is appropriate. Results of the logistic regression (Simple and Multilevel) analysis used to explore the association between FIC and socio-demographic variables are presented in Table 4.3

Simple logistic regression relates to the relationship between FIC and each independent variable at a time, expressed as unadjusted odds ratio for the different categories of each variable without controlling for any other independent variable. Multilevel regression models account for the hierarchical nature of the data (2013 DHS) and were used to investigate the association between child, household and community factors and FIC, expressed as adjusted odds ratios. Table 4.3 presents fixed effects for each variable in odds ratio with 95% confidence interval, random effects in variance, intraclass correlation and Akaike information criterion for the model's goodness of fit. The three-level multilevel logistic regression included four models: Model 0 had only the dependent variable, Model 1 adjusted for child level factors, Model 2 for the child and maternal/household factors and the full Model 3 for the child, maternal/household and community factors.

In unadjusted logistic regression analyses, there were statistically significant associations between FIC and nearly all sociodemographic variables. Child-level factors such as ANC attendance and place of delivery were strongly associated with FIC, with children of mothers who attended ANC 9.8-times more likely to be fully immunised than those with mothers without ANC attendance. Being delivered in the health facility made the child 5-times more likely to be fully immunised than being delivered at home children. Maternal education level, a household-level variable, was strongly associated with FIC: compared to children whose mothers had no formal education, children with mothers who had attained primary, secondary, and higher education were 4.9-times ($p<0.001$), 10.8-times ($p<0.001$), and 20.6-times ($p<0.001$) more likely, respectively, to be fully immunised. These unadjusted odds ratios presented in Table 4.3 are similar to the associations seen in the crude bivariate analyses described in Table 4.2.

With adjustment, the size of all ORs reduced in all models and for some variables the association was no longer statistically significant. For the child-level factors, (Model 1), children of birth order 1 had 1.6-fold (aOR=1.6, 95% CI=1.3-2.0) significantly higher odds of being fully immunised than the 6 or more birth order child (reference category), children of birth order 2-3 (aOR=1.4, 95% CI=1.1-1.7) and 4-5 (aOR=1.1, 95% CI=0.8-1.3) also had increased odds. Children delivered in a health facility (aOR=2.4, 95% CI=2.0-2.9) had a significantly increased likelihood of being fully immunised than children delivered at home. For maternal ANC attendance, children whose mothers attended ANC (aOR=5.5, 95% CI=4.2-7.2) had significantly higher odds of full immunisation.

In Model 2 (further adjusting for household level variables), adjustment also reduced the size of OR, except for current marital status and attitude of health staff variables, where the adjusted odds were higher than the unadjusted odds. Fully immunised child status remained significantly associated with child level variables such as place of delivery and maternal ANC attendance, but with reduced odds ratios. ANC attendance by mothers provided a four-fold increase in the child's odds of full immunisation (aOR=3.8, 95% CI=2.9-5.1), while delivery in the health facility (aOR=1.4, 95% CI=1.1-1.7) had higher odds of being fully immunised than home delivered child. Children of mothers with primary education (aOR=1.8, 95% CI=1.4-2.3), secondary education (aOR=2.7, 95% CI=2.0-3.5) and higher education (aOR=4.0, 95% CI=2.5-5.8) had significantly increased odds of being fully immunised compared to children of mothers with no formal education. There was no significant association between sex of the household head and FIC, although the child from a female-headed household (aOR=1.2, 95% CI=0.9-1.5) had a higher, but not significant, odds of full immunisation than children from a male-headed household. Children from Christian households (aOR=1.8, 95% CI=1.4-2.4) were nearly two-times more likely than those from Moslem homes to be fully immunised. Having an employed mother (OR=1.0, 95% CI=0.7-1.3) was not statistically significantly associated with the child's odds of being fully immunised compared to children with unemployed mothers. Compared to children whose mothers were aged 14-19 at the child's birth, children of mothers with birth age 20-29, 30-39 and 40-49 years were 1.8- to 2.1-fold more likely to be fully immunised. Maternal factors such as marital status, decision-maker on spending of mothers' income and attitude of health staff variables were not significantly associated with FIC. Household media exposure increased the child's likelihood of full immunisation about 2-fold (aOR=1.6, 95% CI=1.3-2.0) compared to those from homes without media exposure. Children from the middle (aOR=1.2, 95% CI=1.0-1.4) and rich (aOR=1.2, 95% CI=0.9-1.7) households had increased odds of full immunisation compared to children from the poor homes, and although the latter association did not reach significance, that of the middle class was of borderline significance.

The Community level variables (place of residence, regions and distance to the health facility) were added in Model 3; birth order, place of delivery, maternal ANC attendance, maternal education level, maternal religion, maternal age at child birth and media exposure variables remained significantly associated with FIC. Children residing in urban communities (aOR=1.7, 95% CI=1.4-2.3) had a nearly 2-fold increased odds of being fully immunised compared to rural children. The region of residence was significantly associated with being fully immunised, with the children from the Southwest having the lowest odds and Southsouth children had the highest odds. The other community level variable, distance to the health facility where seeking health care, was significantly associated with FIC after adjustment. Children of mothers who felt the distance to the health facility to seek care was not a big problem (aOR=1.4, 95% CI=1.1-1.7) had significantly higher odds to be fully immunised than children whose mothers said the distance to the health facility was a big problem.

Random effect estimates were obtained from the analysis. The multilevel regression analysis accounted for the hierarchical data style and quantified the differences in FIC that are mostly due to social, cultural and other rare occurrence. As shown in Table 4.3, in Model 1 (child level factors), the variation in the odds of being fully immunised was significant across the communities ($\tau = 1.5, SE = 0.17$) but not significant across households ($\tau = 1.9, SE = 0.12$). While the intra-community and intra-household correlations reveal that 32% of the fully immunised child could be linked to community and household level factors. The community and household level variance were not significant in Model 2 (child and household level factors). Finally, in Model 3 (child, household and community level factors), the variance was only significant across the communities ($\tau = 0.74, SE = 0.11$), with 21% of the variation in the fully immunised child odds attributed to community level factors.

Models' goodness of fit, measured by the value of the Akaike information criterion (AIC), improved as the higher models were built. The successive reduction in the value of AIC for subsequent models: Model 1= 5461, Model 2= 5105 and Model 3= 5058) was indicative of a gradually improved model fit.

4.5 Drop-out rates

Vaccine drop-out rate (DOR) is used as a proxy for the strength of the health system and indicative of community utilisation of immunisation services (Chinawa, 2014; Nwokeukwu *et al.*, 2015; Kazungu and Adetifa, 2017). Children are said to have dropped-out if, after receiving earlier vaccines, they did not return for subsequent scheduled immunisations (Chinawa, 2014; Nwokeukwu *et al.*, 2015; Kazungu and Adetifa, 2017), or in other words, vaccine drop-out means that an eligible child who started the immunisation schedule did not complete it or has missed one or more immunisation sessions (Chinawa, 2014; Nwokeukwu *et al.*, 2015; Kazungu and Adetifa, 2017). Drop-out rates are calculated as the percentage value difference between two vaccine doses (BCG and Measles, OPV1 and OPV3, DPT1 and Measles, DPT1 and DPT3), expressed as a percentage of the first (earlier) vaccine dose. A drop-out of more than 10% is suggestive of the health system being a barrier to immunisation service utilisation (World Health Organization and UNICEF', 2002; Chinawa, 2014; Nwokeukwu *et al.*, 2015; Kazungu and Adetifa, 2017).

The DPT1 and Measles DOR and DPT1 and DPT3 DOR (DPT DOR) are the most widely accepted and used (Mane, 2015; Kazungu and Adetifa, 2017). The DPT drop-out rate, calculated by subtracting the DPT3 number (or percentage coverage) from the DTP1 number (or percentage coverage) divided by the DPT1 number (or percentage coverage) and multiplied by 100% [(DPT1- DPT3)/DPT1 x 100] (Chinawa, 2014; Nwokeukwu *et al.*, 2015), is a measure of how well the immunisation service delivery system provides the multiple doses of DPT to children over the short period between 6 and 14 weeks of age (Mane, 2015; Kazungu and Adetifa, 2017). DPT1 and Measles DOR assesses drop-out over a longer period (age 6 weeks to 9 months) and is accepted by some as a more accurate measure of quality of immunisation services; DPT1 to Measles DOR is calculated by subtracting the Measles number (or percentage coverage) from the DTP1 number (or percentage coverage) divided by the DPT1 number (or percentage coverage) and multiplied by 100% [(DPT1- Measles)/DPT1 x 100] (Mane, 2015; Kazungu and Adetifa, 2017).

The DPT DOR was chosen based on the PhD's candidate knowledge that Measles vaccine is given in supplemental immunisation activities (including Nigeria 2011 Measles campaign) which are not limited to the health facilities (Salako and Sholeye, 2015), as such the measles coverage may be higher than the doses administered during the health facility based routine immunisation sessions. The trend of the injectable immunisation as shown in Table 4.1 was supportive of the doubts about the Measles coverage, as subsequent injectable immunisation coverages (BCG -51.2%, DPT1-50.4%, DPT2-45.5%, DPT3-38.5%) reduced except for the Measles immunisation coverage (42.1%) which was higher than the DPT3 coverage.

4.5.1 DPT Drop-Out

Table 4.1 presented the coverage rates of the routine childhood vaccines as reported for children aged 12-23 months in 2013 in Nigeria. The DPT1 coverage was 50.4% and DPT3 was about 12 points lower. To optimise child immunisation in Nigeria, the number of eligible children who utilise immunisation services must increase and at least 90% of children who receive the first vaccine must complete the schedule. Table 4.4 shows the distribution of DPT1 and DPT3 vaccine coverage, and the DPT drop-out rates across sociodemographic characteristics. The DPT drop-out rate varied across the variable categories. Generally, in most variables, the category with the highest DPT1 coverage had the highest DPT3 coverage and the least drop-out rate. Also, the category with the least DPT1 coverage had the lowest DPT3 coverage and the highest drop-out rate (DOR). This means the low coverage categories have both access and utilisation challenges.

For child level variables, birth order, sex of the child, place of delivery and maternal ANC, the drop-out rates were all above the 10% cut off. Birth order 1 child had the highest DPT1 and DPT3 coverage with the least DOR at 19%. Children delivered at home had lower DPT1 and DPT3 coverage, and higher DOR than children delivered in a health facility. The DOR of children of mothers who had not attended ANC was more than double that of children whose mother who had attended ANC

The DPT DOR of children with mothers who had no formal education, primary education, secondary education and higher education was 41%, 34%, 15% and 8.1% respectively. Despite having lower DPT vaccine coverages, the DOR of the Muslim child was about twice the Christians child's value. Although the DOR of children with employed (23%) and unemployed mothers (24%) were similar, vaccine coverage was higher for children who had employed mothers. Children of the youngest and oldest mothers had the highest DOR. The children of Ibo mothers had a DOR of 8.5% when children of Fulani and Hausa mothers had a DOR of 45% and 40% respectively. The DOR of children from households exposed to media was lower than children whose parents were not exposed. The richer the household, the lower the DOR.

The urban child had a DPT1 coverage that was about double the rate of the rural child, with a DOR that was about a quarter of the rural child. The rural child had the highest DOR (67.9%), which means just 1 in every 3 children who started the DPT vaccination completed it. The Northern regions had lower DPT coverage than the southern regions, with higher DOR. The Southeast that is predominantly Ibos' had an acceptable DOR of 8.8%.

Table 4.4: DPT vaccine Dropout rates among children aged 12-23 months (DHS 2013, weighted data, total sample 5900)

		DPT 1		DPT 3		DPT Dropout rate (%)
		Received	%	Received	%	
Child Level						
Birth order						
1	1,173	720	61.4	582	49.6	19.2
2-3	1,851	1004	54.2	782	42.3	22.1
4-5	1,444	724	50.2	532	36.8	26.5
>=6	1,433	36.5	36.5	377	26.3	27.9
Sex						
Male	3,066	1595	52.0	1217	39.7	23.7
Female	2,834	1376	48.6	1056	37.3	23.3
Place of delivery						
Home	3,652	1111	30.4	708	19.4	36.3
Health facility	2,248	1860	82.7	1564	69.6	15.9
Antenatal attendance						
No	1,907	240	12.6	132	6.9	45.0
Yes	3,580	2468	68.9	1932	54.0	21.7
Don'tknow/ missing	414	264	63.8	208	50.3	21.2
Maternal level						
Maternal education level						
No education	2,807	580	20.7	342	12.2	41.0
Primary	1,062	653	61.4	430	40.4	34.1
Secondary	1,608	1337	83.2	1131	70.3	15.4
Higher	423	403	95.2	370	87.4	8.1
Sex of Household head						
Male	5,304	2542	47.9	1912	36.0	24.8
Female	596	429	72.0	361	60.5	15.9
Religion						
Christian	2,238	1833	81.9	1525	68.1	16.8
Islam	3,568	1097	30.8	722	20.2	34.2
Traditionalist/ others	94	41	43.3	26	27.4	36.6
Mother employment status						
No	1,705	685	40.2	519	30.4	24.2
Yes	4,196	2287	54.5	1753	41.8	23.4
Maternal age at the child's birth						
14-19	841	284	33.8	180	21.4	36.6
20-29	3,123	1627	52.1	1259	40.32	22.6
30-39	1,658	919	55.4	726	43.7	21.0
40-49	277	142	51.2	107	38.62	24.7
Current marital status						
Never married	114	97	85.2	73	64.0	24.7
Married/partner	5,637	2783	49.4	2128	37.8	23.5
No longer together	150	92	61.2	71	47.8	22.8

Maternal ethnicity						
Fulani	447	76	17.1	41	9.2	46.1
Hausa	1,995	406	20.3	245	12.3	39.7
Ibo/Igbo	700	625	89.2	572	81.7	8.5
Yoruba	667	567	85.1	468	70.2	17.5
Others	2,091	1297	62.0	946	45.3	27.1
Decision maker on spending of mothers income						
Mother alone	2,658	1238	46.6	951	35.8	23.2
mother & spouse	677	498	73.6	394	58.2	20.9
spouse alone	383	240	62.8	167	43.7	30.4
No income mother /missing	2,183	996	45.6	760	34.8	23.7
Attitude of health staff						
Big problem	936	361	38.5	275	29.4	23.8
No/Not a big problem	4,964	2611	52.6	1997	40.2	23.5
Media exposure						
No	2,030	527	26.0	341	16.8	35.3
Yes	3,871	2445	63.2	1931	49.9	21.0
Household wealth						
Poor	2889	1288	44.6	957	33.1	25.7
Moderate	2732	1499	54.9	1164	42.6	22.3
Rich	280	185	66.0	151	53.9	18.4
Community Level						
Place of residence						
Urban	2,113	1556	73.6	1319	62.4	15.2
Rural	3,787	2972	37.4	953	25.2	67.9
Region						
Northcentral	812	502	61.8	358	44.1	28.7
Northeast	1,023	349	34.1	219	21.4	37.3
Northwest	2,100	465	22.2	294	14.0	36.8
Southeast	550	488	88.6	445	80.9	8.8
Southsouth	591	497	84.2	414	70.0	16.7
Southwest	823	670	81.4	542	65.8	19.1
Distance to nearest Health Facility						
Big problem	1,823	585	32.1	409	45.7	30.1
No/Not a big problem	4,077	2386	58.5	1863	22.5	21.9

4.5.2 Simple regression of DPT drop-out rate and Sociodemographic characteristics

The sociodemographic characteristics associated with DPT drop-out rates (DOR) are presented in Table 4.5. The pattern was like the predictors of being fully immunised in Table 4.3. The characteristics that increased the likelihood of being fully immunised, reduced the odds of having a higher drop-out rate. In this simple, unadjusted, regression analysis, sex of the child, mothers' employment status, mothers' current marital status, decision maker on spending of mothers' income and the attitude of health workers were not statistically significantly associated with DPT DOR.

As expected children who were delivered at home (OR=0.4, 95% CI=0.3-0.5) were more likely to drop-out than those delivered in a health facility. Other child level factors such as birth orders 1 and 2-3 had significantly lower DPT DOR than birth order of 6 and more. Also, maternal attendance of ANC had significantly lower DPT DOR (OR=0.4, 95% CI=0.3-0.5) than mothers who did not attend ANC.

Children with higher level educated mothers were less likely to drop out than children of less educated women. Also, significantly lower DOR odds were seen in these household level variables: Female household head compared (OR=0.6, 95% CI=0.4-0.7) to male household head, Christian (OR=0.4, 95% CI=0.3-0.5) compared to Muslim, Maternal age at child birth 20-29 (OR=0.6, 95% CI=0.4-0.7), 30-39 (OR=0.5, 95% CI=0.4-0.7) and 40-49 (OR=0.6, 95% CI=0.4-0.9) compared to 14-19 years group, Ethnic group Ibo (OR=0.1, 95% CI=0.1-0.2), Yoruba (OR=0.1, 95% CI=0.1-0.4) compared to Fulani, Media exposure (OR=0.5, 95% CI=0.4-0.6) compared to no media exposure and moderate household wealth (OR=0.8, 95% CI=0.7-1.0) compared to poor household wealth.

Children living in rural areas were more likely to drop out than children living in urban areas (OR=0.4, 95% CI=0.3-0.5). Living in the Northeast (OR=1.9, 95% CI=1.4-2.4) and Northwest (OR=1.9, 95% CI=1.4-2.5) increased the likelihood of DPT drop out compared to living in the North central region. Compared to the Northcentral region, the three southern regions, Southeast (OR=0.3, 95% CI=0.2-0.4), Southsouth (OR=0.6, 95% CI=0.5-0.8) and Southwest (OR=0.7, 95% CI=0.5-0.9) had reduced DPT DOR odds. Distance to the nearest health facility when seeking care was significantly associated with DPT DOR, with children of parents who saw the distance as a not/ not a big problem had lower odds (OR=0.7, 95% CI=0.6-0.8) than children whose parent saw it as a big problem.

Table 4.5: Simple regression analysis of DPT drop-out rate and sociodemographic characteristics among children aged 12-23 months in Nigeria (2013 DHS data)

Child level			**Household level**			**Community level**		
Variable	**Unadjusted Odd ratio 95% Confidence interval**	**P value**	**Variable**	**Unadjusted Odd ratio 95% Confidence interval**	**P value**	**Variable**	**Unadjusted Odd ratio 95% Confidence interval**	**P value**
Birth order >=6 1 2-3 4-5	 1.0 0.6(0.5,0.8) 0.7(0.6,0.9) 1.0(0.7,1.2)	 0.001 0.002 0.665	**Maternal education level** No education Primary Secondary Higher	 1.0 0.7(0.5,0.8) 0.3(0.2,0.4) 0.1(0.1,0.2)	 0.001 0.001 0.001	**Place of residence** Rural Urban	 1.0 0.4(0.3,0.5)	 0.001
Sex Male Female	 1.0 1.0(0.9,1.2)	 0.729	**Sex of Household head** Male Female	 1.0 0.6(0.4,0.7)	 0.001	**Region** Northcentral Northeast Northwest Southeast Southsouth Southwest	 1.0 1.9(1.4,2.4) 1.9(1.4,2.5) 0.3(0.2,0.4) 0.6(0.5,0.8) 0.7(0.5,0.9)	 0.001 0.001 0.001 0.001 0.009
Place of delivery Home Health facility	 1.0 0.4(0.3,0.5)	 0.001	**Religion** Islam Christian Traditionalist/ others	 1.0 0.4(0.3,0.5) 1.4(0.7,2.8)	 0.001 0.350	**Distance to nearest Health Facility** Big problem No/Not a big problem	 1.0 0.7(0,6,0.8)	 0.001
Antenatal attendance No Yes Don’t know	 1.0 0.4(03,0.5) 0.3(0.2,0.5)	 0.001 0.001	**Mother employment status** No Yes	 1.0 0.9(0.8,1.1)	 0.368			

			Maternal age at the child's birth 14-19 20-29 30-39 40-49	 1.0 0.6(0.4,0.7) 0.5(0.4,0.7) 0.6(0.4,0.9)	 0.001 0.001 0.016			
			Current marital status Never married Married/partner No longer together	 1.0 1.1(0.7,1.8) 1.1(0.6,2.2)	 0.587 0.604			
			Maternal ethnicity Fulani Hausa Ibo/Igbo Yoruba Others	 1.0 0.8(0.5,1.2) 0.1(0.1,0.2) 0.2(0.1,0.4) 0.4(0.3,0.7)	 0.224 0.001 0.001 0.001			
			Decision maker on spending of mothers income No income mother /missing Mother alone mother& spouse spouse alone	 1.0 0.9(0.7,1.1) 0.8(0.6,1.0) 1.1(0.8,1.6)	 0.222 0.56 0.409			
			Attitude of health staff Big problem No/Not a big problem	 1.0 1.1(0.9,1.4)	 0.391			

			Media exposure No Yes	1.0 0.5(0.4,0.6)	0.001			
			Household wealth Poor Moderate Rich	1.0 0.8(0.7,1.0) 0.8(0.6,1.2)	0.001 0.285			

4.6 Conclusion

4.6.1 Summary

- The chapter aimed to estimate the current childhood immunisation coverage in Nigeria, using the 2013 Nigeria Demographic and Health Survey and to address the first objective of the PhD study.
- Individual vaccine coverage ranged from 42.1% (DPT3) to 76.3% (OPV1). Failure to reach 90% coverage for any vaccine is indicative of the poor state of childhood immunisation in Nigeria, and the urgent need to optimise immunisation service delivery.
- Coverage differed for Injectable and oral vaccines given at the same age/time, with oral vaccines having higher coverage than injectable vaccines.
- Only 25.3% of children aged between 12 and 23 months at the time of the survey were reported to be fully immunised, 54.0% received and missed at least one vaccination, and 20.7% did not receive any vaccine.
- FIC varied by socio-demographic characteristics. For several variables (place of delivery, maternal education level, sex of household heads, religion, ethnicity, household wealth place of residence and region), categories with most of the sampled population had the lowest FIC
- Sex of the child was the only socio-demographic characteristic not significantly associated with FIC, except for BCG immunisation.
- The hierarchical nature of the data (2013 DHS) was accounted for in multilevel logistic regression analysis to investigate the relationship between FIC and socio-demographic characteristics. In the final model that fully adjusted for child, household and community levels variables, birth order, place of delivery, maternal ANC attendance, maternal education level, maternal religion, mothers ethnicity, maternal age at child birth, media exposure, place of residence, regions and distance to health facility were significantly associated with FIC, but the odds ratios had reduced from the values in the earlier, less-adjusted models.
- The findings of the significant association between FIC and birth order, place of delivery, maternal ANC attendance, maternal education level, maternal religion, mothers ethnicity, maternal age at child birth, media exposure, place of residence, regions and distance to health facility supports the evidence discussed in the Chapter 2, literature review. Contrary to the evidence synthesised in this study's literature review, rich household category, mother employment status and attitude of health staff had no relationship with FIC.
- About 21% of the total variation in odds of being fully immunised was attributed to community-level differences.

- DPT drop-out rates, used as a proxy for the strength of the immunisation health system, was much higher than the maximum acceptable value of 10% for good utilisation of immunisation services. Rural children had the highest DPT DOR of 67.9%.
- The likelihood of DPT DOR was not due to chance, as most associations with the sociodemographic characteristics were significant
- The same sociodemographic groups that are at risk of lower odds of being fully immunised were also at higher odds of dropping out.

4.6.2 Key finding

- Sociodemographic categories that made up the majority of the sampled population, such as delivery at home, non-formally-educated mother, Hausa ethnic group, Muslims, poor household, residence in rural areas, and Northeast and Northwest regions, had the lowest FIC coverage and highest DPT DOR.
- With the highest DPT DOR of 67.9% in rural areas, it justified this PhD's study plan to explore the association between FIC and socio-demographic factors by analysis of the datasets stratified by place of residence: Rural and urban (Chapter 5) and Urban formal and Urban slum (Chapter 6), as a novel way to improve understanding of childhood immunisation in Nigeria.

4.6.3 Chapter Abstract.

Currently, child routine immunisation is very low in Nigeria, despite the proven benefits of child vaccination that prevented 2 million child deaths globally. Achieving optimal child immunisation coverage is associated with multifactorial sociodemographic factors acting at the child, household, community, country, health system and policy levels.

In this chapter, the PhD study's first research objective, to estimate the current childhood vaccination coverage in Nigeria was addressed. The secondary analysis of the 2013 Nigeria Demographic and Health Surveys (NDHS) datasets, which was obtained from mothers aged 15-49 years relating to children aged between 12-23 months was conducted using descriptive, cross tabulations, simple and multilevel regression methods.

Fully Immunised Child (FIC) coverage, which is the percentage of children aged 12-23 months who had received all doses of routine infant vaccines was 25.3% in 2013, which was much lower than the 90% global target set by the World Health Organisation varied across sociodemographic characteristics. Birth order, place of delivery, maternal ANC attendance, maternal education level, maternal religion, maternal age at child birth, media exposure, place of residence, regions and distance to the health facility were significantly associated with FIC,

DPT DOR, the proportion of children that received the first dose of DPT vaccine (DPT1) but failed to receive the final dose of the vaccine (DPT3) was much higher than the acceptable value of less than 10%. Only the mother with higher education, Ibo ethnic group and southeast region (home region of the Ibos) had drop-out rates less than 10%.

The very low FIC and very high DPT drop-out rates spotlight the abysmal state immunisation delivery system in Nigeria. With most of the less than expected children who received the first and early vaccines not completing the later recommended doses. Planned improvement strategies must have a two-prong approach: First, address the less than an optimal number of children starting the immunisation schedule, and secondly, ensure at least 90% immunisation completion of the children that start the immunisation schedule.

Chapter 5 Patterns of child immunisation coverage over time and the role of place of residence.

5.1 Introduction

In Chapter 4, the analysis of the 2013 Nigeria Demographic Survey data (NDHS) showed the current low fully immunised child (FIC) coverage in the total population, with considerable disparity across socio-demographic characteristics. Also the influential role of socio-demographic characteristics such as birth order, place of delivery, maternal ANC attendance, maternal education level, maternal religion, maternal age at child birth, media exposure, place of residence, regions and distance to health facility in the likelihood of a child being fully immunised was established. Place of residence, rural/ urban, had some of the widest disparity: FIC rate (urban- 42.5%, rural-15.8%), significant odds of being fully immunised (urban- aOR=1.7, 95% CI=1.4-2.3 compared to rural) and DPT drop-out rates (urban- 15.2% and rural- 67.9%). The availability of previous NDHS provided the opportunity to examine patterns of FIC levels over time, and the role of rural/urban place of residence. Further, associations between sociodemographic variables and FIC, may well differ by urban/rural setting, and stratified analysis could therefore lead to improved understanding of FIC.

Although there are some Nigerian studies on rural-urban childhood immunisation coverage disparities (Antai, 2011; Olorunsaiye and Degge, 2016) , none was found to have conducted rigorous analysis with pooled NDHS data over a decade from 2003 to 2013, allowing for changes in sociodemographic and other variables over time in their overall effect on FIC. Hence, the objective of this chapter was to quantify with the use of 2003, 2008 and 2013 NDHS, the association between child, household and community factors and childhood immunisation coverage overall, over time and by rural and urban locality. The chapter addressed these research questions:

Have community, household and child factors associated with childhood immunisation coverage changed overtime?

Are community, household and child factors associated with childhood immunisation coverage in urban and rural areas, and how do they differ across the strata?

The analysis was done in accordance with the conceptual framework developed in Chapter 2, which identified four levels (child, household, community and health system) of variables that are associated with child immunisation coverage.

In the first part of this chapter, results from the description and bivariate analyses of the fully immunised child status across the selected sociodemographic characteristics is presented separately for each of the three NDHS datasets, with the results from the 2013 DHS presented in Chapter 4 repeated here for ease of comparison. The middle section of the Chapter presents the result from multilevel logistic regression analysis of the pooled 2003, 2008 and 2013 NDHS datasets, with interaction terms of place of residence with some key variables. Finally, the pooled data were stratified into rural and urban places of residence, and analysed using multilevel regression technique to explore the association between the FIC with sociodemographic characteristics for urban/ rural locality separately to explore whether the associations between FIC and socio-demographic variables are similar in rural and urban areas.

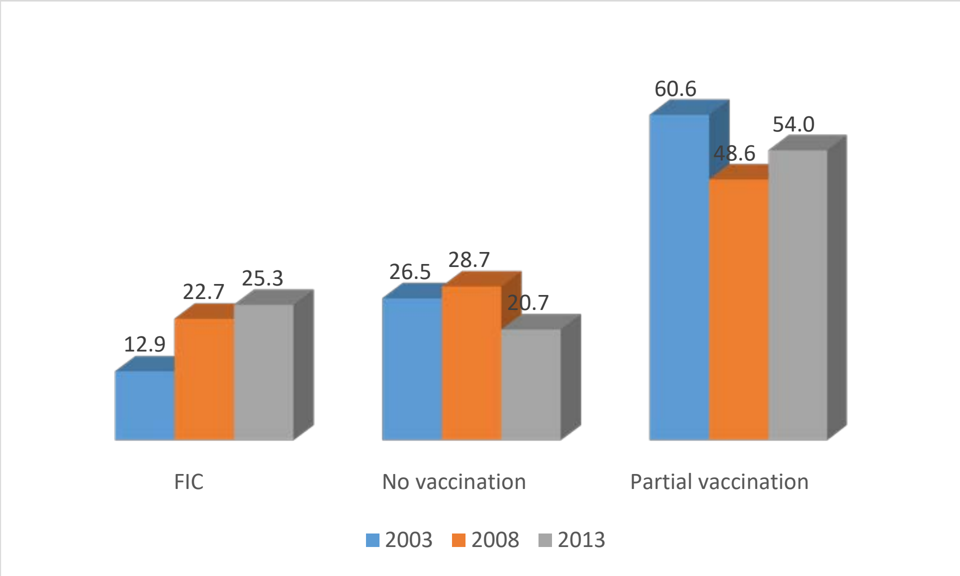
Definitions of NDHS variables are as detailed in Chapter 3 and used in Chapter 4; the outcome variable was FIC.

5.2 Fully immunised child coverage (FIC) by sociodemographic characteristics (NDHS 2013, 2008, 2003).

This section focusses on the comparison between the three NDHSs (2003, 2008 and 2013), with the description of FIC by socio-demographic characteristics common to all three surveys. Overall, fully immunised child (FIC) coverage doubled between 2003 and 2013, from 12.9% in 2003, 22.7% in 2008 to 25.3% in 2013 (Figure 5.1). There was a reduction in the non-immunisation coverage (of children aged 12-23 months at the time of the survey, the percentage who had not received any vaccine) from NDHS 2003 and 2008 figures of 26.5% and 28.7% respectively to 20.7% in 2013. The percentage of children who started immunisation but missed at least one vaccine reduced from 60.6% in 2003 to 48.6% in 2008, and increased to 54.0% in 2013. Although FIC increased in subsequent surveys, FIC coverage remained unsatisfactory overall. Combining those who received partial immunisation with those fully immunised represents the number of children who ever accessed immunisation services, estimated at 73.5%, 71.3% and 79.3% in 2003, 2008 and 2013 NDHS respectively. Thus, FIC of over 70% could have been achieved, if all who had at least one vaccine had completed the child immunisation schedule. The percentage increase in access to immunisation from 2003 to 2013 was 7.9% (% immunisation access in 2013- % immunisation access in 2003 divided by % immunisation access in 2003 and multiplied by 100), which equates to less than one percent increase per year.

Certain sociodemographic groups with no access to immunisation services in 2003 may have remained excluded in 2013.

Figure 5.1: Fully immunised, non-immunised and partially immunised percentage coverages in DHS 2003, 2008 and 2013



Two variables (mother's ethnicity and attitude of health workers) included in the NDHS 2013 analysis presented in Section 4.2 were excluded from the analyses presented here as these variables were not reported in the 2003 NDHS. Though the exclusion of these two variables in the analysis of the three NDHS datasets may affect the understanding the association of FIC and sociodemographic variables, results from Tables 4.2 and 4.3 showed that ethnicity was closely related to religion and region, while the attitude of the health worker variable was not statistically significant.

Table 5.1 presents the associations between full immunisation coverage in children in all three DHSs and various child, maternal/household and community-level factors. The population of mothers who had children age 12-23 months sampled rose from just 999 in 2003 NDHS to 4945 in NDHS 2008 and 5900 in 2013 NDHS. The limited sample in 2003 NDHS reduces overall statistical power and the chance of achieving statistical significance in the relationship between FIC and sociodemographic variables (Hinkin, 1998).

For all child level factors, FIC increased across all categories in successive NDHS. Birth order 1 children had the highest FIC, in all three NDHS. Within birth order characteristics, the variation of FIC across the categories was not significant in 2003 but became significant in 2008 and 2013. In 2003, the female FIC was 9.1% higher than males (female =17.0% and males =7.9%), the difference fell to 0.2% in 2008 (female =22.8% and males =22.6%) and the FIC in 2013 was 25.7 and 24.9% for males and females respectively (0.8% difference). The very low FIC of males in the 2003 DHS may have been due to the unfounded fear from most Muslims in the Northern regions of Nigeria that the vaccines contained chemical substances that would make boys sterile (Kapp, 2004; Ophori *et al.*, 2014). In all NDHS, FIC was related to the place of delivery, with FIC for children delivered in a health facility ranging from 27.1 – 46.3, and from 2.68 – 12.4 for home deliveries. Home deliveries were most common in all DHS: 2003 (51.3%), 2008 (62.7%) and 2013(61.9%). The FIC of children whose mothers' attended ANC was several times more than those with mothers who did not in the NDHS. It was good that in 2003, 2008 and 2013, more children had mothers who attended ANC than those who did not.

FIC coverage increased in all categories of all household variables in successive NDHS. FIC increased with increasing level of maternal education, except in the 2003 NDHS. Children of mothers with secondary education had a higher FIC coverage than children of mothers with higher education in 2003 DHS, which may be due to the small weighted sample size of higher educated mothers' children of 38 that was less than 50. This result may be inaccurate as the DHS has cautioned on the interpretation of results from sample sizes of less than 50 (United States Agency for International Development, 2008). Female-headed households were few, but rose from 7.6% of all households in 2003 to 9.5% in 2008 and 10.1% in 2013, while their children consistently had higher FIC coverage than peers from male-headed households. Children from Muslim homes, who made up the majority in each NDHS, had lower FIC than Christian children, with FIC in Christian children at least thrice that of Muslim children in each NDHS. The majority of children had mothers who were employed, and FIC was higher for children of employed than unemployed mothers. There was no particular pattern to the variation of FIC coverage across the categories of current maternal marital status, children whose mothers were never married (2003=26.8%, 2008=32.8% and 2013=46.2%) had higher FIC than children with married parents (2003=12.9%, 2008=22.6% and 2013=24.7%) and those whose parents are no longer together (2003=2.3%, 2008=19.2% and 2013=32.8%). Mothers who never married may have a lower number of children, and the lower birth order has higher FIC coverage compared to the higher birth orders, hence the higher FIC coverage of their children compared to the other categories. For the variable, decision-making on the spending of mother's income, in 2003 the highest FIC coverage was for 'mother alone' and lowest for 'spouse alone', in 2008 the highest FIC coverage was 'mother & spouse' and lowest was 'spouse alone' and in 2013 the highest FIC coverage was 'in mother & spouse' and lowest in 'no income mother'. Children from households that were exposed to media, had FIC coverage many times that of peers from homes with no media exposure in all the surveys. Children from the homes that were exposed to media formed the majority of the sample. FIC coverage was related to household wealth, the wealthier the household, the higher the coverage. Generally, children from poor households had the lowest FIC coverage, followed by the middle children and the rich households had children with the highest coverage.

The three community factors, place of residence, region and distance to health facility showed significant association with FIC coverage in all NDHS. The percentage point difference between FIC in urban and rural places of residence increased with successive NDHS, from 17.7 in 2003 (urban=25.1% and rural=7.4%), to 21.3 in 2008 (urban=37.5% and rural=16.2%) and 26.7 in 2013 (urban=42.5% and rural=15.8%). This huge urban/rural disparity in FIC coverage is a challenge since about 69% of 2003, 70% of 2008 and 64% of 2013 sample population were rural residents. Also, the increased urban population in 2013 was in line with the faster growth of urban settlements compared to rural area in Nigeria (UN HABITAT, 2016a). The rise in the level of FIC coverage did not affect the regional pattern over the years. The northern regions consistently performed less than their southern peers did. The Northwest region which is the most populous of the six regions in Nigeria, consistently had the least FIC coverage. The Southeast had the highest FIC coverage in 2003 and 2008, and in 2013 was next to the highest (Southeast=51.7% and Southsouth=52%). The distance to the nearest health facility to seek health care was no/not a big problem to most mothers, and their children had a higher FIC coverage(2003=15.9%, 2008=27.7% and 2013=30.0%) compared to those whose mothers found the distance a big problem (2003=3.9%, 2008=14.6% and 2013=14.9%).

Major differences were in the relationship between FIC and sociodemographic variables such as birth order, sex, maternal education level, mothers 'age at child's birth, current marital status, decision maker on spending of mothers income and household wealth across the 2003, 2008 and 2013 NDHS. In the case of the sex of household head, the pattern in 2003 NDHS is the same as in 2008 and 2013 but had lower level and the lack of significance may likely be due to the small sample size in 2003 NDHS. In the remaining sociodemographic variables, which had similar association with FIC coverage, the coverage varied a lot. Therefore pooling the NDHS datasets will provide definite information on the FIC coverage over the years, since the three NDHS differ in the relationship between FIC coverage and some sociodemographic variables. Also, in most cases with similar association pattern, the level of FIC coverage and significance of the association varied.

Table 5.1: Fully immunised child coverage across categories within sociodemographic characteristics reported in the NDHS 2003, 2008 and 2013 (weighted data).

Independent variable	Dependent variable					
	NDHS 2003 (weighted sample size =999) FIC=12.9%		NDHS 2008 – (weighted sample size=4945) FIC=22.7%		NDHS 2013 – weighted sample size =5900) FIC=25.3%	
	FIC Coverage % and total(row) frequency ()	Chi test P value	FIC Coverage % and total(row) frequency()	Chi test P value	FIC Coverage % and total(row) frequency ()	Chi test P value
Child level						
Birth order 1 2-3 4-5 >=6	 17.8 (187) 13.4 (332) 14.4 (220) 7.6 (259)	0.093	 27.2 (940) 26.4 (1652) 22.3 (1208) 14.0 (1146)	0.001	 34.1 (1173) 27.7 (1851) 25.0 (1444) 15.7 (1433)	0.001
Sex Male Female	 9.1 (512) 17.0 (486)	0.011	 22.6 (2448) 22.8 (2497)	0.086	 25.7 (3066) 24.9 (2834)	0.529
Place of delivery Home Health facility	 5.0 (641) 27.1 (358)	0.001	 2.68 (3099) 34.59 (1847)	0.001	 12.4 (3652) 46.3 (2248)	0.001
Antenatal attendance No Yes Don't know/ missing	 0.81 (333) 18.1 (599) 26.9 (66)	0.002	 2.4 (1720) 35.1 (2563) 27.2 (662)	0.001	 4.5 (1907) 35.6 (3580) 32.5 (414)	0.001
Household Level						
Maternal education level No education Primary Secondary Higher	 3.8 (484) 13.0 (247) 32.4 (230) 11.3 (38)	0.001	 6.5 (2248) 23.1 (1107) 41.4 (1283) 61.2 (307)	0.001	 6.9 (2807) 26.3 (1062) 46.6 (1608) 64.1 (423)	0.001
Sex of Household head Male	12.3 (923)	0.166	22.0 (4475)	0.002	23.7 (5304)	0.001

Female	20.2 (76)		29.2 (470)		39.6 (596)	
Religion						
Christian	25.8 (355)		38.5 (2199)		46.4 (2238)	
Islam	5.4 (632)	0.001	10.0 (2650)	0.001	12.4 (3568)	0.001
Traditionalist/ others	27.6 (12)		10.9 (97)		15.0 (94)	
Mother employment status						
No	9.2 (356)	0.045	16.0 (1586)	0.001	20.0 (1705)	0.001
Yes	15.0 (643)		25.8 (3360)		27.5 (4196)	
Maternal age at the child's birth						
14-19	4.61 (167)		10.1 (698)		13.3 (841)	
20-29	15.0 (533)		23.6 (2671)		26.7 (3123)	0.001
30-39	13.0 (261)	0.072	27.5 (1332)	0.001	28.9 (1659)	
40-49	19.1 (37)		22.5 (244)		25.0 (277)	
Current marital status						
Never married	26.8 (18)		32.8 (90)		46.2 (114)	0.001
Married/partner	12.9 (958)	0.069	22.6 (4748)	0.079	24.7 (5637)	
No longer together	2.3 (22)		19.2 (108)		32.8 (150)	
Decision maker on spending of mothers income						
Mother alone	14.5 (410)	0.815	22.7 (1739)		23.0 (2658)	
mother & spouse	14.1 (85)		42.8 (465)	0.001	40.0 (677)	0.001
spouse alone	10.7 (66)		18.5 (361)		29.9 (383)	
No income mother /missing??	11.7 (439)		21.3 (2376)		22.8 (2183)	
Media exposure						
No	6.0 (236)	0.015	8.1 (1519)	0.001	9.6 (2030)	0.001
Yes	15.1 (762)		29.1 (3426)		33.6 (3871)	
Household wealth						
Poor	13.1 (315)		19.0 (2486)		21.8 (2889)	
Middle	12.7 (607)	0.978	26.2 (2228)	0.001	28.2 (2732)	0.001
Rich	13.8 (77)		28.2 (231)		33.7(280)	
Community level						
Place of residence						
Urban	25.1 (312)	0.001	37.5 (1498)	0.001	42.5 (2113)	0.001
Rural	7.4 (687)		16.2 (3447)		15.8 (3787)	

Region						
Northcentral	12.4 (149)		25.9 (640)		26.8 (812)	
Northeast	6.0 (219)		7.6 (780)		14.2 (1023)	
Northwest	3.7 (356)	0.001	6.0 (1545)	0.001	9.6 (2100)	0.001
Southeast	44.6 (74)		42.9 (504)		51.7 (550)	
Southsouth	20.8 (120)		36.1 (663)		52.0 (591)	
Southwest	32.5 (81)		42.8 (814)		40.9 (823)	
Distance to nearest Health Facility						
No/Not a big problem	15.9 (753)	0.001	27.7 (3048)	0.001	30.0 (4077)	0.001
Big problem	3.9 (246)		14.6 (1897)		14.9 (1823)	

5.3 Analysis of Pooled NDHS 2003, 2008 and 2013 Dataset

5.3.1 Descriptive analysis of pooled data

The pooled dataset had information from 11,844 children aged 12-23 months, with 7921 (69%) rural and 3921 (31%) urban setting children (Table 5.2). About 23% of the children were fully immunised, which was higher than the values in 2003 and 2008 NDHS but lower than 2013 NDHS.

The FIC was related to all but one of the selected sociodemographic variables. These variables are birth order, place of delivery, antenatal attendance, maternal education level, sex of household head, religion, mother employment status, maternal age at the child's birth, current marital status, decision maker on spending of mother's income, media exposure, household wealth, place of residence, region and distance to the nearest health facility. Only sex of the child was not significantly associated with FIC, similar to findings in 2008 and 2013 NDHS but contrasting to the 2003 NDHS. The wide urban–rural disparity in FIC remained, with a 24 percentage point difference. Further analysis with the use of regression models was used to explore the role of place of residence in the relationship between FIC and sociodemographic variables.

Table 5.2: Sociodemographic characteristics and their crude association with full immunisation coverage (Pooled NDHS 2003, 2008 and 2013 weighted data, total sample 11,844)

Independent variables	Dependent variable								
	Pooled=11844, FIC=23.2%			Rural = 7921 (69%), FIC= 15.2%			Urban = 3923 (31%), FIC =39.2%		
	Number FIC/ Total number	FIC %	P-value	Number FIC/ Total number	FIC %	P-value	Number FIC/ Total number	FIC %	P-value
Child Level									
Birth order									
1	689/2300	30.0		254/1,424	17.9		435/ 876	49.7	
2-3	992/3835	25.9	0.001	427/2,444	17.5	0.001	566/1,391	40.7	0.001
4-5	658/2871	22.9		287/1,918	15.0		370/952	38.9	
>=6	405/2839	14.3		237/2,135	11.1		168/704	23.8	
Sex									
Male	1388/6027	23.0	0.739	606/4,038	15.0	0.604	782/1,988	39.3	0.903
Female	1357/5818	23.3		600/3,882	15.5		757/1,935	39.1	
Place of delivery									
Home	784/7392	10.6		514/5,919	8.7		269/1,473	18.3	
Health facility	1961/4452	44.0	0.001	692/2,002	34.6	0.001	1,269/2,450	51.8	0.001
Antenatal attendance									
No	129/3961	3.3	0.001	101/3,510	2.9	0.001	28/451	6.3	
Yes	2283/6742	33.9		942/3,689	25.5		1,341/3,053	43.9	0.001
Don'tknow/ missing	332/1142	29.1		163/722	22.6		169/420	40.3	
Household level									
Maternal education level									
No education	359/5539	6.5		247/4,621	5.3		112/918	12.2	
Primary	567/2417	23.5	0.001	318/1,629	19.5	0.001	249/788	31.6	0.001
Secondary	1355/3120	43.4		535/1,488	35.9		821/1,632	50.3	
Higher	463/768	60.3		107/183	58.2		357/485	61.0	

Sex of Household head									
Male	2355/10702	22.0	0.001	1,020/7,212	14.2	0.001	1,336/3,489	38.3	0.009
Female	389/1143	34.1		186/708	26.3		203/434	46.7	
Religion									
Christian	1947/4644	41.9		874/2,674	32.7		1,073/1,971	54.5	
Islam	735/6365	11.5	0.001	311/4,657	6.7	0.001	424/1,708	24.8	0.001
Traditionalist/ others	26/835	7.5		20/590	3.5		42/245	17.1	
Mother employment status									
No	628/3647	17.2	0.001	280/2,546	11.0	0.001	348/1,101	31.6	0.001
Yes	2116/8198	25.8		926/5,375	17.2		1,190/2,822	42.2	
Maternal age at the child's birth									
14-19	190/1706	11.1		120/1,377	8.7		70/329	21.3	
20-29	1544/6327	24.4	0.001	642/4,122	15.6	0.001	903/2,206	40.9	0.001
30-39	879/3253	27.0		388/2,044	19.0		491/1,209	40.6	
40-49	132/559	23.5		56/379	14.9		75/180	41.8	
Current marital status									
Never married	87/222	39.2		45/139	32.5		42/83	50.3	
Married/partner	2587/11343	22.8	0.001	1,120/7,605	14.7	0.001	1,467/3,739	39.3	0.040
No longer together	70/279	25.1		41/178	22.9		30/102	28.9	
Decision maker on spending of mothers income									
Mother alone	1065/4807	22.2		391/3,082	12.7		675/1,725	39.1	
mother& spouse	481/1226	39.3	0.001	223/726	30.8	0.001	258/500	51.5	0.001
spouse alone									
No income mother	188/810	23.3		80/545	14.7		108/265	40.8	
	1010/5002	20.2		510/3,561	14.3		498/1,433	34.8	

Media exposure									
No	332/3785	8.8	0.001	245/3,297	7.4	0.001	88/488	17.9	0.001
Yes	2412/8059	29.9		961/4,624	20.8		1,451/3,435	42.2	
Household wealth									
Poor									
Middle	1143/5690	20.1	0.001	521/4038	12.9	0.001	622/1652	37.7	
Rich	1431/5567	25.7		593/3491	17.0		838/2076	40.4	0.455
	170/587	28.9		92/391	23.5		78/196	39.8	
Community Level									
Place of residence									
Urban									
Rural	1538/3923	39.2	0.001						
	1206/7921	15.2							
Region									
Northcentral	402/1601	25.1		251/1,228	20.4		152/374	40.6	
Northeast	218/2022	10.8		126/1,477	8.5		93/545	17.0	
Northwest	308/4000	7.7	0.001	147/3,190	4.6	0.001	161/811	19.9	0.001
Southeast	533/1128	47.3		199/487	40.8		334/641	52.2	
Southsouth	571/1374	41.6		328/938	35.0		243/436	55.9	
Southwest	712/1719	41.4		156/601	26.0		555/1,118	49.7	
Distance to nearest Health Facility									
No/Not a big problem	2185/7878	27.7	0.001	863/4,633	18.6	0.001	1,322/3,245	40.8	0.018
Big problem	559/3967	14.1		343/3,288	10.4		216/678	31.9	

5.3.2 Multilevel logistic regression analysis of the pooled NDHS 2003, 2008 and 2013

The NDHS data structure was considered in the analysis with the use of the multilevel logistic regression models to investigate the relationship between the selected sociodemographic factors and FIC of children aged 12-23 months in the pooled 2003, 2008 and 2013 NDHS. Table 5.3 presents the multivariable logistic regression that made use of four models. The models were fitted progressively, starting from Model 0 and Model 3 was the last. Model 0 included the dependent variable (FIC) and two independent variables, place of residence and NDHS variable that indicated each NDHS as a time category. In Model 1, the child level variables were added, then household variables for Model 2 and finally, Model 3 had community variables and place of residence interactions with some child and household variables introduced into the model. Fixed effects (adjusted odds ratios (aOR) and 95% confidence interval), random effects (variance components), and goodness of fit of the models are presented in Table 5.3.

In this pooled dataset, place of residence was associated with FIC, urban children were more likely to be fully immunised than children in rural communities. However, this significant relationship in Models 0 to 2 was lost in Model 3 with the introduction of community variables and interaction terms, but the higher odds of the urban child (aOR=1.60, 95% CI=0.60-4.24) being fully immunised compared to the rural child remained. In Model 0, the result showed progressively significantly increased higher odds of a child being fully immunised, with 2013 NDHS (aOR=3.12, 95% CI=2.24-4.34) higher than 2008 NDHS (aOR=2.02, 95% CI=1.47-2.78), which was higher than the reference, 2003 NDHS. This pattern continued in all the subsequent models fitted.

Child level variables (birth order, place of delivery and maternal attendance of ANC) were introduced in Model 1. The likelihood of the child being fully immunised reduced as the child's birth order increased. The birth orders 1, 2-3 and 4-5 were significantly related with 1.6, 1.52 and 1.24 times, respectively, higher odds of being fully immunised than the birth order 6 or more. Also being delivered in the health facility compared to home delivery significantly increased the child's odds of full immunisation. While the child whose mother attended ANC compared to those with mothers who did not, was 11.3 times more likely to be fully immunised.

With the household level variables (maternal education level, sex of household head, maternal age at the child's birth, maternal marital status, decision maker on maternal income, media exposure, household wealth) being added in model 2, the significant relationship between FIC and the child variables remained but with reduced odds ratio estimates except for birth order 1 that had a marginally higher odds ratio in Model 2 (aOR=1.82, 95% CI=1.30-2.55) compared to Model 1 (aOR=1.60, 95% CI=1.27-2.01). As suggested in several studies (Antai, 2009b; Adedokun *et al.*, 2017), the more educated the mother, the greater the odds of the child being fully immunised. Children of mothers with primary education (aOR=2.14, 95% CI=1.66-2.75), secondary education (aOR=3.42, 95% CI=2.57-4.56) and higher education (aOR=5.08, 95% CI=3.36-7.66) had higher odds of being fully immunised than children of mothers with no education. The child from a female-headed household (aOR=1.16, 95% CI=0.91-1.48) had 16% more odds of being fully immunised compared to peers from a male-headed household. The 2002/2003 religious inspired concerns about the real purpose of global funded immunisation programme in Nigeria may have played a role in the reduced fully immunised odds of the Muslim child compared to the Christian child, whose full immunisation odds was 3.23 times higher. The age of the mother at the birth of the child was significantly related to the child's fully immunised odds with the children of the youngest mothers having the highest odds of not getting all the recommended immunisation. This evidence strengthens the medical advice that cautions against early childbearing. Parents' exposure to media, print and electronic significantly influenced the odds that a child will be fully immunised. The odds of children from households who were exposed to media (aOR=1.89, 95% CI=1.51-2.36) was about twice of children whose parents were not exposed to media. Although the odds of completing immunisation by children of the rich (aOR=1.31, 95% CI=0.93-1.95) and Middle class (aOR=1.14, 95% CI=0.96-1.35) were higher than children of the poor, these associations did not reach statistical significance, a result that was similar to the findings of 2013 NDHS multilevel analysis in Chapter 4.

The introduction of community variables (regions and distance to the health facility) including interactions of place of residence with maternal education, household wealth, maternal antenatal care, place of delivery and maternal age at birth was done in Model 3. This model with all the variables fitted affected the odd estimates and significance of relationships between FIC and the variables seen in the earlier models. The association between birth order and maternal ANC, and FIC were found to be significant with reduced odds ratios. For the remaining child level variable, place of delivery, delivery in the health facility compared to home delivery had increased fully immunised odds ratio (aOR=3.86, 95% CI=1.94-7.67) compared to model 1 (aOR=3.75, 95% CI=3.00-4.68) and Model 2 (aOR=2.07, 95% CI=1.69-2.54). As expected, maternal education's association with completing immunisation in children remained significant: compared to children whose mother had no education, the fully immunised odds of children of mothers with primary education fell from 2.14 (model2) to 2.11, while for the children with secondary and higher educated mothers it increased from 3.42 and 5.08 (model 2) to 3.83 and 6.57 respectively. A similar result was obtained in household media exposure where odds of being fully immunised for the child from a media exposed household compared to children from the household lacking media exposure was slightly higher than in model 2. The significant association between religion and FIC continued, and the Christian child (aOR=2.37, 95% CI=1.82-3.10) still had higher odds compared to the Muslim child. The relationship between wealth and FIC was not significant. Children living in the Northwest and Northeast were least likely to complete their immunisation compared to the other four regions in Nigeria. The Northeast and Northwest are the most populous and have the highest levels of illiteracy in Nigeria (National Population Commission, 2014). Children of parents who considered the distance to the health facility when seeking health care, a big problem had the odds of being fully immunised 69% less than children of parents who did not find the distance to the health facility a big problem. The results of the interactions between place of residence and maternal education (aOR=0.92, 95% CI=0.75-1.14), household wealth (aOR=1.24, 95% CI=0.93-1.66), maternal antenatal care (aOR=1.31, 95% CI=0.88-1.96), place of delivery (aOR=0.64, 95% CI=0.43-0.95) and maternal age at birth (aOR=1.05, 95% CI=0.83-1.33) was of variable significance. Only the interaction of place of residence and place of delivery was significant, which suggest that the child's odds of being fully immunised was reduced by the place where the child was delivered. Understanding this significant interaction required stratified analyses by urban/rural residence.

Table 5.3: Association between socio-demographic factors and full immunisation status (assessed at 12-23 months) in Nigeria, multivariable logistic regression analysis (pooled DHS data)

Variable	Model 0		Model 1		Model 2		Model 3	
	Adjusted Odds ratio 95% Confidence interval	P value	Adjusted Odds ratio 95% Confidence interval	P value	Adjusted Odds ratio 95% Confidence interval	P value	Adjusted Odds ratio 95% Confidence interval	P value
Place of Residence								
Rural	1.00		1.00		1.00		1.00	
Urban	5.70 (4.30,7.55)	0.001	2.12 (1.75,2.59)	0.001	1.78 (1.45,2.18)	0.001	1.60 (0.60,4.24)	0.346
DHS								
2003	1.00		1.00		1.00		1.00	
2008	2.02 (1.47,2.78)	0.001	3.00 (2.15,4.19)	0.001	2.74 (1.82,4.11)	0.001	3.24 (2.10,5.00)	0.001
2013	3.12 (2.24,4.34)	0.001	4.17 (2.96,5.89)	0.001	3.81 (2.51,5.77)	0.001	4.49 (2.89,7.00)	0.001
CHILD LEVEL FACTORS								
Birth order								
>=6			1.00		1.00		1.00	
1			1.60 (1.27,2.01)	0.001	1.82 (1.30,2.55)	0.001	1.69 (1.19,2.41)	0.004
2-3			1.52 (1.23,1.87)	0.001	1.47(1.11,1.94)	0.007	1.38 (1.03,1.85)	0.033
4-5			1.24 (1.00,1.54)	0.053	1.19 (0.92,1.53)	0.178	1.13 (0.86,1.47)	0.376
Place of delivery								
Home			1.00		1.00		1.00	
Health facility			3.75 (3.00,4.68)	0.001	2.07 (1.69,2.54)	0.001	3.86 (1.94,7.67)	0.001

Antenatal attendance No Yes Don't know			1.00 11.33(8.06,15.92) 7.63(5.30,10.98)	0.001 0.001	1.00 7.44 (5.32,10.39) 4.80 (3.31,6.98)	0.001 0.001	1.00 4.42 (2.00,9.76) 1.79 (0.44,7.28)	0.001 O.417
HOUSEHOLD LEVEL FACTORS								
Maternal education level No education Primary Secondary Higher					1.00 2.14 (1.66,2.75) 3.42 (2.57,4.56) 5.08 (3.36,7.66)	0.001 0.001 0.001	1.00 2.11 (1.35,3.31) 3.81 (1.79,8.12) 6.57 (2.32,18.59)	0.001 0.001 0.001
Sex of Household head Male Female					1.00 1.16(0.91,1.48)	0.245	1.00 1.10(0.85,1.41)	0.489
Religion Islam Christian Traditionalist/ other					1.00 3.23 (2.50,4.17) 0.84 (0.52,1.38)	0.001 0.495	1.00 2.37 (1.82,3.10) 0.85 (0.51,1.41)	0.001 0.515
Mother employment status No Yes					1.00 1.22 (0.93,1.60)	0.146	1.00 1.16 (0.88,1.54)	0.297

Maternal age at the child's birth 14-19 20-29 30-39 40-49					1.00 2.22(1.62,3.04) 2.85(1.95,4.16) 3.31(1.96,5.56)	 0.001 0.001 0.001	1.00 1.92(1.12,3.29) 2.17(0.89,5.29) 2.30(0.62,8.46)	 0.017 0.087 0.212
Current marital status Never married Married/partner No longer together					1.00 0.69(0.43,1.12) 0.77(0.40,1.48)	 0.134 0.437	1.00 0.77(0.47,1.28) 0.93(0.47,1.83)	 0.310 0.829
Decision maker on spending of mothers income No income mother /missing Mother alone mother& spouse spouse alone					1.00 1.12 (0.86,1.46) 1.24 (0.91,1.69) 0.77 (0.53,1.12)	 0.410 0.169 0.169	1.00 1.16 (0.88,1.54) 1.18 (0.85,1.63) 0.75(0.51,1.11)	 0.301 0.320 0.156
Media exposure No Yes					1.00 1.89 (1.51,2.36)	 0.001	1.00 1.91 (1.51,2.42)	 0.001
Household wealth Poor Moderate Rich					1.00 1.14 (0.96,1.35) 1.31 (0.93,1.85)	 0.129 0.126	1.00 0.78 (0.48,1.27) 0.62 (0.23,1.69)	 0.316 0.348

COMMUNITY LEVEL FACTORS								
Region Northcentral Northeast Northwest Southeast Southsouth Southwest							 1.00 0.55 (0.40,0.77) 0.30 (0.21,0.43) 1.10 (0.78,1.55) 1.55 (1.11,2.16) 0.90 (0.65,1.24)	 0.001 0.001 0.593 0.009 0.512
Distance to nearest Health Facility Big problem No/Not a big problem							1.00 1.69 (1.37,2.09)	 0.001
Interactions with place of residence Maternal Education Household wealth ANC attendance Place of delivery Mothers birth age							0.92(0.75,1.14) 1.24 (0.93,1.66) 1.31 (0.88,1.96) 0.64 (0.43,0.95) 1.05 (0.83,1.33)	0.454 0.140 0.183 0.028 0.685

5.4 Analysis of the pooled DHS dataset (2003, 2008 and 2013) stratified by rural and urban place of residence

5.4.1 Descriptive analysis of the pooled NDHS datasets (2003, 2008 and 2013)

Also presented in Table 5.2 were cross-tabulations and p-values of the chi-square test of the within variable association with FIC, for urban and rural residency separately. In both rural and urban communities, FIC was associated with, and varied across, child birth order, child place of delivery, maternal antenatal care attendance, maternal education level, sex of household head, maternal religion, maternal employment status, maternal age at the child's birth, maternal current marital status, decision-maker on spending of mother's income, media exposure by mother, household wealth, region and distance to nearest health facility characteristics. Comparatively, FIC was much higher in the urban than rural setting, but FIC pattern across variable categories was similar, with the lowest to highest categories in the urban setting similar to that in the rural setting. However, within most sociodemographic variables, the point difference between the category with the lowest and highest FIC was greater in urban than rural areas: child birth order (rural -6.8 and urban -25.9), child place of delivery (rural -25.9 and urban -33.5), maternal antenatal care attendance (rural -19.7 and urban -34.0), maternal employment status (rural -6.2 and urban -10.6), maternal age at the child's birth (rural -6.2 and urban -20.5), maternal current marital status (rural -9.6 and urban -21.4), media exposure by mother (rural -13.4 and urban -24.3), region (rural -36.2 and urban -38.9) and distance to nearest health facility (rural -8.2 and urban -8.9). This wider FIC disparity in the urban area is most likely due to increased urban heterogeneity that results from living in some part of the urban settlement (Unger and Riley, 2007; Unger, 2013).

The FIC was about the same for both sexes in each place of residence: urban (female 39.1% and male 39.3%) and rural (female 15.5% and male 15.0%). FIC coverage was highest for first birth order children and lowest for sixth or more birth order children in both rural and urban areas. The FIC was lower for children delivered at home (8.69% in rural and 18.29% in urban) compared to those delivered in the health facility (34.55% in rural and 51.78% in urban). In addition, 73% of the rural children were delivered at home, in contrast to 38% of urban children. The majority of mothers attended antenatal care and their children had a higher FIC than children whose mothers did not attend antenatal care in both urban and rural settings. ANC attendance was higher in urban (78%) than in rural communities (47%).

For both rural and urban areas, FIC rates increased with increased maternal education, FIC was 5.34% in rural and 12.2% in urban children of mothers who had no formal education, compared to 58.16% and 60.97% respectively for children of mothers with higher education. Higher FIC was recorded in female-headed households compared to male headed ones in both places of residence. The highest proportion of FIC was among Christians in the urban areas (54.5%) and a similar result was observed in the rural setting (32.70%). Working mothers made up the majority in rural (67.86%) and urban (71.94%), and their children had higher FIC compared to non-working mothers, of 17.23% and 10.99% in rural and 42.17% and 31.63% in urban respectively. The lowest FIC (rural of 8.69% and urban of 21.13%) was found in mothers who had their children when aged 14-19 years old compared to the older age groups (20-29 years, 30-39 years and 40-49years). For marital status, in the rural area, FIC was highest among children of mothers who had never married (32.5%) and lowest in the married mothers group (14.7%) who made up 96.0% of the rural dwellers. While in urban areas, the highest FIC was among the never married mothers' cohort (50.3%) and lowest in children whose parents were no longer together. The best FIC was attained in children whose parents jointly decided how maternal income was spent in both rural (30.8%) and urban (51.5%) settings. Most urban (87.56%) and rural (58.38%) households were exposed to media, and FIC was higher among those who were (42.2% for urban and 20.8% for rural) than among no media exposure households. The FIC varied with wealth differently in urban and rural settlements. As expected, the richer the rural dweller, the higher the FIC (Poor 12.9%, Middle 17.0% and Rich 23.5%), while in the urban setting, FIC was similar among the wealth categories (Poor 37.7%, Middle 40.4% and Rich 39.8%). The children of the urban poor had higher FIC than children of the rural rich.

In the urban setting, FIC was lowest in the Northeast (17.0%) and highest in the Southsouth (55.9%) region, while for rural settlements, Northwest (4.6%) and Southeast children (40.8%) had the lowest and highest FIC respectively. The Northeast and Northwest make up 50.9% (6023/11844) of the total. In both rural and urban areas, the distance to the nearest health facility to seek health care was no/not a big problem to most (58.5% for rural and 82.7% for urban), and had higher FIC (18.6% for rural and 40.8% for urban) than children of mothers who found the distance a big problem (10.4% for rural and 31.9% for urban).

5.4.2 Multilevel analysis of the pooled NDHS datasets (2003, 2008 and 2013) stratified by rural and urban place of residence

In section 5.4.1, results suggested that place of residence was a key variable associated with FIC, but it was not possible to know the similarities and differences in the odds of a child being fully immunised across the other socio-demographic characteristics if residing in the urban or rural place of residence. In addition, the significant interaction between the place of residence and place of delivery points to the likelihood of the various sociodemographic variables playing different roles in rural versus urban residence. Consequently, the association between FIC and sociodemographic variables were explored, by multilevel logistic regression analysis of the pooled dataset stratified into urban and rural. Each place of residence had a 3-level logistic regression with 4 models fitted to explore the relationship between FIC and selected socio-demographic variables. Model 0 included the dependent variable (FIC). In Model 1, the child level variables were added, then the inclusion of the household variables for Model 2 and finally, Model 3 had community variables. The fixed effects (adjusted odds ratios (aOR) and 95% confidence interval), random effects (variance components), and goodness of fit of the models are presented in Table 5.4.

Results from Model 1 show a significant association between FIC and place of delivery and maternal antenatal attendance in both rural and urban communities, but the birth order was significantly related to FIC only in the urban area. This association pattern remained in subsequent models.

In Model 2, maternal education level, mother's religion, mother's age at the birth of the child and household media exposure were significantly associated with FIC in both rural and urban settings. In rural areas only, one (mother and spouse) of the four categories in the decision-maker on spending of mother's income characteristics variable was significantly associated with FIC.

Model 3 had all the selected sociodemographic characteristics fitted, and of the four Models it had the best fit, indicated by having the lowest Akaike information criterion value. In both rural and urban areas, factors significantly associated with FIC were place of delivery, maternal ANC attendance, maternal education level, mother's religion, mother's age at the birth of the child, household media exposure, region and distance to the nearest health facility when seeking health care. Only in the urban area was the child's birth order significantly related to FIC. Further discussion on the similarities and differences in the FIC in both places of residence across the sociodemographic variables were based on the results of Model 3. With respect to the different population of the rural and urban areas, the comparison of the quantitative results was cautiously carried out in the discussion of the patterns of the adjusted odds ratios.

Although FIC was significantly related to place of delivery and maternal ANC in both rural and urban residence, the pattern of their categories adjusted odds ratio differed. The increased fully immunised odds of being delivered in the health facility compared to home delivery was higher among urban dwellers than rural. A similar result was observed in the birth order characteristics. This finding may be suggestive of wider disparity in the urban than rural areas. In contrast, for maternal ANC, rural areas had the largest point difference between reference, non-ANC attendance and category with highest odds, ANC attendance (aOR=8.37, 95% CI=5.34-13.12) compared to urban values (aOR=5.65, 95% CI=2.73-11.71). The strong influence of ANC attendance on odds of being fully immunised in the rural setting showed the opportunity that increasing the number of rural women attending antenatal from the present 46.6% (3689/7921) to the urban ANC attendance of 77.8% (3053/3923) will improve rural FIC.

The adjusted odds of the child being fully immunised significantly increased with higher maternal education level in both urban and rural areas, with urban areas having higher values for the variable categories than rural area. The results for mothers' age at birth of the child was similar, with the higher adjusted odds in the urban compared to corresponding rural values. In rural areas, the categories of the religion and household exposure to media had higher adjusted odds ratio compared to the urban. The urban dweller would be expected to be more informed and enlightened about immunisation as there are more media establishment and health facilities that provide these services in the urban compared to the rural location (Antai, 2011). The lack of an adequate number of health facilities and media outfits in the rural area may explain why the effect of media exposure and religion was more in the rural area.

The region was among the variables that are related to the child being fully immunised in both rural and urban areas. In urban areas, the child who resided in the Northeast had the lowest odds of being fully immunised compared with children in the other regions of Nigeria. However, in the rural area, children that resided in the Northwest had the lowest odds of being fully immunised compared to the other regions. These two regions are predominantly populated by Muslims and the least educated in Nigeria (National Population Commission, 2014). The distance to the nearest health facility when seeking health care was significantly related to FIC with similar odds of being fully immunised in both places of residence.

The multilevel regression analysis accounted for the hierarchical data style and quantified the unexplained differences in FIC that are mostly due to social, cultural and other rare occurrence. In both places of residence, the variation of fully immunised child odds was significant only in communities. In the final model that controlled for the child, household and community level factors, the variance across the rural and urban area communities was (τ = 0.21,SE = 0.14) and (τ =

0.34,SE = 0.80), with 20% and 18% of these variation in the fully immunised child odds attributed to community level factors respectively.

The goodness of fit measurement with the use of Akaike information criterion reduced as subsequent models were fitted, which indicated that the final model was the best.

Table 5.4: Association between socio-demographic factors and full immunisation status (assessed at 12-23 months) in Rural and Urban Nigeria, Multilevel logistic regression analysis (DHS 2003, 2008 and 2013 data

Variable /Category	RURAL			URBAN		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
	Adjusted Odd ratio / (95% C.I)	Adjusted Odd ratio / (95% C.I)	Adjusted Odd ratio / (95% C.I)	Adjusted Odd ratio / (95% C.I)	Adjusted Odd ratio / (95% C.I)	Adjusted Odd ratio / (95% C.I)
CHILD						
Birth order						
>=6	1.00	1.00	1.00	1.00	1.00	1.00
1	1.28 (0.95,1.73)	1.37 (0.87,2.17)	1.30 (0.81,2.08)	3.00 (1.77,4.95)	3.23 (1.66,6,21)	2.89 (1.49,5.58)
2-3	1.30 (0.99,1.70)	1.21 (0.84,1.76)	1.15 (0.78,1.68)	2.27 (1.43,3.60)	2.12 (1.23,3.63)	1.95 (1.13,3.38)
4-5	1.02 (0.77,1.35)	0.97 (0.69,1.37)	0.94 (0.66,1.34)	1.90 (1.19,3.03)	1.69 (1.03,2.76)	1.58 (0.96,2.60)
Place of delivery						
Home	1.00	1.00	1,00	1.00	1.00	1.00
Health facility	2.94 (2.24,3.85)	1.67 (1.28,2.17)	1.47 (1.12,1.94)	6.84 (4.00,11.70)	3.09 (2.02,4.75)	2.79 (1.83,4.25)
Antenatal attendance						
No	1.00	1.00	1.00	1.00	1.00	1.00
Yes	13.93 (8.99,21.58)	9.14 (5.88,14.22)	8.37 (5.34,13.12)	9.72 (4.53,20.84)	5.84 (2.84,12.03)	5.65 (2.73,11.71)
Don’t know	8.5 7(5.36,13.70)	5.73 (3.49,9.42)	5.07 (3.06,8.41)	6.06 (2.74,13.40)	3.24 (1.49,7.03)	3.01 (1.38,6.58)
HOUSEHOLD						
Maternal education level						
No education		1.00	1.00		1.00	1.00
Primary		2.00 (1.44,2.79)	1.67 (1.19,2.35)		2.35 (1.42,3.91)	1.97 (1.17,3.28)
Secondary		3.04 (2.06,4.49)	2.49 (1.68,3.69)		4.66 (2.65,8.19)	3.84 (2.20,6.71)
Higher		5.72 (2.88,11.38)	4.99 (2.48,10.06)		6.83 (3.36,13.90)	6.04 (2.99,12.20)
Sex of Household head						
Male						
Female		1.00	1.00		1.00	1.00
		1.17 (0.83,1.64)	1.09 (0.76,1.54)		1.25 (0.81,1.94)	1.19 (0.77,1.85)

Religion						
Islam		1.00	1.00		1.00	1.00
Christian		3.93 (2.69,5.74)	2.63 (1.79,3.86)		3.23 (2.09,4.99)	2.39 (1.53,3.73)
Traditionalist/ others		0.21 (0.10,0.47)	0.20 (0.09,0.45)		0.42 (0.21,0.80)	0.40 (0.20,0.77)
Mother employment status						
No		1.00	1.00		1.00	1.00
Yes		1.18 (0.83,1.67)	1.16 (0.81,1.67)		1.26 (0.73,2.18)	1.13 (0.65,1.98)
Maternal age at the child's birth						
14-19		1.00	1.00		1.00	1.00
20-29		1.90 (1.27,2.83)	1.76 (1.17,2.66)		3.24 (1.68,6.23)	2.94 (1.52,5.66)
30-39		2.45 (1.50,4.02)	2.19 (1.32,3.63)		4.21 (1.95,9.09)	3.57 (1.65,7.70)
40-49		2.25 (1.14,4.45)	2.05 (1.02,4.13)		6.83 (2.39,19.47)	5.54 (1.94,15.81)
Current marital status						
Never married		1.00	1.00		1.00	1.00
Married/partner		0.70 (0.37,1.32)	0.80 (0.42,1.54)		0.67 (0.27,1.69)	0.74 (0.29,1.87)
No longer together		0.97 (0.41,2.31)	1.14 (0.47,2.78)		0.55 (0.16,1.88)	0.69 (0.20,2.36)
Decision maker on spending of mothers income						
No income mother /missing		1.00	1.00		1.00	1.00
Mother alone		1.00 (0.71,1.42)	1.05 (0.73,1.50)		1.39 (0.80,2.39)	1.47 (0,84,2.58)
mother& spouse		1.51 (1.00,2.26)	1.42 (0.94,2.15)		1.04 (0.56,1.93)	1.04 (0.55,1.94)
spouse alone		0.79 (0.48,1.32)	0.80 (0.48,1.36)		0.75 (0.37,1.52)	0.74 (0.36,1.51)
Media exposure						
No		1.00	1.00		1.00	1.00
Yes		1.92 (1.46,2.53)	1.91 (1.43,2.54)		1.75 (1.06,2.90)	1.72 (1.03,2.88)
Household wealth						
Poor		1.00	1.00		1.00	1.00
Moderate		1.20 (0.95,1.52)	1.16 (0.91,1.48)		0.95 (0.71,1.27)	0.89 (0.66,1.20)
Rich		1.48 (0.93,2.37)	1.41 (0.87,2.29)		0.97 (0.51,1.83)	0.91 (0.47,1.73)

COMMUNITY						
Region Northcentral Northeast Northwest Southeast Southsouth Southwest			 1.00 0.61 (0.39,0.95) 0.26 (0.16,0.44) 1.15 (0.70,1.92) 1.73 (1.11,2.71) 0.85 (0.51,1.43)			 1.00 0.35 (0.18,0.68) 0.42 (0.22,0.81) 1.12 (0.62,2.00) 1.42 (0.76,2.64) 0.86 (0.51,1.43)
Distance to nearest Health Facility Big problem No/Not a big problem			 1.00 1.76 (1.35,2.29)			 1.00 1.75 (1.15,2.67)
Household variance (S.E)	0.155(0.179)	0.098(0.181)	0.104(0.164)	0.030 (0.075)	0.016 (0.153)	0.030 (0.155)
Household ICC	0.305	0.215	0.245			
Community variance (S.E)	1.291 (0.163)*	0.490(0.211)*	0.212(0.135)*	0.650 (0.107)*	0.359 (0.081)*	0.344 (0.80)*
Community ICC	0.273	0.200	0.200	0.156	0.199	0.176
Goodness of fit- AIC	5924	5517	5457	4335	4126	4112

S.E-standard error: AIC=Akaike information criterion : ICC=Intra class correlation: * =pvalue<0.005

5.5 Conclusion

5.5.1 Chapter summary

- The 2003, 2008 and 2013 NDHS were analysed separately, pooled and stratified by urban and rural location. The sampled population was 999 in 2003 NDHS, 4945 in 2008 NDHS and 5900 in 2013 NDHS.
- The FIC patterns in the 2003, 2008 and 2013 NDHS were similar but the level was lowest in NDHS 2003 and highest in 2013 NDHS. The FIC values : 2003 NDHS 12.9%, 2008 NDHS 22.7%, 2013 NDHS 25.3%, Pooled Total 23.2%, Pooled Urban 39.2% and Pooled Rural- 15.2%.
- In cross tabulations and chi-square analysis of each NDHS, FIC was related to place of delivery, maternal ANC attendance, maternal education level, religion, maternal employment status, media exposure, place of residence, regions and distance to health facility.
- Multilevel analysis of the pooled data showed that the odds of the child being fully immunised independently, substantially increased with successive NDHS. With the most prominent increase between 2003 and 2008; in 2013 the odds of FIC was about 4-times that of 2003
- Place of residence was shown to influence the relationship between FIC and sociodemographic variables. Also the interaction of place of residence and place of delivery significantly reduced the odds of being fully immunised.
- In the analysis stratified by urban and rural location, using the pooled NDHS dataset, the pattern of FIC values among the categories of the sociodemographic variable was similar in both locations, but higher in urban than rural settings. Also, among most sociodemographic variables, the FIC difference between their highest and lowest categories was much larger in urban than rural settings. Similarly, for most sociodemographic variables, the point difference between the category with the highest odds of being fully immunised and the reference category was much higher in urban compared to rural.
- In urban areas, about 18% of the total variation in odds of being fully immunised was attributed to differences within the communities, while in rural areas almost 20% of the variation was due to intra community factors
- The very strong association between ANC attendance and odds of being fully immunised in the rural setting suggests the potential increasing the number of rural women attending antenatal from the present 46.6% (3689/7921) to the urban ANC attendance of 77.8% (3053/3923) would have in improving rural FIC.
- The wider disparity in full immunisation coverage and odds of being fully immunised found in several sociodemographic factors in the urban compared requires further analysis to improve understanding of routine immunisation in Nigeria.

Table 5.5: Significance of the association between socio-demographic variables and FIC in the final Multilevel Logistic Regression Model of pooled datasets (2003, 2008 and 2013 NDHS)

Variable	Total	Rural	Urban
Child level			
Birth order • Birth order 1-5	S ↑	NS	S ↑
Place of delivery • Health facility delivery	S ↑	S ↑	S ↑
Mother's Antenatal care attendance • Attended ANC	S ↑	S ↑	S ↑
Household level			
Maternal education level • Increased education level	S ↑	S ↑	S ↑
Religion • Muslim • Christian	S ↓ ↑	S ↓ ↑	S ↓ ↑
Mother's age at child birth • 20-49 years	S ↑	S ↑	S ↑
Household media exposure No Yes	S ↓ ↑	S ↓ ↑	S ↓ ↑
Community level			
Region • Southsouth • Northeast • Northwest	S ↑ ↓ ↓	S ↑ ↓ ↓	S ↓ ↓
Distance from nearest health facility • No/not a problem	S ↑	S ↑	S ↑

NS: stands for statistically not significant, S for statistically significant

5.5.2 Key finding

Place of residence plays a role in the relationship between FIC and sociodemographic variables. Also, among most sociodemographic variables, the FIC difference between their highest and lowest categories was much larger in urban than rural settings. Similarly, for most sociodemographic variables, the point difference between the category with the highest odds of being fully immunised and the reference category was much higher in urban than rural settings.

5.5.3 Chapter abstract

About 23% of children aged 12-23 months in Nigeria received all the recommended immunisations, approximately a quarter of the World Health organisation's global target of 90%. The disparity in full immunisation coverage (FIC), defined as having received all routine childhood immunisations, persists, with urban coverage nearly thrice that of rural. This study aimed to quantify, with the use of 2003, 2008 and 2013 NDHS, the association between child, household and community factors and childhood immunisation coverage overall, over time and by rural and urban locality.

This study used cross tabulations, chi square test and multilevel logistic regression models for quantitative analyses of Nigeria's 2003, 2008 and 2013 Nigeria Demographic and Health Surveys (NDHS), singly, pooled overall and stratified by rural/urban.

The FIC increased from 12.9% in 2003 NDHS to 22.7% in 2008 NDHS 25.3% in 2013 NDHS. In the pooled analysis, the FIC was 23.2% overall and 39.2% and 15.2% for urban and rural locality respectively. . In analyses of pooled DHS data, overall and stratified, FIC adjusted odds (aOR) were in the 1.**Total population**- ANC attendance (attendance or non-attendance, aOR=4.42, 95% CI=2.00-9.76), place of delivery (health facility or home, aOR=3.86, 95% CI=1.94-7.67), maternal education level (higher or no education, aOR=6.57, 95% CI=2.32-18.59), Religion (Christian or Muslim, aOR=2.37, 95% CI=1.82-3.10) and place of residence (rural or urban, aOR=1.60, 95% CI=0.60-4.24). 2. **Rural** - ANC attendance (aOR=8.37, 95% CI=5.34-13.12), place of delivery (aOR=1.47, 95% CI=1.12-1.94), maternal education level (aOR=4.99, 95% CI=2.48-10.06), Religion (aOR=2.63, 95% CI=1.79-3.86). 3. **Urban**- ANC attendance (aOR=5.65, 95% CI=2.73-11.71), place of

delivery (aOR=2.79, 95% CI=1.83-4.25), maternal education level (aOR=6.04, 95% CI=2.99-12.20), Religion (aOR=2.39, 95% CI=1.53-3.73).

Despite the increased immunisation coverage over the years, 77% of eligible children were not fully immunised. The extent and direction of the associations between FIC and independent variables were similar in rural and urban areas, although there was some suggestion that ANC attendance was associated with a somewhat bigger positive odds in rural areas, while the reverse was for the place of delivery.

Chapter 6 The role of intra-urban place of residence on the association of sociodemographic characteristics and fully immunised child status in Nigeria

6.1 Introduction

Optimising childhood immunisation in Nigeria is dependent on the understanding of several socio-demographic characteristics that are grouped into four levels, which are child, household, community and health system as illustrated in the conceptual framework in Chapter 2. Results presented in Chapter 4, with NDHS 2013 data, and Chapter 5, which used pooled DHS 2003, 2008 and 2013 data, showed that, allowing for birth order, place of delivery, maternal antenatal care attendance, religion, mother's age at the child's birth, media exposure, region and distance to health facility, place of residence (rural or urban), was independently associated with the odds of childhood immunisation. Results from analyses presented in Chapter 5 show that urban fully immunised child (FIC) coverage was about two and a half times the rural FIC coverage. Although the pattern of association was similar in urban and rural settings, across several sociodemographic variables the odds of a child being fully immunised were greater in urban than in rural areas, with wider point differences in odds between categories of the same variable, which would suggest a more heterogeneous population in urban than in rural areas. Despite the fact that the most recent 2013 NDHS, which used the Nigeria 2006 general census enumeration areas that had majority of Nigerians living in the rural areas, recent evidence shows that the majority of Nigerians now live in the urban area (Bobadoye and Fakere, 1926; Olotuah and Bobadoye, 2009; United Nations Human Settlement Programme and UN HABITAT, 2014; UN HABITAT, 2016a). Further, most urban dwellers are said to reside in informal areas (slums), with these slums projected to house an even higher proportion of urban dwellers in the near future (Bobadoye and Fakere, 1926; Olotuah and Bobadoye, 2009). It is thus important to understand whether there are any differences in FIC between urban formal and informal areas, so that this information can be used to improve childhood immunisation programmes. Failure to understand sociodemographic associations with FIC in urban communities may lead to worsening of childhood immunisation coverage in Nigeria. Thus, Chapter 6 aims to explore intra-urban differences in childhood immunisation coverage over time and answer the research question: ‘In the urban setting, does childhood immunisation coverage vary between urban and slum dwellers and what factors are associated with it?’

Pooled data from the 2003, 2008, and 2013 NDHS relating to urban areas only were analysed to compare the intra-urban fully immunised child status, estimate odds and quantify the FIC status differences with the use of descriptive statistics, bivariate analysis and multilevel logistic regression, as explained in Chapter 3 (Methods). This chapter has three main parts. First, with the use of UN-HABITAT guidelines the urban formal and informal (slum) households were defined. The second section first presents a descriptive analysis of the pooled NDHS urban data stratified by formal and slum, and secondly, unadjusted odds ratios of the difference between urban formal and informal slum FIC across the selected sociodemographic variables’ categories, with 95% confidence interval and p-value. Lastly, the hierarchical structure of the NDHS data was accounted for with the use of multilevel logistic regression analysis to separately quantify the relationship between FIC and sociodemographic characteristics with results expressed in odds ratio and variance components in urban formal and slum locations.

6.2 Determination of urban formal and informal (Slum) residence

The NDHS dataset included a variable denoting urban and rural place of residence, with no further stratification of urban communities. The definition of a slum household is complex (UN HABITAT and Global Urban Observatory, 2003; UN HABITAT, 2010), and there may be differences in how slum households are classified within the same state, different states, regions and countries. The UN Habitat’s operational definition of slum household is a household that lacks one or more of the following indicators (Table 6.1): improved water, improved sanitation, sufficient living area, durable housing and secure tenure, with indicators based on millennium development goals (MDGs) indicators where possible (UN HABITAT and Global Urban Observatory, 2003; UN HABITAT, 2010).

For the analysis presented here, the pooled urban dataset was segregated into formal and informal (slum) settlements on the basis of only two indicators: availability of improved sanitation and access to good water; an urban household that lacked both indicators was defined as a slum household, and households that had one or both indicators were classed as formal. The absence of information on the house wall type in the 2003 NDHS led to non-inclusion of the wall as an indicator. The roof or floor quality was not chosen because as people become richer, their roofs and floors may be changed irrespective of where they live and this indicator was thus considered less appropriate in this setting. With the culture of “co-sleeping” with children and polygamous families being common in all settings, overcrowding was deemed not appropriate to define a slum household. Finally, information on the indicator of security of tenure was not available in the NDHS datasets. The final calculated proportion of formal and informal households were within the range estimated by other studies conducted in Nigeria (Okupe, 2002; Olotuah and Bobadoye, 2009).

Table 6.1: Indicators and thresholds for defining slums.[4]

S/N	UN HABITAT		This study	
	Characteristic	Indicators	Decision	Comments
1	Access to water	Improved water drinking sources	Included	Availability of piped water, public tap, tube well, borehole was adapted as improved water drinking sources
2	Access to improved sanitation facilities	Improved sanitation	Included	Availability of flush toilet was adapted for improved sanitation
3	Durable housing	Location and permanency of houses	Rejected	DHS data do not include information on whether the house is built on a hazardous or non-hazardous area. DHS 2003 had no information on wall type, while personal experience shows that floors and roofs can be made permanent if the slum dweller becomes richer, even if he/she does not move.
4	Overcrowding	Sufficient living area that is not more than 3 persons per room	Rejected	The culture of “co-sleeping” with children, and polygamous homes with large families would wrongly classify many households as slum
5	Security of tenure	Security tenure	Rejected	DHS datasets do not have evidence of land documentation

6.3 Descriptive and Bivariate analysis approach

During the conceptualisation phase of this study, the analysis of Abuja (Nigeria’s Federal Capital Territory) data in the DHS 2013 was planned to provide answers to this Chapter’s research questions, as this would provide an appropriate quantitative background for the qualitative data collected in Abuja. However, Abuja contributed only 38 (0.65%) of the 5,900 children aged 12-23 months in DHS 2013, and less than 100 in the pooled three NDHS datasets. Further, the 2013 NDHS 2013 dataset, the largest sample amongst the three NDHS, had several categories of socio-

[4] Adapted from UN HABITAT report, “The Challenge of Slums: global report on human settlements 2003. Chapter 1: development Context and Millennium Agenda. Revised and Updated version, 2010”.

demographic variables with samples of less than 50 (weighted). Results obtained from small samples may increase the potential for bias, and will not be as accurate as results from larger sample size (Baker and Cousins, 1984); it was thus decided to pool the NDHS data from 2003, 2008 and 2013, and to include all urban areas in Nigeria.

The distribution was expressed in numbers and percentages of the independent variables with the dependent variable. The bivariate analysis used chi-square to show the significance of the associations. The level of significance was set at p-value <0.05. Two bivariate analyses were carried out. The first was FIC across the sociodemographic characteristics stratified by urban formal and slum residence with significance expressed in terms of intra variable association, while the other was the analysis of the comparison urban formal and slum's FIC status across sociodemographic characteristics with the relationship expressed in odds ratios and p-value.

6.4 Distribution of Fully Immunised Child Status (Number and coverage) by sociodemographic characteristics, among children aged 12-23 months, by Urban formal and informal area

Presented in Table 6.2 are the overall fully immunised child (FIC) coverage in each NDHS according to the urban place of residence (formal/ slum). The pooled DHS dataset had information for 3923 urban children overall, of whom 53% (2087/3923) in urban formal households and 47% (1836/3923) in urban slum households. The fully immunised child coverage in urban slums was 25% in 2003, 32% in 2008 and 39% in 2013, with a similar increase in FIC in urban formal households from 26% in 2003, 43% in 2008 and 46% in 2013. In the pooled data, urban formal FIC coverage of 43.5% overall was 9.1 percentage points higher than the slum FIC coverage of 34.4%.

Table 6.2: Description of the Pooled NDHS (2003, 2008 and 2013) weighted data segregated into urban formal and slum households

Surveys	Urban Formal settlement		Slums (Urban informal)	
	Number vaccinated/ Total number of children	FIC percentage	Number vaccinated/ Total number of children	FIC percentage
2003	27/ 104	25.6	52/208	24.9
2008	333/ 781	42.7	229/718	31.9
2013	547/1203	45.5	350/911	38.5
Pooled/total	907/2,087	43.5	631/1,836	34.4

6.5 Fully Immunised Child Status (Number and coverage) across sociodemographic variables among children aged 12-23 months by Urban formal and Slum area in Nigeria

FIC coverage by urban place of residence and socio-demographic characteristics are presented in Table 6.3, with cross-tabulation chi-square test and p-values relating to the within-variable variation in FIC (percentage) and between the same category in the different place of residence.

In both urban formal and slum there were significant intra-variable associations with FIC in child birth order, child place of delivery, maternal Antenatal care attendance, maternal education level, maternal religion, maternal employment status, maternal age at the child's birth, household media exposure, region and distance to nearest health facility characteristics, confirming results seen in Chapters 4 and 5. FIC across sex of household head, maternal current marital status and decision-maker on spending of mother's income was significant in slums alone.

FIC coverage was highest for first birth order children and lowest for sixth or more birth order children in both urban formal and slum. FIC was similar for boys and girls in both urban formal and slum. The FIC coverage was lower for children delivered at home, especially in slums, (23% in urban formal, 14% in slums) than in those delivered in a health facility (53% in urban formal, 50% in slum). About 32% and 44% of the children were delivered at home in urban formal and slums respectively. For urban formal and slum, over 75% of mothers attended antenatal care and their children had higher FIC than children whose mothers did not attend antenatal care. Mothers living in urban formal settings had a slightly higher antenatal attendance (80%) than those in slums (75%).

In both urban formal and slum, FIC increased with increasing maternal education; FIC coverage was 14% in urban formal and 11% in slums for children of mothers who had no formal education, compared to 64% and 58% respectively for children of mothers with higher education. In both urban residences, the highest level of FIC coverage was recorded in female-headed households, which made up 11% of all urban households. The highest FIC coverage was among Christians in urban formal (55%) and slum (54%) households. Employed mothers made up the majority in both slum (71%) and urban formal (73%), and their children had higher FIC coverage than those of non-working mothers, at 38% and 26% in slum and 46% and 37% in urban formal respectively. FIC coverage was lowest (slum 22% and urban formal 21%) in children of mothers aged 14-19 years at the time of delivery. There were 159 children of mothers in the 14-19 years age group in urban formal and 170 in slum. For current maternal marital status, in slum, FIC coverage was lowest in the no longer together mothers group (21%) and highest among children of mothers who had never married (68%), who made up only 2% (31/1836) of the slum sample. While in urban formal, the highest FIC was the married mothers' cohort (44%) and lowest in children whose parents are no longer together (39%). In both urban locations, the highest FIC coverage was attained in children whose parents jointly decided how maternal income was spent (slum-51% and formal-52%). Most urban formal (90%) and slum (85%) were exposed to media, and their FIC (46% for urban formal and 38% for slum) was at least twice that of the no media exposed group (21% for urban formal and 15% for slum). The rich household had lower FIC than the poor and middle in both urban places of residence, which was not expected. The very small sample size of the rich households (8% for urban formal and 1.7% for slum) maybe the reason for the unexpected finding. The middle wealth households were the majority in the formal (63%) while the poor households were the largest category in the slums with 57% of the slum sample. This study's urban poor population of 42.1% was similar to the 41.3% estimated urban poor population in Nigeria (United Nations Human Settlement Programme and UN HABITAT, 2014).

In urban formal, FIC coverage was lowest in Northeast (21%) and highest in the Southsouth (61%), while for slum, Northwest (15%) and Southwest (55%) had the lowest and highest FIC respectively.

The FIC coverage of slum in the Northcentral (45%) and Southwest (55%) were higher than their FIC in urban formal Northcentral-36% and Southwest-47%). For urban formal and slum, the distance to the nearest health facility to seek health care was no/not a big problem to most (82% for urban formal and 84% for slum). This may suggest that the distance to health facilities is similar for urban dwellers irrespective of where reside. As expected, those who felt the distance to the health facility to seek care was not a big problem had higher FIC coverage (45% for urban formal and 36% for slum) than those who found the distance a big problem (37% for urban formal and 25% for slum)

Table 6.3: Fully immunised child status (number and coverage) by sociodemographic characteristics among children aged 12-23 months stratified into urban formal and slums in Nigeria

Independent variables	**Dependent variable**							
	Formal = 2,087			**Slum= 1,836**			**Formal Versus Slum**	
	Category size/ % of total sample	**FIC Number/ (%)**	**P-value**	**Category size/ % of total sample**	**FIC Number/ (%)**	**P-value**	**Odds ratio (Confidence interval)**	**P-value**
Child Level								
Birth order								
1	492/ 23.6%	258 / 52.4%		384/ 20.9%	177/46.1%		1.29 (0.99,1.69)	0.063
2-3	784/ 37.6%	338/ 43.1%	0.001	607/ 33.1%	228/ 37.5%	0.001	1.26 (1.01,1.57)	0.037
4-5	483/ 23.1%	208/ 43.0%		469/ 25.6%	163/ 34.7%		1.42 (1.09,1.85)	0.009
>=6	328/ 15.7%	104/ 31.6%		376/20.5%	64/ 17.0%		2.26 (1.57,3.23)	0.001
Sex								
Male	1,093/ 52.4%	483/ 44.2%	0.536	896/ 48.9%	299/ 33.4%	0.440	1.58 (1.32,1.90)	0.001
Female	995/ 47.7%	424/ 42.6%		941/51.3%	333/ 35.3%		1.36 (1.13,1.63)	0.001
Place of delivery								
Home	674/ 32.3%	155/ 23.1%		799/ 43.5%	114/ 14.3%		1.80 (1.37,2.35)	0.001
Health facility	1413/ 67.7%	752/ 53.2%	0.001	1037/ 56.5%	517/ 49.9%	0.001	1.14 (0.98,1.34)	0.100
Antenatal attendance								
No	199/ 9.5%	17/ 8.7%		251/ 13.7%	11/ 4.4%	0.001	2.04 (0.93,4.46)	0.075
Yes	1,674/ 80.2%	799/ 47.7%	0.001	1,379/ 75.1%	542/ 39.3%		1.41 (1.22,1.63)	0.001
Don'tknow/ missing	214/ 11.6%	91/ 42.5%		209/ 11.4%	78/ 38.0%		1.24 (0.84,1.84)	0.275
Maternal level								

Maternal education level No education Primary Secondary Higher	381/ 18.3% 399/ 19.1% 978/ 46.9% 328/ 15.7%	54/ 14.2% 130/ 32.6% 514/ 52.5% 209/63.6%	0.001	537/ 29.3% 388/ 21.1% 654/ 35.6% 257/14.0%	58/ 10.8% 118/ 30.5% 307/ 46.9% 148/ 57.6%	0.001	1.36 (0.92,2.03) 1.11 (0.82,1.49) 1.25 (1.03,1.53) 1.29 (0.93,1.81)	0.125 0.513 0.026 0.132
Sex of Household head Male Female	1,828/ 87.6% 259/ 12.4%	782/ 42.3% 125/ 48.3%	0.193	1,661/ 90.5% 175/ 9.5%	553/ 33.3% 78/ 44.5%	0.019	1.50 (1.31,1.72) 1.16 (0.79,1.71)	0.001 0.450
Religion Christian Islam Traditionalist/ others	1,205/ 57.7% 799/ 38.3% 83/ 4.0%	657/ 54.5% 233/ 29.1% 17/ 21.0%	0.001	765/ 41.7% 909/ 49.5% 162/ 8.8%	416/ 54.4% 191/ 21.0% 24/ 15.1%	0.001	1.01 (0.84,1.21) 1.55(1.24,1.93) 1.48 (0.75,2.94)	0.950 0.001 0.263
Mother employment status No Yes	562/ 26.9% 1,525/ 73.1%	208/ 37.0% 699/ 45.8%	0.008	539/ 29.4% 1,297/ 70.6%	140/ 26.0% 491/ 37.9%	0.001	1.68 (1.29,2.17) 1.39 (1.20,1.62)	0.001 0.001
Maternal age at the child's birth 14-19 20-29 30-39 40-49	159/ 7.6% 1,204/57.7% 631/ 30.2% 94/ 4.5%	33/ 20.8% 537/ 44.6% 292/ 46.2% 45/ 48.2%	0.001	170/ 9.3% 1,002/ 54.6% 578/ 31.5% 86/ 4.9%	37/ 21.8% 366/ 36.5% 199/ 34.4% 30/ 34.8%	0.017	0.94 (0.56,1.60) 1.40 (1.18,1.66) 1.64 (1.30,2.07) 1.71 (0.94,3.13)	0.823 0.001 0.001 0.079
Current marital status Never married Married/partner No longer together	52/ 2.5% 1,988/ 95.3% 47/2.3%	21/ 40.0% 868/ 43.7% 18/ 38.7%	0.740	31/ 1.7% 1,751/ 95.4% 55/ 3.0%	21/ 67.8% 599/ 34.2% 11/ 20.5%	0.001	0.32 (0.13,0.82) 1.49 (1.31,1.70) 2.48 (1.03,6.01)	0.018 0.001 0.044

Decision maker on spending of mothers income								
Mother alone	903/ 43.3%	388/ 43.0%		822/ 44.8%	287/ 34.9%		1.40 (1.16,1.71)	0.001
mother & spouse	292/ 14.0%	151/ 51.6%	0.148	209/ 11.4%	107/ 51.4%	0.001	1.02 (0.72,1.46)	0.910
spouse alone								
No income mother	146/ 7.0%	62/ 42.8%		119/ 6.5%	46/ 38.3%		1.17 (0.72,1.92)	0.530
/missing??	747/ 35.8%	306/ 41.0%		687/ 37.4%	192/ 27.9%		1.79 (1.43,2.23)	0.001
Media exposure								
No	218/ 10.5%	47/ 21.3%		270/ 14.7%	41/ 15.2%	0.001	1.54 (0.97,2.44)	0.070
Yes	1,869/ 89.6%	861/ 46.1%	0.001	1,566/ 85.3%	590/ 37.7%		1.41 (1.23,1.62)	0.001
Household wealth								
Poor	604/ 28.9%	269/ 44.5%		1048/ 57.1%	353/33.7%		1.58 (1.29,1.94)	0.001
Middle	1318/ 63.2%	569/ 43.2%	0.620	758/ 41.3%	269/ 35.5%	0.880	1.38 (1.15,1.66)	0.001
Rich	165/ 7.9%%	69/ 42.0%		31/ 1.7%	9/28.0%		1.76 (0.76,4.05)	0.186
Community Level								
Region								
Northcentral	173/ 8.3%	62/ 36.2%		201/ 11.0%	89/ 44.5%		0.70 (0.46,1.07)	0.098
Northeast	192/ 9.2%	41/ 21.2%		353/ 19.2%	52/ 14.7%		1.57 (1.00,2.47)	0.051
Northwest	328/ 15.7%	83/ 25.2%	0.001	483/ 26.3%	79/ 16.3%	0.001	1.73 (1.23,2.45)	0.002
Southeast	423/ 20.3%	232/ 54.9%		217/ 11.8%	102/ 47.0%		1.37 (0.99,1.90)	0.060
Southsouth	226/ 10.8%	137/ 60.7%		210/ 11.4%	106/ 50.7%		1.51 (1.03,2.21)	0.033
Southwest	745/ 35.7%	352/ 47.3%		373/ 20.3%	203/ 54.6%		0.75 (0.59,0.96)	0.024
Distance to nearest Health Facility								
No/Not a big problem	1,705/81.7%	765/ 44.9%	0.047	1,540/ 83.9%	558/ 36.2%	0.004	1.43 (1.24,1.65)	0.001
Big problem	382/ 18.3%	142/ 37.2%		296/ 16.1%	74/ 24.9%		1.78 (1.27,2.48)	0.001

6.6 Comparison of the relationship between urban Formal and Slum Fully Immunised Child coverage by sociodemographic characteristics in children aged 12-23 months in Nigeria

The unadjusted odds ratio (OR) of the FIC coverage difference between urban formal and slum place of residence are presented, with 95% confidence interval and p-value, in Table 6.3. The fully immunised odds in urban formal (OR=1.47, 95% CI=1.29-1.67) was significantly higher than that in the slum. Of the 44 categories of the 15 selected sociodemographic variables, only in 4 categories was the FIC coverage in the slums higher than the similar category in the urban formal, of which two reached significance (never married mothers and Southwest residents) and the other two, (maternal age at the child's birth 14-19 year and Northcentral residency) did not. Of these 4 categories, only the result of never married mothers could be explained as due to their very small sample size.

The FIC coverage of children of birth order 2-3, 4-5 and 6 or more from urban formal were significantly higher than that for children in these birth orders living in the urban slums. The unadjusted OR of the FIC of birth order 1 children did not significantly differ by urban residence. Other FIC across the categories of child sociodemographic variables such as sex of the child and place of delivery in urban formal were significantly higher than the slum values. The non-significance of the higher FIC in urban formal over slums among children whose mothers did not attend antenatal care may suggest that the health information provided during antenatal care influenced FIC coverage, or that the small sample size of the category limits statistical power, while the antenatal care association may indicate the quality of health information which the mother received.

When classified based on maternal education level, the urban formal FIC coverages were all higher than those of the slums, with no education, primary education and higher education not reaching statistical significance. The reason for the difference in their FIC coverages may just be due to where they reside. Significant differences were found in male headed households, Muslim households, employed mother, unemployed mother, mothers age at the child's birth of 20-29 and 30-39, married or no longer with spouse and household had media exposure of urban formal compared to slums.

Among the regions of Nigeria, the difference in FIC in both urban formal and slum was significant in Northeast, Southsouth and Southwest, but not for Northcentral, Northeast and Southeast. A higher proportion of slum (83.9%) than urban formal (81.7%) residents reported distance to the health facility as no/ not a big problem, yet the FIC coverage in urban formal was higher than the slum based on this category, with the odds ratio of the difference significant.

Despite these findings on FIC and each sociodemographic variable, the influence of co-variables could not be estimated and quantified in this unadjusted odds analysis, and further analysis adjusting for all sociodemographic variables will provide more information on understanding childhood immunisation.

6.7 Multilevel logistic Models for Urban data

Table 6.4 presents the adjusted associations between FIC and selected variables for urban formal and slum households, in 3 parts: Formal HHs, Slum HHs and comparison of Formal and slum HHs.

6.7.1 Urban Formal

FIC was associated with child level sociodemographic characteristics; as before model 1 includes child variables only, model 2 also includes household level variables and model 3 is the full model with the addition of community level variables. As the child's birth order increased, the odds of being fully immunised reduced in all models; this association did not reach statistical significance for birth orders 1, 2-3, 4-5 in model 1 and 2, but in Model 3, for birth order 1 the association was significant, with the adjusted odds ratio (aOR) increasing from 1.91 in model 1 to 2.43 in Model 3. In Model 1, compared to children who were delivered at home, children delivered in a health facility (aOR=5.79, 95% CI=2.73-12.27) had a significantly increased likelihood of being fully immunised, and this association remained significant in Model 2 and 3 despite the reduced ORs. A similar result was obtained for the maternal attendance of antenatal care variable, where in Model 1, the children of attendees (aOR=13.4, 95% CI=7.2-24.8) had significantly higher odds of FIC than children of non-ANC attendees, and this significance held in Models 2 and 3 despite the reduction in ORs.

Three of the nine household level sociodemographic factors (maternal education level, religion and mothers' age at child's birth) showed significant associations with FIC. In Model 2, children of mothers with primary education (aOR=2.13, 95% CI=1.03-4.04), secondary education (aOR=5.43, 95% CI=2.33-12.65) and higher education (aOR=9.59, 95% CI=3.27-28.11) had increased odds of being fully immunised than children of mothers with no formal education. Their adjusted ORs reduced in Model 3, with significance remaining for the secondary and higher education category. The association between FIC and religion, as shown in the multilevel analysis in Chapter 4 and 5, was reduced here. In Model 2, children from Christian households (aOR=2.68, 95% CI=1.51-4.76) were significantly more likely to receive all recommended vaccines than those from Muslim homes, but the introduction of community level variables led to much reduced higher OR that was no longer significant (aOR=1.59, 95% CI=0.89-2.86). Compared to children whose mothers were aged 14-19 at the child's birth, children of older mothers were about 5 to 9-fold significantly more likely to be fully immunised in Model 2, with the ORs increased and remained significant in Model 3. Having an employed mother (OR=1.0, 95% CI=0.6-1.6) was not significantly associated with the child's odds of being fully immunised. Although the other household level sociodemographic characteristics (sex of household head, mothers employment status, current marital status, decision maker on spending of mothers' income, media exposure and household wealth) were not significantly associated with FIC in Models 2 and 3, the pattern and estimates of their aORs are important in understanding utilisation of immunisation services. For example, unexpectedly, the higher FIC odds of children in households with media exposure than in households not exposed to media, which was about the same in Model 2 and 3 (1.38 and 1.35 respectively) was not statistically significant. This may suggest that there may be other sources of health information including immunisation information apart from Television, Radio and Newspaper that are available to the urban formal households. Children from the middle (OR=0.83, 95% CI=0.53-1.28) and rich (OR=0.69, 95% CI=0.33-1.44) households had reduced odds of full immunisation compared to children from the poor homes in Model 2, but not significantly so, and the pattern was unchanged in Model 3. The reduced odds of being fully immunised found in these children is important to optimising childhood immunisation, as it is at variance with reviewed literature that provided evidence of the significant role of wealth to achieve higher FIC in the general population.

Community-level variables (region and distance to the health facility) were introduced in Model 3. Compared to the Northcentral region, only two regions; Southeast (aOR=3.01, 95% CI=1.19-7.57) and Southsouth (aOR=5.61, 95% CI=1.88-16.71) had significantly higher odds for their children to be fully immunised. The other community level variable, distance to the health facility when seeking health care was almost significantly associated with FIC after adjustment. Children of mothers who felt the distance to the health facility to seek care was not a big problem (aOR=1.77, 95% CI=0.99-3.17) had 77% higher odds to be fully immunised compared to peers with mothers who said the distance to the health facility was a big problem.

6.7.2 Slum

Again, all child level sociodemographic characteristics were significantly related to FIC, with the pattern similar to that seen for urban formal, although overall the level of FIC coverage is lower in the slums than in the urban formal. As the child's birth order increased, the odds of being fully immunised reduced in all the models. In Model 1, compared to birth order 6 and more, birth order 1 (aOR= 5.39, 95% CI=1.37-21.29), birth order 2-3 (aOR=3.00, 95% CI=1.00-9.13) and birth order 4-5 (aOR=2.05, 95% CI=0.78-5.40) had significantly higher odds of being fully immunised. After adjustment for household characteristics in Model 2, birth orders 1 and 2-3 maintained the significantly higher odds, while only birth order 1 remained significant in the final Model, which also allowed for community variables. In Model 1, compared to children who were delivered at home, children delivered in a health facility (aOR=16.94, 95% CI=5.26-54.59) had a significantly increased likelihood of being fully immunised, but with a wide confidence interval, and the significance remained in Model 2 and 3 despite the reduced aORs. Also, for the maternal attendance of antenatal care variable, in Model 1, the children of attendees (aOR=15.04, 95% CI=3.93-54.59) had significantly higher odds of being fully immunised than children of non-antenatal care attendees and the trend continued in Models 2 and 3 but the aORs reduced to 6.35 and 5.39 respectively.

Of the six household characteristics that were significantly associated with FIC, four (maternal education level, religion, mothers current marital status and decision maker on spending of mother's income) were significant in Models 2 and 3, while mothers' age at child's birth and household media exposure that were significant in Model 2, were no longer significantly associated with FIC in Model

3, with community-level characteristics fitted into the Model. Children of mothers with primary education (aOR=3.04, 95% CI=1.24-7.47), secondary education (aOR=5.13, 95% CI=1.91-13.81) and higher education (aOR=5.76, 95% CI=1.70-19.58) had higher odds of being fully immunised than children of mothers with no education in Model 2. These adjusted ORs reduced in Model 3 but the significant association with FIC persisted. The influence of religion on FIC was similar to the earlier results of the multilevel analysis in Chapter 4 and 5, and as shown for urban formal. In Model 2, children from Christian households (aOR=6.68, 95% CI=2.54-17.57) were significantly more likely to receive all recommended vaccines than those from Moslem homes, but the introduction of community level variables in Model 3 reduced the OR (aOR=5.69, 95% CI=2.09-15.45) which remained significantly related to FIC unlike in urban formal. In Models 2 and 3, children of mothers who were no longer with their spouses were significantly less likely to be fully immunised than children whose mothers were still married and mothers who never married. Based on the decision-maker on spending of mother's income, when only the mother decides how she will spend her earnings, children had the highest odds to be fully immunised compared to women who earned no income, couples as decision makers and spouse alone. This is further evidence of the health benefits of women empowerment. Compared to children whose mothers were aged 14-19 at the child's birth, children of mothers with aged 20-29, 30-39 and 40-49 years were 3, 4 and 10-fold more likely to be fully immunised respectively in Model 2 with only the association in the oldest age group (40-49 years) being significant. The introduction of community level factors led to the loss of statistical significance and reduction in ORs in maternal age at child's birth categories. As expected, the higher FIC odds of household with media exposure (aOR=2.79, 95% CI=1.05-7.39) than peers whose households were not exposed to media was significant in Model 2, but the aOR (aOR=2.49, 95% CI=0.95-6.53) reduced in Model 3 with the relationship no longer significant. Sex of household head, mothers' employment status and household wealth were not significantly associated with FIC in Models 2 and 3.

Community level variables regions and distance to the health facility were introduced in Model 3. Compared to the Northcentral region, only two regions; Northeast (aOR=0.21, 95% CI=0.07-0.66) and Northwest (aOR=0.20, 95% CI=0.06-0.67) had significantly lower odds for their children to be fully immunised. The other community level variable, distance to the health facility when seeking health care was not significantly related to FIC. Children of mothers who felt the distance to the health facility to seek care was not a big problem (aOR=2.21, 95% CI=0.95-5.13) had 121% higher odds to be fully immunised compared to peers with mothers who said the distance to the health facility was a big problem.

6.7.3 Comparing results of the separate multilevel analysis of urban formal and slum HHs

Based on results from the fully adjusted model, model 3, there were similarities and differences in the association between FIC and sociodemographic characteristics according to the urban places of residence, although overall the pattern was somewhat similar. Birth order, place of delivery, antenatal attendance and maternal education level sociodemographic variables were significantly related to FIC odds in both urban formal and slum, which is also similar to findings in Chapter 4 and 5. Sex of household heads, mother's employment status, media exposure, household wealth and distance to the nearest health facility to seek care sociodemographic variables were not significantly associated with FIC in both urban formal and slum. However, mother's current marital status, religion, decision-maker on spending of maternal income and two regions (Northeast and Northwest) showed significant associations with FIC only in the slums, and the associations with mother's age at birth of child and Southeast and Southsouth region and FIC were significant only in the urban formal.

The three child level socio-demographic variables were significantly associated with FIC in both urban formal and slum. However, in Model 3 of the urban formal and slum analysis, only the birth order 1 child had a statistically significant association with FIC, the Odds ratios were larger in the slums (aOR=5.39, 95% CI=1.37-21.29) than in urban formal (aOR=2.43, 95% CI=1.01-5.87). Similarly, for the place of delivery and maternal antenatal care attendance, the aORs were greater in the slums than in formal households, which may be suggestive of the greater influence of these variables on FIC in the slum.

Maternal education level was the only household level variable that was significantly associated with FIC in all urban households. Compared to no education mothers, aORs of primary education mothers in slum were higher than in urban formal, while the aORs of mothers with secondary education and higher education was higher in the urban formal than slum. The higher odds to complete child immunisation of the Christian child than the Muslim child was much higher in the slums, with the association only reaching statistical significance in the slums. This non-significant relationship between FIC and religion in the urban formal differed from findings in Chapter 4 and 5. In addition to the significant association between FIC and mothers' age at the child's birth that was limited to urban formal households in the final model, a pattern was observed. In the association of mothers' age at the child's birth with FIC, the aORs in urban formal increased from Model 2 to Model 3, while for the slums the aORs in Model 2 reduced in Model 3. In the slums, the significant very low odds of children of mothers who are no longer with their spouses being fully immunised (aOR=0.03, 95% CI=0.01-0.06) compared to children of the never married mothers should be interpreted cautiously because the sample size of the category was only 55. The relationship between decision maker on spending of maternal income and FIC was only significant in the slums, which may be due to less empowered and educated women in the slums or those who can make the decisions are in a selected group. Unexpectedly, media exposure's association with FIC was not significant in both urban formal (aOR=1.35, 95% CI=0.65-2.79) and slum (aOR=2.49 95% CI=0.95-6.53) households, although greater aOR in the slums nearly reached statistical significance.

In both urban formal and slum areas, being fully immunised was significantly associated with residency in two regions, but in different ways. For the slum, it was Northeast and Northwest and for urban formal, it was the Southeast and Southsouth regions. The two northern regions significantly reduced the odds of being fully immunised in the slum, while the southern regions increased the odds of being fully immunised in urban formal. In the urban formal and slum, the increased odds of being fully immunised of children with parents who did not feel that the distance to the nearest health facility to seek care was a big problem was not significant, but the confidence intervals of their odd ratios are suggestive that distance to health facility was related to FIC in slum (aOR=2.21, 95% CI=0.95-5.13) and urban formal (aOR=1.77, 95% CI=0.99-3.17).

The multilevel regression analysis accounted for the hierarchical data style and quantified the unexplained differences in FIC that are mostly due to social, cultural and other unobserved factors. Allowing for the sociodemographic factors listed, there were still significant unexplained differences in the odds of being fully immunised, which might be due to unobserved community factors, given that the household variance was not statistically significant in both urban locations. As presented in Table 6.2, the community level variance was significant in only Model 2 (τ = 0.38,SE = 0.13) and 3 (τ =

0.34,SE = 0.12) in urban formal, while for slums the significance was seen in Model 1 (τ = 0.76,SE = 0.18) and 2 (τ = 0.43,SE = 0.14). In the final model that controlled for the child, household and community level factors, 10% and 13% of the variation in the fully immunised child odds in urban formal and slum areas respectively were attributed to community level factors.

The goodness of fit measurement reduced as subsequent models were fitted, which indicated that the final model was the best fitting model for both places of urban residence.

Table 6.4: Association between socio-demographic factors and full immunisation status (assessed at 12-23 months) in Nigerian Urban formal and Slum Households, Multilevel logistic regression analysis (DHS 2003, 2008 and 2013 data)

Variable /Category	Urban Formal			Slum		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
	Adjusted Odd ratio / (95% C.I)	Adjusted Odd ratio / (95% C.I)	Adjusted Odd ratio / (95% C.I)	Adjusted Odd ratio / (95% C.I)	Adjusted Odd ratio / (95% C.I)	Adjusted Odd ratio / (95% C.I)
CHILD						
Birth order						
>=6	1.00	1.00	1.00	1.00	1.00	1.00
1	1.91 (0.98,3.74)	2.14 (0.94,4.89)	2.43 (1.01,5.87)	6.89 (2.32,20.49)	8.60 (2.03,36.41)	5.39 (1.37,21.29)
2-3	1.51 (0.83,2.77)	1.35 (0.68,2.69)	1.50 (0.72,3.12)	4.52 (1.76,11.55)	4.49 (1.41,14.29)	3.00 (1.00,9.13)
4-5	1.46 (0.77,2.77)	1.31 (0.69,2.53)	1.38 (0.69,2.75)	2.88 (1.19,7.00)	2.58 (0.95,6.97)	2.05 (0.78,5.40)
Place of delivery						
Home	1.00	1.00	1,00	1.00	1.00	1.00
Health facility	5.79 (2.73,12.27)	2.56 (1.44,4.55)	2.62 (1.43,4.79)	16.94 (5.26,54.59)	6.35 (2.49,16.19)	5.39 (2.18,13.33)
Antenatalattendance						
No	1.00	1.00	1.00	1.00	1.00	1.00
Yes	11.23 (3.59,35.17)	6.07 (2.17,17.00)	6.82 (2.29,20.34)	15.04 (3.93,54.59)	9.45 (2.47,36.05)	8.07 (2.15,30.25)
Don’t know	5.98 (1.91,18.71)	3.02 (1.04,8.81)	2.89 (0.94,8.88)	11.03 (2.61,46.55)	5.37 (1.24,23.24)	5.19 (1.21,22.37)
HOUSEHOLD						
Maternal education level						
No education		1.00	1.00		1.00	1.00
Primary		2.13(1.03,4.04)	1.77 (0.83,3.79)		3.04 (1.24,7.47)	2.48 (1.02,6.05)
Secondary		5.43(2.33,12.65)	4.57 (1.94,10.79)		5.13 (1.91,13.81)	4.46 (1.68,11.82)
Higher		9.59(3.27,28.11)	9.18 (3.05,27.64)		5.76 (1.70,19.58)	5.03 (1.52,16.65)
Sex of Household head						
Male		1.00	1.00		1.00	1.00
Female		1.16 (0.66,2.04)	1.04 (0.60,1.94)		1.55 (0.62,3.87)	1.55 (0.62,3.86)

Religion Islam Christian Traditionalist/ others		 1.00 2.68 (1.51,4.76) 0.51 (0.19,1.41)	 1.00 1.59 (0.89,2.86) 0.40 (0.10,1.18)		 1.00 6.68 (2.54,17.57) 0.26 (0.08,0.84)	 1.00 5.69 (2.09,15.45) 0.28 (0.09,0.88)
Mother employment status No Yes		 1.00 2.06 (0.95,4.46)	 1.00 1.78 (0.80,3.98)		 1.00 0.46 (0.15,1.45)	 1.00 0.41 (0.13,1.30)
Maternal age at the child's birth 14-19 20-29 30-39 40-49		 1.00 5.12 (1.89,13.89) 6.49 (2.09,20.18) 8.71 (1.92,39.56)	 1.00 5.25 (1.86,14.85) 6.64 (2.03,21.75) 9.87 (2.01,48.59)		 1.00 2.66 (0.83,8.51) 3.92 (0.94,16.31) 9.83 (1.37,70.62)	 1.00 2.18 (0.70,6.84) 2.63 (0.66,10.53) 5.40 (0.80,36.48)
Current marital status Never married Married/partner No longer together		 1.00 1.20 (0.36,4.01) 1.94 (0.38,9.89)	 1.00 1.48 (0.42,5.22) 2.93 (0.52,16.60)		 1.00 0.15 (0.02,1.12) 0.03 (0.01,0.06)	 1.00 0.19 (0.03,1.33) 0.05 (0.03,0.82)
Decision maker on spending of mothers income No income mother /missing Mother alone mother& spouse spouse alone		 1.00 0.80(0.39,1.66) 0.58 (0.25,1.35) 0.43 (0.16,1.14)	 1.00 1.04 (0.48,2.26) 0.65 (0.27,1.56) 0.43 (0.15,1.20)		 1.00 4.91 (1.44,16.82) 3.53 (0.95,13.20) 2.27 (0.54,9.65)	 1.00 4.52 (1.34,15.30) 3.00 (0.82,10.97) 2.17 (0.51,9.15)
Media exposure No Yes		 1.00 1.38 (0.69,2.75)	 1.00 1.35 (0.65,2.79)		 1.00 2.79 (1.05,7.39)	 1.00 2.49 (0.95,6.53)
Household wealth Poor Moderate Rich		 1.00 0.83 (0.53,1.28) 0.69 (0.33,1.44)	 1.00 0.80 (0.50,1.27) 0.70 (0.32,1.53)		 1.00 0.92 (0.52,1.61) 2.24 (0.27,18.45)	 1.00 0.89 (0.51,1.57) 1.83 (0.22,15.58)

COMMUNITY						
Region Northcentral Northeast Northwest Southeast Southsouth Southwest			 1.00 0.56 (0.20,1.55) 0.85 (0.33,2.14) 3.01 (1.19,7.57) 5.61 (1.88,16.71) 1.12 (0.54,2.33)			 1.00 0.21 (0.07,0.66) 0.20 (0.06,0.67) 0.37 (0.11,1.21) 0.41 (0.13,1.21) 0.88 (0.34,2.31)
Distance to nearest Health Facility Big problem No/Not a big problem			 1.00 1.77 (0.99,3.17)			 1.00 2.21 (0.95,5.13)
Household variance (S.E)	0.001(0.001)	0.002 (0.101)	0.003(0.141)	0.08 (0.095)	0.78 (0.264)	0.131 (0.277)
Household ICC	0.160	0.100	0.090	0.181	0.113	0.098
Community variance (S.E)	0.636 (0.153)	0.383 (.127)*	0.343 (.123)*	0.762 (.181)*	0.427 (0.142) *	0.374 (0.139)
Community ICC	0.163	0.104	0.095	0.188	0.133	0.133
Goodness of fit- AIC	2297	2201	2185	2051	1949	1941

S.E-standard error: AIC=Akaike information criterion: ICC=Intra Class Correlation: C.I=Confidence interval:*p- Value <0.05

6.8 Conclusion

6.8.1 Summary

- Chapter 6 aimed to explore the intra-urban differences in childhood immunisation coverage over time and to answer the research question, 'In the urban setting, does childhood vaccination coverage vary between urban and slum dwellers and what factors are associated with it?'
- The 2003, 2008 and 2013 Nigeria Demographic and Health surveys urban data were pooled and stratified by urban formal and slum, with slums defined and composed using a standard definition
- Overall, the fully immunised child coverage was higher in urban formal (43.5%) than slum (34.4%) areas.
- The FIC relationship between urban places of residence and socio-demographic characteristics analysed with cross-tabulation chi-square test was similar to findings in chapter 4 and 5. The FIC was higher in urban formal compared slums, but with wider point difference between highest and lowest categories seen in slums than in formal settings.
- The unadjusted Odds ratios of the FIC coverage difference between urban formal and informal slum place of residence across the sociodemographic variables with 95% confidence interval and p-value revealed that in urban formal mostly had significantly higher odds than slums. The overall odds of being fully immunised was significantly higher in formal (OR=1.47, 95% CI=1.29-1.67) urban areas than in slum areas.
- A lot of the variations in FIC in the intra-urban locations have been explained from the quantitative analyses of the NDHS datasets, but several findings about the slum have remained unexplained because of the limited information about stakeholders' views on child immunisation barriers and challenges and the state of the health system. An example is the higher proportion of slum dwellers (83.9%) compared to urban formal (81.7%) that saw distance to the health facility as no/not a big problem, yet the FIC in urban formal was higher than the slum based on this category, with the odds ratio of the difference significant. Also this higher proportion of slum dwellers who felt distance to the health facility to access care was no/ not a big problem, did not translate into higher percentage for delivery in the health facility (slum 49.9% and urban formal 67.7%) or antenatal care attendance (slum 75.1% and urban formal 80.2%).
- There is the need to assess the slums health system and seek the views of the slum residents on childhood immunisation enablers and barriers.
- Multilevel regression analysis found similarities and differences in the association between FIC and sociodemographic characteristics according to the urban places of residence

Table 6.5: Findings of the multilevel analysis of the intraurban stratified data

Variable	Formal	Slums
Birth order • Birth order 1-5	S ↑	S ↑
Place of delivery • Health facility delivery	S ↑	S ↑
Mother's Antenatal care attendance • Attended ANC	S ↑	S ↑
Maternal education level • Increased education level	S ↑	S ↑
Sex of household head	NS	NS
Religion • Muslim • Christian	NS	S ↓ ↑
Mothers' employment status	NS	NS
Mother's age at child birth • 20-49 years	S ↑	NS
Mother's current marital status • No longer together	NS	S ↓
Decision maker on spending of mothers income • Mother alone	NS	S ↑
Household media exposure	NS	NS
Household wealth	NS	NS
Region • Southeast • Southsouth • Northeast • Northwest	S ↑ ↑ 	S ↓ ↓
Distance from nearest health facility	NS	NS

S= statistically significant: NS=Not statistically significant: ↑= increased the odds of being fully immunised: ↓= reduced the odds of being fully immunised

6.8.2 Key finding

- The findings presented here on the associations between a range of independent variables and FIC contribute, for the first time, to understanding the barriers and facilitators of FIC in an urban setting, uniquely separating slum areas from formal urban areas
- The non-significance of the relationship between FIC and religion in the urban formal is an important finding; the religion variable was significantly associated with FIC in Chapters 4, 5 and slums.
- Islamic religion had been identified as a barrier to being fully immunised over the years, so being much reduced in the urban formal location will help design child immunisation strategies that will overcome this barrier in other locations.

6.8.3 Chapter Abstract

The fully immunised child coverage (FIC), which is the percentage of children aged 12-23 months who had received all doses of routine infant vaccines showed wide variation in urban.

This chapter analysis aimed to explore the intra urban differences in childhood immunisation coverages over time. The pooled urban datasets from Nigeria Demographic and Health Surveys conducted between 2003 and 2013 were stratified into urban formal and informal (slums) households following UN-HABITAT guidelines, and analysed with descriptive and multilevel logistic regression methods.

Results showed that children in the slums had lower odds of being fully immunised than children in urban formal households. Across sociodemographic variables, the level of FIC was higher in urban formal than in slums, but with wider point difference between highest and lowest variable categories seen in slums. Birth order, place of delivery, antenatal attendance and maternal education level sociodemographic variables were significantly related to FIC odds in urban formal and slum households. Sex of household heads, mother’s employment status, media exposure, household wealth and distance to the nearest health facility to seek care were not significantly associated with FIC in either formal or slum urban areas. In the slums only, FIC was significantly

associated with mother’s current marital status, religion, decision maker on spending of maternal income and two regions (Northeast and Northwest), while mothers age at birth of child and Southeast and Southsouth regions were significant in the urban formal households.

Although this chapter presented exciting findings on the association between FIC and a range of variables in urban areas, the analysis was limited by data available in the NDHS. In particular, stakeholders’ views on child immunisation barriers and challenges, and assessment of the state of the health system are lacking. A qualitative study to investigate the views of the slum stakeholders on barriers and enablers of child immunisation and assessment of immunisation service delivery addressed these issues, with findings presented in Chapter 7.

Chapter 7 The views of parents, community leaders, health workers on childhood immunisation challenges and enabling factors in the slums of Abuja.

7.1 Introduction

The results from Chapters 4, 5 and 6 quantitative analyses using DHS data demonstrated that in the overall low child immunisation coverage in Nigeria, there were marked differences across regions, place of residence, ethnic, religion, education level, wealth class and some other socio-demographic variables. The fully immunised child coverage (FIC) across the selected sociodemographic variables in the slum households had similar patterns to urban formal and total population, but were significantly lower than in urban formal, despite the higher proportion of urban formal residents than slum dwellers who felt the distance to the nearest health facility to seek care was not a big problem. Another key finding from chapter 6 was the wider disparity of FIC, as shown by the point difference in FIC of the lowest and highest categories of the sociodemographic variable, in slums than in formal urban households. Findings from multilevel analyses of the datasets of the total population (Chapter 4), urban/rural populations (Chapter 5) and intra-urban (Chapter 6), showed that current marital status was significantly associated with the odds of being fully immunised only in the slums. These findings are suggestive of a role of other factors, including the health system, associated with FIC in the slums, but which the Nigerian Demographic and Health surveys have little or no data on.

This chapter sought to find explanations for the specific variations of FIC status in the slums. The aim was to collect the views of parents, community leaders and health workers on childhood immunisation challenges and enabling factors, with the use of qualitative research methods, to address two research questions: 1. What are the barriers and enabling factors in the uptake of childhood immunisation in the slums of Abuja? 2. Do health workers practice and attitude affect childhood immunisation in the slums of Abuja?

The PhD candidate embarked on a data collection trip to Nigeria after securing ethics approval for the study from the University of Southampton and the Federal Capital Territory of Nigeria Health and Human Services Secretariat. Data obtained from face-to-face interviews with 20 mothers and in-depth interviews with two health workers and two community leaders provided more understanding of the factors that may facilitate or impede childhood vaccination in the slums. In addition, these stakeholders suggested ways to improve child vaccine coverage. Immunisation service delivery observation and equipment inventory conducted by the researcher supported the discussion of the qualitative results.

7.2 Background

Residents of urban slums constitute about a third of the world's population and make up to 60% of the urban population in the least developed nations (Unger, 2013). Urban slums, defined by lack or absence of necessary infrastructure, poor access to educational, health and social services, inadequate or non-existent safe sanitary system and unhealthy environment (African Population Health Research Center, 2002), put residents at increased risk of disease and preventive health interventions like immunisation are all the more critical in these settings.

Most literature from Nigeria has focussed only on rural /urban differences, identifying easy access to a health facility as the primary reason for rural/ urban child immunisation coverage disparity (Antai, 2009b; Antai, 2011; Adegboye *et al.*, 2014). In the urban setting, access to immunisation services is generally adequate overall, although intra-urban differences in immunisation uptake have been reported in Kenya (Mutua *et al.*, 2011), which is similar to the results from Chapter 6. There is a lack of evidence regarding the reason for intra-urban immunisation uptake differences, and the views of people in the most disadvantaged areas are yet to be heard.

7.3 Methods

This qualitative study was largely based on the Social Ecological Model (SEM) that acknowledges the multiple levels of influence (child, maternal/household, community and Health system) that can shape an individual's behaviour (immunisation utilisation) (McLeroy *et al.*, 1988). The conceptual framework in Chapter 3 further explains the model.

This qualitative study was conducted in two slums in Abuja Municipal Area Council of the Federal Capital Territory of Nigeria. The qualitative study has no set rules and specific formula for its calculation of adequate sample size (Patton, 2002), as such the principle of saturation, in which collection of more data does not yield new information to understand the subject being studied, guided the needed sample size (Glaser and Strauss, 1971). Also, the methodology of the reviewed qualitative literature provided guidance.

The two slums chosen are large with functional health facilities providing routine child immunisation services. The choice of purposive sampling ensured the matching of participants based on some demographics like mother's age, marital status, religion and sex of the child. The final inclusion reason for the selection of the two slums has been withheld to protect the anonymity of the health workers as it is specific to only these locations, and it was raised in the ethics approval stage of the study with the decision being to anonymise the locations. These slums were chosen because they had specific immunisation system challenges identified by the FCT Primary Health Care Board (only these two settlements have had this issue since 2005 in Abuja). Although none of the participants could provide the exact date the slums came into being, most mentioned that the slums had been in existence as villages since the 1970s but grew into a slum between year 2000 and 2002.

Being fully Immunised refers to an infant (12-23 months) who had received all the basic child immunisation schedule vaccines BCG, first, second and third doses of OPV, first, second and third doses of DPT and Measles. This definition is consistent with that used in the NDHS analyses presented in Chapters 4, 5 and 6. Any child, aged 12-23 months who missed one, some, or all of the recommended childhood vaccines was termed not-fully immunised. The age 12-23 months cohort was similar to the fully immunised child group and the cohort used for the quantitative analyses in the previous Chapters. This made the results from this qualitative research complementary to that presented in the earlier Chapters.

In each of the two slums, five mothers with immunised infants and five women with not-fully immunised children were interviewed in the health facility. The mothers of the immunised infants were selected from the immunisation sessions at the facility, while the paediatric outpatient clinic was the setting for the not-fully immunised group. The choice of these participants was through purposive sampling to enable the collection of views from different sociodemographic groups in order to reduce the selection bias error. Most socio-demographic characteristics of the participants in the two groups were similar (Table 7.1).

In addition, the in-depth interview of the head of the Health facility's immunisation team and a community leader in each slum was conducted, as identified by the head (in charge) of the health facility. In both slums, the community leader (chairmen of the development committees) and head of the immunisation clinic were interviewed in the health facility. The community development committees are established in line with the government policy and have several mandates which include community participation, management and access to primary health care (Abdulraheem *et al.*, 2012).

Table 7.1: Description of participants interviewed in the slums in February and March 2017

	All	Mother Immunised child	Mother Partial or un-immunised child	Health workers	Community leaders
Total Participants (20 mothers, 2 health workers, 2 community leaders)	24	10	10	2	2
Birth order of the child focussed on 1 2-3 4-5	 8 10 2	 6 3 1	 2 7 1		
Child's sex Female Male	 11 9	 6 5	 5 4		
Maternal Antenatal care attendance Yes No	 20 0	 10 0	 10 0		
Place of delivery Health facility Home	 16 4	 9 1	 7 3		
Participants Sex Female Male	 22 2	 10 0	 10 0	 2 0	 0 2
Participants age 20-29 30-39 40-49 50 and above	 8 12 3 1	 4 6	 4 5 1	 1 1	 1 1
Mothers marital status Married/partner No longer married	 19 1	 9 1	 10		
Mothers employment status Employed Unemployed	 12 8	 6 4	 6 4		
Mothers level of education No education Primary Secondary Tertiary	 1 4 8 7	 1 4 5	 1 3 4 2		
Participants religion Christianity Islam	 14 6	 8 2	 6 4	 2	 1 1
Residence In study slums Outside these slums	 22 2	 10 0	 10 0	 0 2	 2 0

7.4 Data collection

In February and March 2017, the PhD candidate conducted all interviews in English and its Nigerian variant called Pidgin English. The interviews were held in comfortable and secured rooms in the health facility, with only the participant and PhD candidate. The study's information sheet was given to all potential participant after the PhD candidate had addressed them in the immunisation and paediatric clinics. Thereafter interviews were audio recorded after the participants signed the informed written consent (Appendices 2A, 2B and 2C). Semi-structured but flexible interview guides (Appendices 3 A, B and C) were used, with most questions being open-ended. The use of an interview guide guaranteed consistency in data collection within and across participants and slums. The guides were developed based on reviewed literature, and structured to elicit views from the respondents on how child, maternal/household, community and health system factors are associated with child immunisation status, as conceptualised in the study framework in Chapter 2.

Observations of immunisation sessions and inventory of available immunisation equipment were undertaken using the 2008 Nigerian National Routine immunisation supervisory checklist (Appendix 4) by the PhD candidate during the same period.

7.5 Data analysis

The interviews being transcribed on an ongoing basis provided the avenue to follow up on newly emerged themes such as the parents' desire to have a reliable communication channel with the health workers, in subsequent interviews. Also, this made it simple to identify when the saturation point was reached. Thematic analysis was done using Nvivo 11 software. The analysis was mixed, based on deductive themes from the literature review and inductive themes that emerged from the interviews. The final analysis was the summary of participants' responses and verbatim quotes, and observations of immunisation delivery that were reported in the five main themes: Information about immunisations, family influence, culture and religious factors, health facility environment and health seeking behaviour.

Findings

The views of the participants on enablers and barriers to childhood immunisation were similar in both locations and the separate immunisation groups, with few differences. The findings are reported as transcribed in English language and good pidgin, but where the pidgin was not easily comprehensible for external readers, comments were translated into English by the PhD candidate. Table 7.2 shows the main themes and sub-themes linked to the four levels of influence.

Table 7.2: Themes, sub- themes and levels of influence emerging from the interviews with 20 mothers and four key informants from two Abuja slums.

S/N	Theme	sub-Theme	Level
1	Information about immunisations	knowledge of vaccine types, schedule and disease protection Vaccine safety Source of information	Household Child Community, Health system
2	Family influence	Mothers desire to provide the best health care for the child Mothers education Husbands and relatives support Household wealth	Household Household Household Household
3	Culture and Religious factors	Hausa ethnic group Religion of Islam	Household, community Household
4	Health facility environment	Availability of Health facility in the slum Attitude of health workers Availability of vaccines Conducive setting for service delivery Quality of service Free immunisation services Preferential service for working mothers Inability to provide comprehensive health service Availability of alternative health facility nearby Absence of reminder and feedback channel	Health system Health system Health system Health system Health system Health system Health system Health system Health system Health system
5	Health seeking behaviour	Delivery in the hospital Antenatal care attendance	Child Maternal

7.6 Information about immunisation

7.6.1 Knowledge of vaccine types, schedule and disease protection

Knowledge about immunisation among mothers was limited, with only four of the twenty mothers being able to mention three or more diseases that the routine child vaccines protect against. Only one mother mentioned all the recommended vaccines correctly.

The limited knowledge about the benefits of immunisation was noted as a hindrance to child immunisation both by mothers who immunised their children fully and those who did not. Several respondents wondered if mothers of non-fully immunised knew the benefits their children had missed.

"Some mothers don't bring their children for immunisation because of ignorance, yes they don't really know what they are missing for the child. They don't know". ***Mother, 26, fully-immunised, B6***

"Some people are still ignorant of this immunisation. Like some people that believe in culture that they don't give injection to their children. Their thinking did not come this far the way we are reasoning it, they believe that the child can still survive without giving this immunisation". ***Mother, 40, non-fully immunised, B7***

"Some of them went to school but i don't know. Its education without good information on vaccines". ***Mother, 34, non-fully immunised, B8***

On being told that immunisation does prevent disease, the mother responded that the likelihood of a child contracting a vaccine-preventable disease had nothing to do with immunisation, but the child's destiny.

"If pickin go sick or not, na destiny. I go only do what i fit do". ***Mother, 25, non-fully immunised, B9***

Some children missed the opportunity to be vaccinated because their parents were not aware that vaccination of children was provided free of charge in government-owned health facilities.

"Because they are not well informed, because of the level of poverty they thought that when they go there they would be asked to pay money, so to even attempt going they wont do that because already they have judged themselves". ***Community leader, 52, B***

7.6.2 Vaccine safety

Mothers determined the safety of vaccines by experience from perceived vaccine adverse events and information from a trusted source. In addition, a sickly infant was seen as a contraindication for immunisations. An infant or older sibling's adverse reaction to childhood vaccination was reported by several mothers to have played a role in the completion of the immunisation schedule. The first vaccine, BCG which is given immediately after delivery, was alleged to have caused several children much pain, and to have the capacity to cripple the infant or cause an ear infection. Such experience or idea would leave children vulnerable to vaccine preventable diseases, as BCG is the first of the five routine childhood immunisations and negative experience with BCG may make attendance at subsequent immunisation sessions less likely. A mother with a non-fully immunised child said her fear of the "harmful" side effect of BCG made her stay away from the immunisation session. Another mother alleged that the child developed an ear abscess immediately after BCG immunisation which led to not returning for any other immunisation in the routine immunisation schedule. There is need to tackle this type of barrier at the early stage of immunisation if the infant is to have the opportunity to receive the successive immunisations given at 6 weeks (OPV1, DPT1), 10 weeks (OPV2, DPT2), 14 weeks (OPV3 and DPT3) and 9 months (Measles). Such maternal fears are common in Nigeria; concern and fear about the safety of vaccines was expressed by about 39% of mothers whose children were not fully immunised in a study in Nigeria (Abdulraheem *et al.*, 2011)

"I was afraid of that vaccine like BCG, it pains them in the east (her state of origin in eastern Nigeria). The thing pains them for more than one month. These injections can make them not to walk or cripple their hands. The thing touched their bone". ***Mother, 26, non-fully immunised, A1***

"Because when my baby took BCG, so i think after 3 days he had pus inside her ears the thing is coming out, so they say i should take the baby to the clinic, so before that my friend in kuje said it was because of the vaccine, so after one week it stopped. The fear made me not bring him for vaccination again. My other children got all vaccines". ***Mother, 31, non-fully immunised, A8***

One of the mothers alleged that her child nearly died after receiving the first batch of vaccines. Like all drugs, vaccines have side effects, but those of vaccines are rare (Chen and DeStefano, 1998). Most vaccine adverse effects reported may be due to bad administration technique***.***

"i did not complete her immunisation till after the age of 2. After collecting the first vaccines at 6 weeks. She sick ooh, i nearly lost her, i didnt want her to take again. I was discouraged that time, but my husband said no, i should continue and should not be discouraged. So that one affected her and is affecting me". ***Mother, 23, non-fully immunised, B4***

Most health workers avoid administering immunisation on very sick children (FCT Primary Health Care Board, 2013a). The risk of live attenuated vaccines causing disease in an immune-compromised child is high and the administration of vaccines such as BCG and Yellow fever vaccines on this category of children is discouraged (National Primary Health Care Development Agency, 2009). The health workers explained that it was best for the child to recover from a current ailment, before being administered any vaccine, to prevent immunisation being implicated in an untoward outcome. Also, mothers are hesitant in the immunisation of sickly infants

"I have given immunisations to all my children. None have got anything like a collapse leg or physical disability. No, apart from one baby that i lost, you know that baby i gave birth to her with Down syndrome". ***Mother, 40, non-fully immunised, B7***

With adequate immunisation education, this child with Down's syndrome could have benefited from immunisation.

7.6.3 Source of information

Health workers, posters, churches and media were identified as important sources of information about immunisation. Most mothers, irrespective of their child's immunisation status, identified the health talks received during antenatal visits as a vital source of information on childhood immunisation, which included the different types of vaccine, schedule, diseases it protects against and adverse effects of immunisation.

"For people that don't go for antenatal and those that deliver at home, there is no way they will know about all these things about vaccines". ***Mother, 22, immunised, A7***

"They *use to tell us everything about immunisation during our antenatal. The nurses really trained us on immunisation for our children during antenatal, they kept reminding us each time we visit clinic".* ***Mother, 22, immunised, A7***

*"it is in the clinic during antenatal that I first heard of vaccines"****. Mother, 26, non-fully immunised, Location A1***

An alternative source of immunisation information was from friends, neighbours and other sources within the community. The vaccine information provided by these sources are sometimes unfounded and unproven. Two mothers who claimed to have heard that the administered vaccines killed some infants admitted that the source of information was neither an eyewitness nor the "affected parent". Also, the allegation that vaccines are capable of causing female and male infertility is still alive among some slum population groups, which explains why the association between FIC and religion remained significant only in the slums, as reported in Chapter 6. This misinformation that made the mothers discontinue child immunisation could easily have been verified at the health facility during antenatal or first immunisation contacts. It brought to fore the need for health facility-based information to be well presented. All mother participants reported attending antenatal care. The observation of the immunisation session revealed that about half of the mothers were either outside the venue or standing while waiting to be serviced. Also, it seemed that the mothers just wanted to leave the very uncomfortable clinics as soon as possible. Hence, the absence of questions from the mothers for further information regarding things they were unsure of during the health talks.

*"She said it (vaccine) is too strong for the children that it can paralyse their legs something like that". **Mother, 25, non-fully immunised, A9.***

*"One woman told me that if your baby reaches 9 months, you should not give her the 9 months injection of measles and yellow fever because they stop the child from walking, so my first two babies did not receive them" **. Mother, 35, non-fully immunised, B5***

*"One of my friends, she said she don't like to bring her baby because it will bring fever that she don't like it. Another of my friend when they are in Gwagwalada gave the baby that last vaccine, after that day the baby died , so i did not take my second baby for the last vaccines. Since then with better information from our church doctor, my last children completed their vaccinations". **Mother, 34, non-fully immunised, B8***

No posters or other Information, Education and Communication (IEC) materials were seen in Location A, which may be due to the lack of walls at the immunisation venue (pavilion). This absence of IEC materials in Location A deprived the mothers of another source of immunisation information. Immunisation information on posters in Location B was outdated.

7.7 Family influence

7.7.1 Mothers desire

Mothers in both locations acknowledged the barriers to child immunisation and expressed their determination to overcome them because of the benefits to their children. Some mothers who did not complete their child's immunisation reported their desire to overcome the challenges to child immunisation. These mothers reported their willingness to seek vaccines in nearby General hospital in the city, which suggest that in they believe that the slum health facilities provide poorer services than those in the urban formal settlements.

*"If they don't treat me well I will go to another place at gwarimpa, they give at gwarimpa, other places, what is important is my child gets". **Mother, 26, non-fully immunised, A1***

A mother expressed her desire to borrow money to cover the transport fare to the slum's health facility on the immunisation day.

> *"It is better to borrow money to keep vaccination appointment than miss the appointment because of lack of transportation money".* ***Mother, 34, non-fully immunised, Location B8***[5]

This maternal characteristic was also expressed by mothers who had ensured the full immunisation of their children. They were ready to accept any insult, spend long hours waiting to be served and come several times until the out-of-stock vaccines were available in order to have their children healthy.

> *"i dey serious make my child okay, even if the workers abuse me, abi I come three times I no see vaccine, I go still bring my pickin come".* ***Mother, 31, immunised, A3***

> *"No matter the time spent waiting, it does not matter. Vaccination is for the good of the baby and even you as a mother will have rest, because when you did not vaccinate the child maybe one sickness or the other would now weigh the child down for the rest of his or her life, you as a mother would be carrying the child up and down. So you do the right thing and be free and let the child too be free"* ***Mother, 35, immunised, B2***

> *"Sometimes some of them (health workers) can get angry and say you i will not give you, i will make sure you did not take it today. I will go that day and come back tomorrow or i will go to another person and talk to that person or i will sit behind by the time they give everybody and remain only me... aah aah, your heart is not stone now, you will still answer me".* ***Mother, 35, immunised, B2***

> *"You know all these people (health workers), even though they misbehave to people. But you know the importance to the health of your baby you will stay, you can't just because of peoples character run away from them. You have to adapt".* ***Mother, 23, immunised, B10***

> *"Bad attitude from health workers will discourage me in other way like for my own treatment but as this is for my baby, after all i will get what i want, i would balance it".* ***Mother, 33, immunised, B3***

> *"all these things like come today, come tomorrow because of no vaccine, the long wait in the clinic, big woman nurses attitude, I just try to overcome them in order that all these diseases would not affect my baby's body".* ***Mother, 23, immunised, B10***

[5] Transcript of the bad pidgin, *"instead for wey you no get money ,go make you no go and take immunisation, you better borrow na for the baby"*

These mothers' responses showed the importance of maternal commitment to optimising childhood immunisation.

7.7.2 Mothers education

In line with the reviewed literature, education was seen by several participants as very important in understanding and accepting child immunisation services. Several mothers felt that being educated made them realise the advantage immunisation has over cultural practices, like the use of herbs, and being cost effective as a fully immunised child is less likely to be infected with the vaccine preventable disease, whose treatment would be at a cost.

*"These local people they don't want to be come, they depend on their herbs or something like that, so as an educated person you have to come here because it is good and free and we don't spend money". **Mother, 25, non-fully immunised, A9.***

Most mothers saw not being educated as a barrier to accessing immunisation services. Lack of formal education was seen as the major reason why most people do not access childhood immunisation because illiterates do not understand the importance of immunisation.

*"i think that most people that doesn't go for immunisation are illiterate, they don't understand the importance of this immunisation to their children. It is based on their level of education and not religion or ethnicity". **Mother, 23, immunised, B10***

The immunisation health talks at the clinics were conducted in English, with few sentences in local languages. Some mothers without primary education may not comprehend the health information because of their limited knowledge of the English language.

7.7.3 Husband's and relatives' support

Many mothers and their partner/spouse lived with no relative nearby, with nobody to assist during pregnancy and the immediate post-delivery period, leading to several of them travelling to their place of origin to have their babies. Extended family members took care of these women in their places of origin. This temporary place of residence may have become a barrier to child immunisation in several cases. The rural areas where most of them travelled to, have been reported to lack adequate number of health facilities and reduced quality of service (Antai, 2011; Singh, 2013; Chidiebere *et al.*, 2014). Although results presented in Chapter 5 and 6 showed that the challenges of distance to the health facility when seeking care was similar in rural/urban, and urban formal/slum locations, the quality of immunisation service could not be assessed due to data limitations, nor could the cost of getting to the facility be assessed. The assessment of immunisation services in the slums revealed that service provision needed a lot of improvement.

"Who will take care of me? My husband is too busy and it will be too much work for him? In Imo all my people are there I will not feel it at all". ***Mother, 26, non-fully immunised, A1***

Prolonged absence of husbands due to jobs in a distant part of the country led to some mothers moving back to their villages of origin. Since these slums can be demolished at any time, and with no relative to support them in the absence of the husbands, women moved back to the villages.

"My oga (husband) travelled to do work for kano , so I went to stay with my people in the village till oga finish. That is why I miss the 9 months injection". ***Mother, 30, non-fully immunised, A4***

The inability of some mothers to obtain permission from their husbands to attend immunisation clinic was a barrier

"Yes. If oga (husband) does not let me come, i can't come". Sometimes one can be tired......... once I was in the village and nobody to take her for vaccine. ***Mother, 25, non-fully immunised, B9***

Among this group of 20 women, those who had more than two children were less likely to move back to their rural family for the delivery than those with fewer children.

The involvement of men/husbands was identified as a way to improve child immunisation by mothers, health workers and community leaders. The suggested roles for the husbands were to help in dispelling negative immunisation rumours and misinformation and remind wives/spouses of child immunisation appointment dates. In addition, some mothers had to secure approval from their husbands before coming for immunisation. Several others said their husbands provided the funds to cover the transport cost of coming to the immunisation clinic. Yet, during this study's two month data collection period in the health facilities, no man was seen in the immunisation clinics of the two health facilities.

"The husbands, yes the men, sometimes woman will forget since she has many things on her head. So she forgets the next appointment but if the man knows what the woman is coming for, he too will remind the wife, i think you have immunisation today and she will come".
Health *worker, 49, A*

"It is the knowledge i have during my antenatal, whenever i get home i discuss it with my husband. I will be telling him some of the things i learnt. That is what happen and he supported me too, at times, he is the one reminding me of our immunisation date". **Mother, 22, immunised, A7**

"They can encourage the both parents because maybe your wife is ignorant the husband might be sensible enough to put the wife through or the wife may be sensible enough to put the husbands through". ***Mother, 26, immunised, B6***

7.7.4 Household wealth

Ideally, the free service provision of childhood vaccines and the presence of the health facility should make it inexpensive to attend immunisation clinic in these slums. Results from multilevel analyses of pooled data from Chapters 5 and 6 that revealed the non-significant relationship between FIC and household wealth might be due to the no user fee charge on child immunisation service and majority not seeing distance to the nearest health facility as a big problem. The rapid expansion in the geographic size of these slums has the potential of increasing the transport cost to the clinic for immunisation from the farthest parts of the slums, which are beyond normal walking distance.

"i will be discouraged if the clinic is far because if you don't have money you cannot fly, so if your house is too very far you cannot trek, but thank God the clinic is close to us here". ***Mother, 23, non-fully immunised, B4***

7.8 Culture and Religious factors

Some participants felt that ethnicity could be a barrier to child vaccination. The Hausa tribe who are mostly Muslims were identified by several mothers in both locations as those who did not immunise their children. The Muslim mother who had a non-fully immunised child attributed it to her need to return to her place of origin to give birth. Culture and religion could not be separated. Though religion was significantly related to FIC in the total, rural, full urban and slum populations in Chapters 4, 5 and 6, the significance of the role of religion depends on other co-variables that are not captured in the NDHS such as injection pains, cultural/religious practice.

"i know that when you deliver a baby, you must give them immunisation but some people like these Hausa people they don't do it. So some of them don't do it because of the pains and religious problems". ***Mother, 26, non-fully immunised, A1***

A reason given by a mother for the reluctance of the Hausa mothers who were practising Islamic female social exclusion, was the minimal interactions they had with others including knowledgeable people, and lack of access to relevant immunisation information. During the observation of the immunisation sessions, women with full covering (Muslim/Hausa) were clustered together and separated from other mothers. This may be part of the reason why the relationship between FIC and religion was only significant in the slums in the analyses presented in Chapter 6.

*"....Its not education, mostly all these Hausa mummies, all these mata kule (women in Purdah) or what do you call them, they are not exposed, and don't get the needed information". **Mother, 30, immunised, B1***

Another mother explained that the religion that forbade women from exposing any body part in the public impeded child immunisation, since it left both the mother and child uncomfortable in the tropical weather. This can cause the mother not to return for subsequent immunisation sessions.

"Is it related to religion? I will say yes because whenever we are here, some mothers don't feel free to breastfeed their child. They like to cover and when the child will be under the heat, they keep the cover on and the child is suffering of heat. Really I didn't see some again". ***Mother, 33, immunised, B3***

A community leader voiced his frustration at the poor utilisation of immunisation services by the Hausa people. He said their efforts were hampered because the women could not be forced since the community was not their husband's. In this regard, slums are not different from most African societies, where the husbands must permit the mother to take the child for vaccination.

"It is the Hausa who do not permit their wives to bring the children for immunisation. The Hausa are guilty of this. Nobody can force them because the women are their wives."[6] ***Community leader, 44, A***

The reluctance of the Hausas to embrace child immunisation was on the wane, according to the account of one of the health workers. This was attributed to the engagement of the Hausa community leadership in the slum

"When this clinic was newly opened we were not seeing Hausa people but because of sensitization visiting meetings with their leaders, telling them the importance. So they have begun allowing their wives come for the immunisation". ***Health worker, 32, B***

[6] Original transcript in poor pidgin English, "*Na Hausa people na im no dey gree im wife come for riga kefi(vaccination) .Some people like Hausa na im dey do that one. we no go fit go tell that person say by force im wife go hospital collect riga kefi. No be our wife".*

7.9 Health facility environment

The earlier analyses in Chapters 4, 5 and 6 using DHS datasets did not have relevant information on the immunisation service system, hence the interview of participants and observation/inventory of immunisation service provision by the interviewer to provide immunisation specific and other health data of the health system. The NDHS data is limited to information on how participants viewed the distance to the nearest facility when seeking care, including immunisation, which could relate to any care for the survey respondents, child and other family members.

7.9.1 Availability of Health facility in the slum

A health facility providing immunisation services was mentioned as a facilitator for childhood immunisation by numerous participants. The facility being within walking distance was generally acknowledged to have made it easier to utilise immunisation services. Despite the health facility not being well equipped, the respondents commended the government for providing the health facility in the slum. These narratives of the slum dwellers were in line with the pooled NDHS data analysed in chapters 5 and 6 that found that the of all places of residence, the proportion of slum dwellers who did not see distance as a big problem to accessing care was the highest.

*"What government is doing now is very, very good because in particular area now they will locate a centre there, so that it will not be distant from the people. So that you will not say the distant is very, very far and you will not go for vaccination and treatment". **Mother, 23, immunised, B10***

An additional merit of the location of the health facility in the slum was that it saved transport cost, which may have been incurred if it was far away from the slum. The respondents acknowledged that this transport cost was a likely barrier to the immunisation of a child.

*"In this place (name withheld) the clinic is close for anyone to trek, but the other places that don't have clinic and come here, yes sometimes money can stop some from coming". **Health worker, 32, B.***

7.9.2 Attitude of health workers

Several mothers reported that the attitude of the health workers was in contrast to their expectation. In the immunisation clinic, they believe the services should be rendered with respect, care and love to the baby and mother.

"The health workers shouting at and abusing mothers will discourage me, because they are meant to love and care for everybody, the mother and the baby". ***Mother, 26, immunised, B6***

"it is very very discouraging as in at times you will come as early as you can, to make sure that you give your child the proper immunisation, but at the end of the day you will go home very very upset because of what one nurse or doctor, how he or she reacted. It is not good, i think their work is not only for the child but how to relate to mothers". ***Mother, 22, immunised, A7***

The mothers felt the bad attitude of the health workers was carried out in all health services provided. The abusive nature of the health worker happened everywhere and not only in the slums according to two mothers

"The health workers are the same everywhere, even if you take them oversea. Sometimes I feel they enjoy abusing us.". ***Mother, 26, immunised, B6***

7.9.3 Availability of vaccines

Non-availability of vaccine was a most important barrier; without vaccines, no child can be immunised. In both slums, mothers had experienced vaccine stock-outs, but their opinions differed on the vaccine types and the effect of the stock-outs. The mothers agreed that vaccine stock-outs can discourage the completion of childhood immunisation. The mothers and health workers did not seem to be aware of the current childhood immunisation schedule, with Vitamin A supplementation, frequently mentioned, was no longer part of the schedule. Since 2010, Vitamin A supplementation is only given to eligible children in the twice yearly Maternal, Newborn and Child Health Weeks (MNCHW) (Onimawo and Alo, 2015), rather than to all children during routine immunisation clinics. Seven years on, the health workers and mothers are yet to be fully informed, and the private health facilities have taken advantage of the situation.

"Non availability of vaccine can cause people not to come for immunisation. Because like now they don't have six month vaccine here and i came that time they say they don't have that they only give 9 month so i have to go to private hospital to go and get for him. So it can cause it". ***Mother, 28, immunised, A6***

The mother who did not complete the immunisation of her first two children, was being prevented from completing the immunisation of her third child because of the non-availability of measles vaccine**.**

"Like for her younger brother, i came at 9 months and was not supposed to come again, they gave him some and one was remaining. So i was kind of discouraged. Infact, i said aah if he doesn't get it what is going to happen? But along the line i said let me come again and see if they will give him". ***Mother, 23, non-fully immunised, B4***

Not all mothers who came to the health facility may have their children immunised as vaccines could be exhausted during the session.

"Only one day that i came and they say there was no vaccine and i still receive that day but some people did not receive. I received because i came early to pick my number". ***Mother, 23, immunised, B10.***

The child immunisation coverage decreased after stock-outs of some vaccines, according to the health workers.

"See we didn't have much coverage in December, we are not having antigens because when i go for the antigens around November some are not there like BCG and PCV". **Health worker, 49, A**

In the urban areas, it is likely that stock-out of vaccines are limited to health facilities in the slum. The health worker admitted that when the vaccine stocks are low, priority is given to the big hospitals in the city. A respondent explained that she overcame the absence of vaccine in the slum facility by accessing care in the general hospitals in the urban formal settlement.

"The only thing that discourage me from coming here at times is that 6 weeks, 6 months sorry, the vitamin A, they don't usually have it. It is only when you go to general hospitals like Wuse, Maitama and or all these big private hospital in town that you have it. At times this 9 months that you come here today at times they don't have it, so for you to say let me come and check may be at the end of the day you will come and be told that they don't have it. You might decide not to come and take it again". **Mother, 22, immunised, A7**

7.9.4 Conducive setting for service delivery

The location of the health facility in the community was expected to ensure geographical access to immunisation service, but the poor state of the ceiling and pavilion style immunisation venue in location A left mothers drenched by the rains. In location B, the poor drainages in the slums have led to the health facility and access roads to be flooded during the period of heavy rains. The magnitude of this barrier was made clear when the resultant flood was described as being powerful enough to drown an able-bodied man. The availability of the health facility nearby does not translate to access to service at all times.

"When rain fall, everywhere will be flooded, even a man will be washed away by the water". ***Mother, 25, non-fully immunised, B9.***

The two community leaders highlighted how the rains were barriers to coming to the health facility to access the immunisation services. The hot rays of the sun can discourage mothers in slum A since the pavilion will be very hot.

"If it were during rainy season you wouldn't like this place, the compound itself, the environment will be flooded. Where the facility is located is not well taken care of, the access road during rainy season becomes rivers, honestly it could be very very discouraging". ***Community leader, 52, B***

"After being drenched by the rain and burnt by the sun in the facility, will the mothers come again?"[7] ***Community leader, 44, A***

Immunisation sessions being prevented from holding or disrupted is limited to the slums by the sun and rain. The Abuja formal settlements are well planned with adequate infrastructures, and the general hospitals well built.

"Government has abandon us, go maitama and wuse see good hospitals. The rain and sun do not worry them. If the community had money we for do the ceiling and put correct canopy". ***Community leader, 44, A***

The health facility in location A was very dilapidated. The ceilings were all torn or missing, while in few places the roof had been blown off. The solar refrigerator that was meant to keep the vaccines in the optimal temperature was not functional because the roof on which the solar panel was mounted had been blown off. All efforts by the community to get the government to renovate the existing structure had been futile as the government seemed reluctant to spend money on a structure in an area earmarked for demolition. The community leader explained that the health facility was being utilised as a last resort.

" It's only those without choice that come to this facility. This place is not good. The government has refused to repair this old clinic or complete the new building, because this community is billed for demolition one day. But when elections come, we are remembered"[8]***Community leader, 44, A***

The other community leader highlighted what needs to be done to the health facility and concluded that the government has not been fair to the community

"So concerning this place, I know I am a stakeholder, government cannot sack me, I am not an employee like the in charge. He was employed, if he wants to talk he can be economical with the truth. Me, I gain nothing I lose nothing. There is great need for expansion, staffing and to improve the environment. We need to expand the building and to equip. In this the government has not tried and are unfair. This place has no facilities. ***Community leader, 52, B***

Despite the poorer state of the health facilities, and greater need in the slum compared to the formal urban settlements, the government has recently added more health facilities in the formal

[7] Original transcript in bad pidgin, "*Dey come hospital rain beat them, sun finish them, dey go come again?"*

[8] Original transcript of the bad pidgin, *"Na only when choice no dey person dey come here. This place no good now. Government say dem no fit repair this old clinic and complete the new one because dem go demolish here one day, but when election come, dem dey remember us"*

urban settlements (Vanguard, 2017). So the deplorable state of the slum health facility may not due to the paucity of funds but the government's decision of prioritising the formal areas.

The immunisation sessions were crowded in both locations, with the immunisation room too small for the attendees. In location A, the immunisation sessions were held in a pavilion with open sides, some mothers were sitting and others standing inside or outside the pavilion, and the PhD candidate was informed that during the rains, mothers are usually drenched. In the other slum, the room where immunisation sessions took place was small and stuffy with most mothers standing outside during the health talk. These places had rickety and broken down furniture. The people deterred by the physical state of the health facilities may not be limited to mothers coming for immunisation alone, but include pregnant women seeking antenatal services or place to deliver. Thus, the lower levels of antenatal attendance and hospital delivery by slum dwellers compared to urban formal residents shown in Chapter 6 may be related to the physical state of their health facilities. The two community leaders described the harrowing experience mothers go through during child immunisation.

"There is no ceiling. When patients visit this clinic and see the poor physical state, they will not come again. During the visit, patients are drenched by the rain and burnt by the sun, do you think they will come again?"[9] ***Community leader, 44, A***

"*If you come the day we are doing our immunisation like today, my brother the crowd, the crowd you see here, you will pity our women. The building itself cannot take them. Two thirds of them would have to be outside. There is great need for expansion".* ***Community leader, 52, B***

The free immunisation service provided by the health facility immunisation unit left it unable to generate funds and carry out minor repairs. The health workers asserted that the sorry state of the venues for immunisation was compounded by the non-priority status given to immunisation service delivery by the health facility management. As a result, the funds generated in other units in the health facility are not made available to undertake minor repairs in the immunisation unit.

"it is not encouraging people oh especially the seats we did the bench ourselves and we still added some this year. You know immunisation section does not generate any fund in immunisation section. We have to ask the in charge to add more bench which is not enough my women come and stand". ***Health worker, 49, A***

[9] Original transcript in bad pidgin- *"Ceiling no dey. If some people come to see how hospital be and the hospital no fine, dem no go fit come. Dey come hospital rain beat them, sun finish them, dey go come again?"*

7.9.5 Quality of service

The provision of good immunisation service has the potential of ensuring that all those who start the routine immunisation schedule complete it. The quality of services provided by the health workers was reported by mothers as an important factor, which can determine if the mother will complete her child's immunisations.

"i will say it is the health workers that bring us here, because when we come to this place they are always the one coaching us not to miss our children appointments. I think it is the health workers". ***Mother, 33, immunised, A5***

Unfortunately, some mothers doubted the competence of the health workers providing immunisation services. Adverse reaction to a vaccine was seen as the consequence of the health worker's incompetence, and the inability of the health workers to provide accurate answers to questions were said to affect the mother and baby negatively. Some mothers felt the health workers posted to the slums were not as competent as those in the general hospitals in formal urban areas. The lower levels of antenatal attendance and health facility deliveries seen in slum dwellers may be attributable to these beliefs.

*"The way a child reacts to immunisation depends on the health centre, as some of the nurses and doctors are not as good as others. At times self when you ask them some questions, when you need to be cleared on a particular thing, they will not give you the accurate answer, so it affects the mother and not really the child"****. Mother, 22, immunised, A7***

In a bid to reduce vaccine wastage, the health workers will not open a new vaccine vial until a reasonable number of eligible children are available to be administered (FCT Primary Health Care Board, 2013a). This practice is restricted to the vaccines that have to be reconstituted by the health worker before administration. The health worker confirmed the mothers' allegation that although BCG vaccine was available, it was not administered because of the very low number of babies waiting for the vaccine. The BCG vaccine is a 20 dose vial and must be used within 4-6 hours after opening. Though the immunisation policy recommends the administration of any vaccine if only one child was present (National Primary Health Care Development Agency, 2009), most health workers and immunisation managers will not open a new vial of BCG for less than 5-10 children depending on the locality. In practice, this is the only way stock-outs can be avoided, as vaccines are allocated to facilities based on a fixed target population with a 20% allowance for wastage (FCT Primary Health Care Board, 2014a), hence a wastage rate of more than 20% will lead to a stock-out.

"For BCG, it happens at times. We just plead with the mother, madam please the vaccine is for 20 children and if we are to open for only your child the remaining 19 will be waste. So we give Hepatitis and OPV 0. We ask her to come back the following immunisation day". ***Health worker, 32, B***

"They will tell us if the numbers of the children was not enough they will not open because they will not keep and it will waste". ***Mother, 34, non-fully immunised, B8***

The health workers are important in increasing child immunisation coverage in the slums. All the mothers interviewed had at least one contact with child immunisation services. This indicated that the mothers had all, some or little faith in immunisation, which can be built upon to improve childhood immunisation. The health system accounts for most of the reasons for the non-completion of immunisation by a child who started the schedule (Rwashana *et al.*, 2009). The health workers are aware of interventions that can facilitate child immunisation. More effort and attention are required from the health workers. The health worker's friendly disposition to the mothers will ensure that the mothers complete their child's immunisation.

"*The most important thing that brings them is just being friendly. When you are talking to them, laughing with them, they will come some will even come when it's not their appointment. Today, we returned eight of them because it's not their appointment date but they were rushing to come".* ***Health worker, 49, A***

Although all mothers remembered being verbally informed of the next immunisation appointment, after it was written down in the child immunisation card, few mothers said their spouses had to remind them of the appointment days. Writing down and telling the mothers the date of the next immunisation appointment was as crucial as educating mothers on the importance of immunisation.

"The number one thing is health education from us because there is no other place that they can get it and also to let them know the importance of immunisation and to also let the mother know when to come back for the next appointment. It is very important". ***Health worker, 32, B***

7.9.6 Free immunisation services

The government policy that ensured the provision of free immunisation services in the slum's health facility was reported by the mothers to have enabled immunisation of their children, which is the likely reason for the non-significance of the wealth variable in the fully immunised children odds in the slums in Chapter 6. The mothers commended the government and acknowledged that an immunisation user fee charge, would have been a barrier to childhood immunisation for some section of the populace. Despite the free immunisation service, not all the target population were brought for vaccine administration.

"Thanks to the government for providing vaccines free, some people because of the money will not bring children". ***Mother, 33, immunised, A5***

"Our government is helping with free vaccines and because of that you know some people are coming .Even now that it is free many are not coming for it , much less will come when they are ask for money". ***Mother, 28, immunised, A6***

In addition to free immunisation, the government in conjunction with partners provided items like baby nappies free of charge to children brought for immunisation. This additional gesture encouraged child immunisation.

"Because it's free it encourages people to come. Sometimes even when they come they get some gifts from here like some Pampers (nappies)". ***Mother, 40, non-fully immunised, B7***

The community efforts to increase utilisation of immunisation services was helped by the free provision of vaccines for the eligible children. During the community led door-to-door campaigns aimed at increasing utilisation of health services provided in the slum health facility, the free immunisation service was a key message.

"We know ourselves, we go in door to door to encourage our people, most especially our women that they should please bring their children for vaccination. So it is highly important and beneficial that it is free, it is 100% free". ***Community leader, 52, B***

7.9.7 Preferential service for working mothers

The long hours spent in the immunisation clinic can discourage working mothers from bringing the infants for immunisations. Working mothers do not want to spend much time in the immunisation clinics; they want to get the vaccines quickly and return to work. The long wait has led those with the means to go elsewhere.

"Like in that St Mary (private hospital in town) that i went for antenatal, though why i normally go there is that you won't spend much doing it. I need a place that i will quickly be attended to and go back to my business" ***Mother, 35, immunised, B2***

The health workers recognised the need to encourage mothers who are working and have limited time to spend in the immunisation clinic. In both locations, a preferential service was available for these mothers with their infants immunised first, but each health facility had a different delivery style.

In location B, working mothers had their babies immunised in the full glare of other mothers after the health worker had explained to the mothers the reason why the working mothers had to be attended to first.

"If someone comes with a complaint, please ooh i am from office or i want to go to office so i came to collect immunisation for my baby before going. We do consider them and we start with them first so that they can go". ***Health worker, 32, B***

In Location A, under the guise of treating the mother or baby for an ailment, the health worker administered the vaccine on the child in the privacy of the storage room. Here, the health worker felt any accusation of bias or being partial was avoided.

"*Like women that are working i have only one. She is the first person i gave the injection. Women that works when they take excuse and they tell me i will carry them inside here so they can go back. So that other women will not complain that I am doing partiality, so i will do as if i want to give her treatment and i will come and give them the vaccine. i have working class mothers*".
Health worker, 49, A

7.9.8 Inability to provide comprehensive health service

These health facilities were providing limited primary health care services, with mothers and community leaders expressing concern over the quality of health care provided. Non-availability of drugs for common ailments in the health facility was seen as a barrier to patients returning to the facility to access other services including immunisation. A mother in location A recounted the case of her neighbour who was poorly attended to and later referred to the general hospital by the health facility, has been discouraging mothers from utilising immunisation and other services from the clinic. Others suggested that a disappointment in care sought led to the loss of confidence in the services available in the health facility.

"Without drugs the health facility will not be patronised. If someone comes today but is told the prescribed drugs and injections are not available. The patient comes around tomorrow, still no drugs and injection. Surely such a person will not bring the child for immunisation"[10] ***Community leader, 44, A***

The limited services provided by the health facility have made slum dwellers seek health care from the general hospitals close to the slums, which increased the cost of accessing care, which may lead to the poor losing out if they cannot afford it. In addition, it highlights the availability of higher quality of service in the health facilities in the urban formal settlements

"I go to General Hospital most times because sometimes you get to this place they wont deal with any other problem they will refer you from here to that place". ***Mother, 40, unimmunised, B7***

[10] Original transcript of bad pidgin, *"if medicine no dey, people no go come, if person come today, person come e no see medicine, e no see injection, this medicine no dey, tomorrow e no go come if im pikin need rigakefi".*

7.9.9 Availability of alternative health facility nearby

Both slums were close to four public-owned general hospitals situated in Abuja that also provided free immunisation services. Mothers resident in the slums were aware of their existence and the services provided in these hospitals. The general hospitals provided alternatives to failures in immunisation service delivery like vaccine stock-outs or perceived poor service in the health facilities located in the slums. This alternative health facility provided an option for childhood immunisation of slum dwellers, when the slum facilities had vaccine stock out, offered poor quality service, inaccessible or otherwise lacking. These mothers also noted the better service and regular availability of vaccines in the formal urban hospitals.

*"if there is no vaccine here, i will go to either Gwarinpa or Maitama General hospital, its that simple". **Mother, 30, immunised, A2***

*"If they don't treat me well I will go to another place at gwarimpa, they give at gwarimpa, other places, what is important is my child gets". **Mother, 26, non-fully immunised, A1***

Despite the presence of four bigger and better equipped health facilities close to the slums, the health facility in the slum remained the first choice of mothers for their infants' childhood immunisation. Not paying transport cost and spending less time to attend the immunisation clinic was stated as the reasons for their decision.

7.9.10 Absence of reminder and feedback channel

Mothers have tried to establish communication channels with the health workers, but the health workers were reluctant. A simple innovation that may improve the immunisation coverage in the slum was suggested by a mother who did not complete her child's immunisation. The health workers should provide their phone numbers when there are vaccine stock-outs, to enable the affected mothers to confirm the vaccine availability before coming for the next appointment day.

*"Yes, when a person comes and there is no vaccine, they should give phone number for us to call before coming the next time. It is not good to just waste time and transport money". **Mother, 34, non-fully immunised, B8***

In both slums, the health workers agreed that improved out of health facility communication with mothers will improve the immunisation coverage. The health workers did not accede to mothers who requested their phone numbers, as they felt the mothers would disturb a lot and call at odd times.

*"Mothers ask for our phone numbers, but if you give them you will not rest or sleep again". **Health worker, 32, B***

7.10 Health seeking behaviour

7.10.1 Delivery in the hospital

The benefit of child delivery in the hospital was more than just a safe delivery. It went beyond mere information on immunisation schedule, as it ensured timely immunisation of the baby. Several mothers who delivered their children in the slum's health facility received the first vaccines within hours or a few days. The first batch vaccine was given once a week in these facilities, hence the delay of a few days for some infants who were delivered in these facilities to get the first immunisation. Delivery in the health facility conferred timely immunisation administration advantage on the infant, since all the children delivered in the facilities may get their first set of immunisation within hours or a few days, compared to findings of a Nigerian study where just 50% of the children were immunised within their first two weeks of life (Sadoh and Eregie, 2009). This corroborated the results in Chapters 4, 5 and 6 where delivery in the health facility was significantly associated with the child being fully immunised.

*"I delivered in the early hours and it was vaccination day so we collected all the first vaccine before we were discharged that same day". **Mother, 30, immunised, A2***

Some mothers felt that delivery in the hospital facilitated immunisation of infants while non-delivery in the facility may be the reason for not being vaccinated.

*"The reason may be they will forget or they no deliver for hospital or they delivered in the village". **Mother, 30, immunised, A2***

Delivery of babies in the slum's health facilities after the official working hours of 8.00am to 4.00pm was challenging. The slum A health facility offered no delivery services after 4.00pm. Any pregnant woman in labour is referred to any of the nearby general hospitals. While in slum B, being opened for delivery after 4.00pm depends on the capacity of the health worker who is on the evening shift.

7.10.2 Antenatal care attendance

Another aspect was the continuum of immunisation health talk from the antenatal clinic to immunisation clinic where the immunisation messages progressed from having the baby immunised to ensuring the completion of the schedule by giving mothers a date for the next immunisation appointment**.** All the participants who fully immunised their children attended antenatal clinics. Several mothers reported the regular immunisation messages that were provided during antenatal care visits, which increased their knowledge of child immunisation including the importance. This is in line with the findings in Chapters 4, 5 and 6 that revealed the significant effect of antenatal attendance on the odds of being fully immunised. Consequently, the lower FIC in slums can be partly explained by the lower proportion of slum dwellers compared to urban formal peers that attended antenatal care.

"Right from my first baby, i don't know whether me i was vaccinated ooh but when i have my first baby during the antenatal they will start telling you once you give birth you start coming for immunisation so when you come for the first one, they will now give you date for the second one".
Mother, 35, immunised, B2

7.11 Conclusion

7.11.1 Summary

- The views of this qualitative study participants, 20 mothers, 2 health workers and 2 community leaders on barriers and enablers of childhood immunisation has provided insight to understanding the lower levels of FIC in slums compared to that of other urban residents.
- The interviews revealed probable reasons for the Chapter 6 results of lower fully immunised child coverage and lower FIC odds in slums than in urban formal areas, and the significant relationship between FIC and sociodemographic variables such as birth order, antenatal care attendance, delivery in the health facility, maternal education, religion, region and current marital status in the slums
- The health facilities in the slums were in poor physical condition, some immunisation equipment was lacking, the immunisation clinics were overcrowded, quality of service provided was average and flooding which occurs during the rainy season prevents access to the health facility.
- Five themes: information about immunisation, family influence, culture and religious factors, health facility environment and health seeking behaviour emerged from the thematic analysis of the interviews.
- Information about immunisation was less than envisaged. Mothers' knowledge of administered vaccine was poor, health workers did not adequately answer the mothers' questions, the absence of a strategy to address negative immunisation rumours and misinformation and an inadequate number of immunisation posters were identified during the study.
- Family influence was recognised as necessary to improve childhood immunisation in the slums. The mothers desire to have the child immunised irrespective of the barriers, the mother's level of education, the married mother who had a spouse to remind her of the immunisation appointment and made available funds to cover transport cost, and the rapid geographic growth of the slum leading to high transport costs were key findings.

- Culture and religion were intertwined and difficult to tease apart. The Muslims in the slums cluster together in the clinic and where they reside, and many Muslim mothers are not educated as such they lag behind in knowledge of immunisation.
- The health facility environment in the slums is in need of urgent improvement. The physical structures were dilapidated, immunisation rooms were too small, health workers said to be abusive, intolerant and incompetent, frequent vaccine stock-outs, flooded during rains, average quality of service, preferential service to working mothers, absence of a feedback system, nearby alternative health facility and provision of free immunisation services are findings under the theme.
- Health seeking behaviour was found to be important based on the challenges the slum dwellers face to immunise the children. Mothers who had delivered in the health facility or/and attended antenatal care during pregnancy received regular immunisation education. Health facility-delivered babies sometimes had the first batch of immunisations before their discharge from the health facility.
- The stakeholders had easily implementable suggestions to improve childhood immunisation in the slums. This meant the participants knew that the immunisation service delivery needed improvement. Some of these suggestions like improved immunisation education, improved quality of service provision and have been reported in immunisation studies (Soura *et al.*, 2015). Suggestions such as mothers having the health workers phone number for information on the availability of vaccines and health workers accepting that the assistance of the media is important in developing and disseminating immunisation messages in the over 350 indigenous languages of Nigeria were new and have potentials of improving childhood immunisation coverage in the slums.

7.11.2 Key findings

- Specific barriers to childhood immunisation in the slums are flooding by the rains and the rays of the sun.
- The preferential service provision to the working mothers is an innovation
- The inadequate health facility child delivery services in the slums
- The improved attitude of Muslims/Hausa to childhood immunisation
- The desire of mothers to establish out-of-health facility communication with health workers

7.11.3 Chapter abstract

Slum dwellers have lower immunisation coverage rates than other urban dwellers. Without improving immunisation rates in the slums, which are the fastest growing settlements in Nigeria, the Nigerian immunisation coverage will not improve. This qualitative study aimed to investigate the view of parents, community leaders and health workers on childhood immunisation challenges and enabling factors

This qualitative study was primarily based on the Social Ecological Model (SEM) that acknowledges multiple levels of influence (child, maternal/household, community and Health system) that can shape an individual's behaviour (immunisation utilisation). After obtaining informed consent, information was obtained from face-to-face interviews with 20 mothers and in-depth interviews with two health workers and two community leaders, in two slum areas of Abuja, using semi-structured interview guides and analysed with the thematic analytical method. Also, an assessment of the immunisation service that comprised of observation of immunisation session and inventory of immunisation consumables and equipment was conducted.

Several of the findings in the slums were in line with those for the general population. Mothers, health workers and community leaders mentioned similar barriers and enablers of childhood immunisation, as shown in the analyses of DHS data. Generally, slum dwellers had a varying degree of utilisation of immunisation service as none of their children was found who had received no immunisation at all. The health facilities were in poor physical state. Child delivery services were limited, quality of service provision was average, attitude of the health workers were unacceptable, sessions were overcrowded, floods prevented sessions from holding, regular vaccine stock-outs, and improved Muslim acceptance of immunisation although still lower than among other slum dwellers, are the some of the key findings

The government will be reluctant to renovate the slum health facilities because the slums are marked for demolition. The non-costly but effective interventions that can improve the immunisation utilisation in the slums: Establishment of communicational channel between health workers and the mothers, the Muslim communities should be engaged by the community leadership for better utilisation of immunisation services, the health facilities to offer 24 hours child delivery services every day of the week, ensure there are discriminatory no vaccine stock outs, deploy adequate number of current immunisation posters and improve inter personal communication skills of the health workers

Chapter 8 Discussion and Conclusion

8.1 Introduction

Childhood immunisation prevents millions of child deaths annually; however, the low full immunisation child coverage (FIC) in Nigeria remains a major public health challenge, with global relevance given the large population size of Nigeria. Despite national and international effort, the current FIC coverage is still below the 1990 value (Federal office of Statistics, 1992) and lowest in the West African sub-region (Kazungu and Adetifa, 2017). Reasons for this low child immunisation coverage are unclear.

This PhD study aimed to inform improvement of childhood immunisation programmes in Nigeria through examination of nationally representative survey data on child immunisation in Nigeria, with a particular focus on place of residence, and explore the views of parents, heath workers and community leaders in the slums around Abuja on the enablers and barriers to child immunisation. The study was guided by a theoretical framework with four levels of influence (child, household, community and health system), and findings are relevant for increasing child immunisation coverage in Nigeria. The PhD research objectives, research questions, gaps in literature before starting the research and key research findings are presented in Table 8.1.

Findings from the 2013 NDHS showed that the current FIC level was among the lowest globally, varied across the selected sociodemographic variables and was significantly associated with birth order, place of delivery, maternal ANC attendance, maternal education level, maternal religion, maternal age at child birth, media exposure, place of residence, regions and distance to health facility.

The second objective, to quantify with the use of 2003, 2008 and 2013 NDHS, the association between child, household and community factors and childhood immunisation coverage overall, over time and by rural and urban locality was met. Key findings were the significant increase in the fully immunised child odds in subsequent NDHS, the pattern of FIC values among the categories of sociodemographic variable was similar in both urban and rural location, but higher in urban than in rural, with place of residence influencing the association between FIC and other sociodemographic variables.

The FIC across sociodemographic variables in urban formal mostly had significantly higher odds compared to slums, birth order, place of delivery, antenatal attendance and maternal education level sociodemographic variables were significantly related to FIC odds in urban formal and slum HHs and wider variations in the FIC odds in the slum compared to urban formal remain mostly unexplained. Thus, the objective, to explore the intraurban differences in childhood immunisation coverages over time, was addressed but the full explanation remains elusive.

As the fourth objective, a qualitative study to investigate the view of parents, community leaders and health workers on childhood immunisation challenges and enabling factors was conducted to add to the limited information available in the quantitative analysis in the first three objectives. In summary, this qualitative research revealed probable reasons for the chapter 6 results of lower fully immunised child coverage and lower FIC odds in slums than in urban formal settings. Also, the significant relationship between FIC and sociodemographic variables such as birth order, antenatal care attendance, delivery in the health facility, maternal education, religion, region and current marital status in the slums was explained.

Despite the multifactorial reasons for low FIC coverage, the implementation of these research findings and recommendations for child, household, community and health system levels in the different populations by all stakeholders, government, immunisation managers, community leaders, health workers, parents and researchers has the potential to improve the immunisation coverage in the short term and lay the foundation for sustained improvement in Nigeria.

Table 8.1: Research objectives, research questions, gaps in literature prior to the start of the research, and key research findings

Research Objectives	Research Questions	Gaps in Knowledge prior to the start of research (March 2015)	Key Research findings
To estimate childhood immunisation coverage, using DHS 2013 data.	What is the childhood immunisation coverage presently? What are the child, household and community-related factors associated with childhood immunisation coverage in Nigeria presently?	No recent review of Nigerian immunisation coverage (after DHS 2008).	• Immunisation coverage ranged from 76.3% (OPV1) to 42.1% (DPT3) • Only 25.3% of children were reported to have received all routine infant vaccinations (fully immunised), 54.0% received and missed at least one vaccination, and 20.7% had not received any vaccine. • In the fully adjusted multilevel logistic model, child (birth order, place of delivery, maternal ANC attendance), maternal (education level, religion, age at child birth), household (media exposure, place of residence), community (regions and distance to the health facility) variables were significantly associated with FIC • DPT drop-out rates across sociodemographic variables were considerably higher than 10%.
To quantify, the association between child, household and community factors and childhood vaccination	What are child, maternal/household and community related factors associated with childhood	* No current comprehensive study of immunisation coverage in Nigeria over a longer period.	• The pattern of fully immunised child coverage by child, maternal, household and community variables was similar over the years; but the level improved slightly from the 2003 NDHS level at 12.9% to 22.7% and 25.3% in 2008 and 2013 NDHS respectively.

coverage overall, and by rural and urban areas over time.	immunisation coverage in Nigeria and have they changed over time?		• The odds of being fully immunised significantly increased in subsequent NDHS, 2008 NDHS- 3.24 (2.10,5.00) and 2013 NDHS- 4.49 (2.89,7.00) • Urban/rural place of residence influenced the relationship between FIC and sociodemographic variables. • In stratified analyses, the association between FIC and sociodemographic variables differed by urban/rural place of residence in level but not pattern. • The very strong association between ANC attendance and the odds of being fully immunised in the rural setting suggests an opportunity that by increasing antenatal care attendance from the present 46.6% (3689/7921) to the urban ANC attendance of 77.8% (3053/3923) would improve FIC in rural areas. • There was wider disparity in full immunisation coverage, and odds of being fully immunised, in several sociodemographic factors in urban than rural areas
	What is the difference in childhood immunisation coverage between urban and rural areas, and are the associations with child, household and community factors different in rural and urban areas?	No study on association between child, maternal and community factors and childhood vaccination coverages stratified by rural and urban area using nationally representative data No current literature on the role of place of residence on the association of each sociodemographic variable with immunisation uptake.	
To explore the intra urban differences in childhood immunisation coverage over time.	In the urban setting, does childhood immunisation coverage vary between	No literature on whether immunisation utilisation varies	• Within urban areas, overall fully immunised child coverage was higher in the formal (43.5%) than the slums (34.4%) area • The FIC across sociodemographic variables was higher in urban formal compared slums, but wider point difference between highest and lowest categories were seen in slums

	urban and slum dwellers and what factors are associated with it?	within the urban area (urban formal centre and informal slum)	• The overall unadjusted odds of being fully immunised was significantly higher in formal urban areas (OR=1.47, 95% CI=1.29-1.67) than in slums • In the final multilevel logistic models, Birth order, place of delivery, antenatal attendance and maternal education sociodemographic variables were significantly related to FIC odds in urban formal and slum
To investigate the view of parents, community leaders and health workers on childhood immunisation challenges and enabling factors.	What are the barriers and enabling factors in the uptake of childhood immunisation? Do health workers practice and attitude affect childhood immunisation in Abuja?	The absence of immunisation specific study on views of mothers, and of health workers on enabling factors and challenges of immunisation service delivery and observation/inventory of service provision.	• The health facilities in the slums were in poor physical condition, some immunisation equipment was lacking, immunisation clinics were overcrowded, quality of service provided was average, and flooding during the rainy season prevents access to the health facility • Five themes: information about immunisation, family influence, culture and religious factors, health facility environment and health seeking behaviour emerged from the thematic analysis of the interviews. • Mothers' knowledge of administered vaccine was poor, health workers did not adequately answer the mother's questions, the absence of a strategy to address negative immunisation rumours and misinformation and an inadequate number of immunisation posters were identified during the study. • The stakeholders had easily implementable suggestions to improve childhood immunisation in the slums

8.2 Fully immunised child (FIC) coverage in 2013

This section covers the first research question, "What is the childhood immunisation coverage presently". As expected and in line with most studies on child immunisation in Nigeria, the FIC coverage obtained from the 2013 NDHS of 25.3% was much lower than the global target of 90.0 %. About 54.0% of children aged 12-23 months were reported to have received and missed at least one immunisation, while 20.7% of children had reportedly not received any vaccine. An explanation for the low immunisation coverage in Nigeria could be the development and implementation of immunisation policy and interventions devoid of evidence from rigorous research evidence. This low level of FIC offers no herd immunity and puts children at high risk of contracting vaccine preventable diseases. This is probably why Nigeria has one of the highest child mortality and morbidity rates globally (Hug *et al.*, 2017).

The current overall FIC coverage 25.3% was higher than the coverage in 2003 and 2008 NDHS (National Population Commission, 2004; National Population Commission, 2009; National Population Commission, 2014). Reasons for the increase in FIC may be due to the efforts of the government, development partners and other stakeholders to increase the number of children fully immunised in Nigeria. Immunisation coverage in low- and middle-income countries has generally been reported to have increased (World Health Organisation, 2013). The current FIC coverage in Nigeria was the lowest among 13 West African countries: Benin, Burkina Faso, The Gambia, Ghana, Guinea, Cote d'Ivoire, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo, based on the analyses of the two most recent DHS datasets of each country (Kazungu and Adetifa, 2017). This overall FIC coverage was lower than the urban location FIC coverage but higher than the rural, which is similar to findings from other studies (Antai, 2009b; Antai, 2011; Adegboye *et al.*, 2014; Ushie *et al.*, 2014).

In this PhD study, FIC coverage differed by sociodemographic variables including place of residence and was significantly associated with several sociodemographic variables, which was in line with reviewed literature (Antai, 2011; Mutua *et al.*, 2011). In addition, across the different population in Nigeria, place of delivery, maternal antenatal care and maternal education level remained significantly associated with fully immunised child, which was similar to other studies that analysed NDHS datasets (Antai, 2009b; Olorunsaiye and Degge, 2016; Adedokun *et al.*, 2017). Several previous studies in Nigeria reported similar findings to my PhD result that the sex of the child was not related to the FIC status (Antai, 2010; Adegboye *et al.*, 2014; Ushie *et al.*, 2014).

The DPT drop-out rate is a widely used proxy for the assessment of the immunisation health system (Nwokeukwu *et al.*, 2015; Kazungu and Adetifa, 2017). The current overall DPT drop-out rate of 23.6% was much higher than the maximum acceptable value of 10% for good utilisation of immunisation services (Oyo-Ita *et al.*, 2012; Chinawa, 2014; Nwokeukwu *et al.*, 2015; Kazungu and Adetifa, 2017). In most cases, the DPT drop-out (DOR) across most sociodemographic variables were much higher than 10%. Contrary to the findings of the study of 972 children in rural Nigeria where the DPT drop-out rate was very low (Chinawa, 2014), the current rural child had the highest DOR of 67.9%. This study has provided new evidence of the pattern and level of DPT drop-out rate, with rates being much higher than normal and categories with the lowest FIC having the highest drop-outs.

Table 8.2: Summary of key findings of the association between fully immunised child and child, household and maternal factors in total and rural/urban stratified populations.

Sociodemographic variables		Current (2013 NDHS)	Over the years (pooled NDHS)	Rural (Pooled NDHS)	Urban (Pooled NDHS)
Child level factors	Birth order				
	>=6	1.0	1.00	1.00	1.00
	1	1.5(1.1,2.1)	1.69 (1.19,2.41)	1.30 (0.81,2.08)	2.89 (1.49,5.58)
	2-3	1.2(0.9,1.6)	1.38(1.03,1.85)	1.15 (0.78,1.68)	1.95 (1.13,3.38)
	4-5	0.9(0.7,1.2)	1.13 (0.86,1.47)	0.94 (0.66,1.34)	1.58 (0.96,2.60)
	Place of delivery				
	Home	1.0	1.00	1,00	1.00
	Health facility	1.2(1.1,1.6)	3.86 (1.94,7.67)	1.47 (1.12,1.94)	2.79 (1.83,4.25)
	Antenatal attendance				
	No	1.0	1.00	1.00	1.00
	Yes	3.7(2.8,4.9)	4.42 (2.00,9.76)	8.37(5.34,13.12)	5.65(2.73,11.71)
	Don't know	2.6(1.8,3.7)	1.79 (0.44,7.28)	5.07 (3.06,8.41)	3.01 (1.38,6.58)
Household level factors	Maternal education level				
	No education	1.0	1.00	1.00	1.00
	Primary	1.6(1.3,2.1)	2.11 (1.35,3.31)	1.67 (1.19,2.35)	1.97 (1.17,3.28)
	Secondary	2.3(1.7,3.0)	3.81 (1.79,8.12)	2.49 (1.68,3.69)	3.84 (2.20,6.71)
	Higher	3.2(2.2,4.7)	6.57(2.32,18.59)	4.99(2.48,10.06)	6.04(2.99,12.20)
	Religion				
	Islam	1.0	1.00	1.00	1.00
	Christian	1.8(1.6,4.2)	2.37 (1.82,3.10)	2.63 (1.79,3.86)	2.39 (1.53,3.73)
	Traditionalist/ others	1.0(0.4,2.2)	0.85 (0.51,1.41)	0.20 (0.09,0.45)	0.40 (0.20,0.77)
	Maternal age at the child's birth				
	14-19	1.0	1.00	1.00	1.00
	20-29	1.6(1.2,2.2)	1.92(1.12,3.29)	1.76 (1.17,2.66)	2.94 (1.52,5.66)
	30-39	1.9(1.4,2.8)	2.17(0.89,5.29)	2.19 (1.32,3.63)	3.57 (1.65,7.70)
	40-49	1.9(1.1,3.1)	2.30(0.62,8.46)	2.05 (1.02,4.13)	5.54(1.94,15.81)
	Media exposure				
	No	1.0	1.00	1.00	1.00
	Yes	1.5(1.2,1.8)	1.91 (1.54, 2.44)	1.91 (1.43,2.54)	1.72 (1.03,2.88)

	Household wealth				
	Poor	1.0	1.00	1.00	1.00
	Moderate	1.2(1.0,1.4)	0.78 (0.48,1.27)	1.16 (0.91,1.48)	0.89 (0.66,1.20)
	Rich	1.2(0.9,1.7)	0.62 (0.23,1.69)	1.41 (0.87,2.29)	0.91 (0.47,1.73)
Community level factors	Region				
	Northcentral	1.0	1.00	1.00	1.00
	Northeast	1.0(0.7,1.4)	0.55 (0.40,0.77)	0.61 (0.39,0.95)	0.35 (0.18,0.68)
	Northwest	0.8(0.5,1.2)	0.30 (0.21,0.43)	0.26 (0.16,0.44)	0.42 (0.22,0.81)
	Southeast	0.9(0.5,1.5)	1.10 (0.78,1.55)	1.15 (0.70,1.92)	1.12 (0.62,2.00)
	Southsouth	1.8(1.3,2.6)	1.55 (1.11,2.16)	1.73 (1.11,2.71)	1.42 (0.76,2.64)
	Southwest	0.6(0.4,1.0)	0.90 (0.65,1.24)	0.85 (0.51,1.43)	0.86 (0.51,1.43)
	Distance to nearest Health Facility				
	Big problem	1.0	1.00	1.00	1.00
	No/Not a big problem	1.4(1.1,1.7)	1.69 (1.37,2.09)	1.76 (1.35,2.29)	1.75 (1.15,2.67)

8.3 The associations between childhood immunisation coverage and child, household and community variables

8.3.1 Background on childhood immunisation, associated factors and rural/urban place of residence

This section addresses three of this study's research questions: 1. What are the child, household and community-related factors associated with childhood immunisation coverage in Nigeria presently? 2. What are the child, maternal/household and community related factors associated with childhood immunisation coverage in Nigeria and have they changed over time? 3. What is the difference in childhood immunisation coverage between urban and rural areas, and are the associations with child, household and community factors different in rural and urban areas?

The overall fully immunised child coverage was exceptionally low in 2003 (12.9%), increased in 2008 (22.7%) and then increased a bit more in 2013 (25.3%). The patterns of FIC coverage across sociodemographic variables were similar in each NDHS, with the lowest and highest values in 2003 and 2013 respectively. After separately fitting multilevel logistic models, which adjusted for the selected child, household and community level variables for each NDHS, the fully immunised odds across sociodemographic variables were alike as reported in the section above (section 8.2). To provide more information on the association between childhood immunisation and sociodemographic variables, the analyses of the pooled 2003, 2008 and 2013 NDHS was undertaken with the datasets in two formats, total and rural/urban stratified.

Allowing for all the selected child, household and community level factors, in the multilevel logistic analysis of the pooled data set, the odds of being fully immunised in 2008 NDHS was double that in the 2003 NDHS, and in the 2013 NDHS it was 4.5-times increased. However, although the immunisation odds of the Nigerian child had improved, in 2013 still only about 1 of every 4 children was fully immunised. Also, the FIC odds was significantly associated with child level variables (birth order, ANC attendance, place of delivery), household level variables - maternal education level, Religion, maternal age at the child's birth, media exposure), and community level variables (region (Northcentral, Northeast) and distance to the nearest health facility). Although place of residence was not statistically significantly associated with FIC, it had practical significance as the urban child was 60% more likely to be fully immunised than the rural child; this association was further attenuated with the significant interaction between place of residence and place of delivery on FIC, showing that the child's odds of being fully immunised was reduced by the place where the child was delivered. This study has revealed that the FIC coverage has significantly increased over the years in Nigeria, but remains far below the global target. Wide disparity remains, which is incompletely understood. Also, the role of location in influencing the relationship between FIC and other sociodemographic variables has been identified. Unexpectedly, household wealth was not significantly related to FIC, which maybe due to the free provision of childhood immunisation services in Nigeria.

The pooled dataset that had information from 11,844 children aged 12-23 months, the rural children were 7921 (69%) and the remaining 3921 (31%) resided in urban settings were used in chapter 5. In the pooled dataset analysis stratified by urban and rural location, the pattern of FIC values among the categories of the sociodemographic variable was similar in both locations, but levels were higher in urban than in rural setting. Also, among most sociodemographic variables, the FIC difference between their highest and lowest categories was much larger in urban than in rural location. In the fully adjusted models, the association between FIC and child level factors (place of delivery, antenatal attendance), household factors (mothers education level, religion, mothers age at child birth, media exposure), and community factors (region, distance to health facility) were significant in the urban and rural locations. Similarly, for most sociodemographic variables, the point difference between the category with the highest odds of being fully immunised and the reference category was much higher in urban compared to rural. The variable birth order was related to FIC in the urban population but none was found in the rural location. The key result of the wider disparity in full immunisation coverage and odds of being fully immunised found in several sociodemographic factors in the urban compared to rural was further explored to improve understanding of routine immunisation in Nigeria.

8.3.2 Association of child, household and community level factors with childhood immunisation

Child level factors such as birth order, place of delivery and mother attendance of antenatal care were associated with the fully immunised child (FIC) coverage in Nigeria over the years, as presented in Table 8.2. The analyses of the association between these sociodemographic characteristics and FIC in the total population and rural/urban places of residence has provided some answers to the questions on the role of child level factors in improving FIC coverage. This PhD study found that lower birth orders had higher fully immunised odds than higher birth orders. This is similar to evidence from previous studies in Nigeria and India (Antai, 2009b; Babalola and Lawan, 2009; Antai, 2012; Mathew, 2012; Chidiebere *et al.*, 2014). Like this study, Antai and Chidiebere et al. undertook secondary analysis of 2003 and 2008 NDHS datasets respectively, but this study pooled three different NDHS that yielded similar findings in two dimensions, for total and stratified by rural and urban populations as described in Table 8.2. Competing demands for family resources and time as the number of children increases may probably contribute to the lower fully immunised odds of the higher birth order child (Fatiregun and Okoro, 2012).

In my study, fully immunised odds was significantly higher among children delivered in the health facility than in home-delivered children in the pooled datasets of total and rural/urban stratified population. This has been documented in other studies in Nigeria (Antai, 2009b; Adegboye *et al.*, 2014; Olorunsaiye and Degge, 2016; Adedokun *et al.*, 2017). Ushie et al. (Ushie *et al.*, 2014), conducted a multilevel analysis of pooled data of 1990, 1999, 2003 and 2008 NDHS, controlled for individual, household and community factors and had similar findings, but their findings have been criticised on methodological concerns (Demographic and Health Survey Program, 1999). A similar finding was reported from a study in India using non-nationally representative data from 30-clusters with 510 children aged 1-23 months (Nath *et al.*, 2007). The child delivered in the health facility stands to benefit from the birth dose vaccines, BCG, OPV and HBV and appropriate immunisation health messages such as the dates for subsequent immunisation session (Kumar *et al.*, 2010; Etana and Deressa, 2012; Mathew, 2012; Adedokun *et al.*, 2017). Non-delivery in a health facility may be suggestive of distrust and lack of confidence in modern medicine and its providers (Ushie *et al.*, 2014).

Further, children of mothers who attended antenatal care during their pregnancy had higher FIC coverage and significantly greater odds of being fully immunised than children whose mothers did not attend antenatal care. Similar findings have been reported in previous studies in Nigeria

(Babalola and Lawan, 2009; Etana and Deressa, 2012; Adedokun *et al.*, 2017) and Ethiopia (Etana and Deressa, 2012). The positive effect of antenatal attendance on fully immunised odds was not limited to Nigeria, and also reported in Ethiopia (Babalola and Lawan, 2009; Etana and Deressa, 2012; Adedokun *et al.*, 2017). The multilevel logistic analysis of the 2013 NDHS allowing for individual, community and regional characteristics that found the increased fully immunised odds of children whose mother attended immunisation, was limited as this had no information on trends over the years and magnitude across places of residence (Adedokun *et al.*, 2017). In addition to previously reported evidence, this study provided the strength and pattern of the significance of the association between antenatal care and fully immunised odds in the total population and rural/urban places of residence (Table 8.2).

Household level factors significantly influenced childhood immunisation as presented in Table 8.2. Among the household variables, maternal education level was consistently associated with the fully immunised status of the child: as the mothers' level of education increased, the child's fully immunised odds increased, which was in line with the results of several studies from Nigeria and other countries (Federal office of Statistics, 1992; Gage *et al.*, 1997; National Population Commission, 2000; Bonu *et al.*, 2004; National Population Commission, 2004; Antai, 2009b; Antai, 2009a; Babalola, 2009; National Population Commission, 2009; Antai, 2010; Mushtaq *et al.*, 2010; Babalola, 2011; Antai, 2012; Fatiregun and Okoro, 2012; Fatiregun *et al.*, 2013; Obiajunwa and Olaogun, 2013; Adegboye *et al.*, 2014; Chidiebere *et al.*, 2014; National Population Commission, 2014; Okoronkwo *et al.*, 2014; Ushie *et al.*, 2014; Mukherjee *et al.*, 2015) and elsewhere (Gage *et al.*, 1997; Bonu *et al.*, 2004; Mushtaq *et al.*, 2010; Mukherjee *et al.*, 2015). Hence, children whose mother had no formal education had the lowest full immunisation odds, followed by children of mothers with primary, secondary and higher education level in this order. A DHS study of household structure and childhood immunisation in Niger and Nigeria using DHS data also reported that children of educated mothers had 80% higher likelihood of being fully immunised than children of uneducated mothers, after controlling for socioeconomic factors (Gage *et al.*, 1997). Findings of a multi-year trend analysis of the Nigeria DHS 1990, 1999, 2003 and 2008 showed a 17% reduced likelihood of being immunised for a child of a non-educated mother compared to a child of a primary level education mother (Adegboye *et al.*, 2014). Reasons for the influence of maternal education are the increased health seeking behaviour, better understanding of immunisation messages, better knowledge of available immunisation delivery sites and having more money by the more educated mother (Mathew, 2012; Wiysonge *et al.*, 2012; Singh, 2013) (Olorunsaiye and Degge, 2016). Although some studies with similar findings undertook multilevel logistic analysis of DHS data (Adegboye *et al.*, 2014) (Gage *et al.*, 1997), my PhD study additionally explores and quantifies the pattern and trend of the association between maternal education and FIC status over the years.

Mother's religion affects the likelihood of the child to be fully immunised, such that a Christian child was several times more likely to be fully immunised than a Muslim child. This finding corroborated results from previous research in Nigeria and other countries (Renne, 2006) (Antai, 2009a) (Mathew, 2012) (Chidiebere *et al.*, 2014). Renne explained that Muslim leaders in Nigeria felt the vaccines were contaminated with HIV and anti-fertility substances aimed at reducing the Muslim population, but a systematic review carried out in India revealed that the religious barrier is not particular to Nigeria (Mathew, 2012). In the Indian study that systematically reviewed 54 papers on immunisation inequities, the fully immunised rates of Muslim children (45.5%) was lower than that of Hindu (55.4%), Sikh (81.9%) and Christian (67.3%) children (Mathew, 2012). A study in Nigeria that investigated attitudes to polio vaccination and immunisation in Northern Nigeria reported that household religion did not correlate with the decision to refuse the administration of Polio vaccine, rather political and socioeconomic factors were identified as reasons for acceptance or refusal of polio vaccine administration (Taylor Sebastin, 2015).

The association between the age of the mother and fully immunised child status was found to be significant in several studies (Mukherjee *et al.*, 2015) (Antai, 2011; Chidiebere *et al.*, 2014). A study in a rural population of Nigeria reported that children of mothers aged less than 30 years had lower immunisation rates than children of the 30 years and above mothers (Odusanya *et al.*, 2008). Reasons suggested are the lack of child care experience by the young mother, the experience garnered over the years by the older mothers on the effectiveness of vaccines and the effect of treating child illness on family income (Antai, 2009b; Adedokun *et al.*, 2017). In my PhD study, the study population was larger than those in previous studies, and the urban and rural populations were nationally representative, as such making the finding that the children of mothers aged 20 years and above were more likely to be fully immunised than children of mothers aged 14-19 years of age more reliable.

The household with regular exposure to media had children with higher fully immunised child status compared to households without regular media exposure in Nigeria. This relationship had been documented as a determinant of childhood immunisation in previous research that conducted secondary analysis of NDHS datasets (Chidiebere *et al.*, 2014; Adedokun *et al.*, 2017). Similarly, the multilevel analyses of DHS from 24 sub-Saharan African countries reported the positive effect of media exposure on childhood immunisation (Wiysonge *et al.*, 2012). The media provides information on the benefits of immunisation, health activities and location of health facilities, as such can serve as a tool to improve childhood immunisation (Wiysonge *et al.*, 2012).

Contrary to the findings of previous studies in Nigeria also using NDHS datasets (Chidiebere *et al.*, 2014; Adedokun *et al.*, 2017), the significant association between wealth and childhood immunisation was limited to the overall analysis of 2013 NDHS in this study. In the earlier studies, the immunisation odds increased as the parent's wealth class grew, with the poorest and richest children having the lowest and highest fully immunised odds respectively (Chidiebere *et al.*, 2014; Adedokun *et al.*, 2017). Despite the free provision of immunisation services in public owned health facilities, there are still indirect costs that can be barriers, such as transport cost to the health facility that is far from the mothers, and for the low income earner inability to be excused from work as a result of the considerable time spent for journey to and time spent in the health facility (Olorunsaiye and Degge, 2016). Also, the lack of money has been reported to cause poor health seeking behaviour (Adedokun *et al.*, 2017).

Community level factors were associated with the likelihood of a child being fully immunised. Earlier studies in Nigeria had revealed similar findings (Antai, 2009b; Antai, 2011; Adedokun *et al.*, 2017). The Northern regions, Northcentral, Northeast and Northwest region had lower fully immunisation child coverage compared to the Southeast, Southsouth and Southwest regions of the South of Nigeria. All Demographic and Health surveys conducted in Nigeria reported this result (Federal office of Statistics, 1992; National Population Commission, 2000; National Population Commission, 2004; National Population Commission, 2009; National Population Commission, 2014). Reasons suggested for this scenario are that southerners are more educated and wealthier than the northerners, the northerners are mostly Muslims, and the southerners are predominantly Christian and the new Muslim insurgency in the Northeast (Chidiebere *et al.*, 2014; Adedokun *et al.*, 2017). Across the six regions in Nigeria, there was a high disparity in the likelihood of being fully immunised. The Northwest region which is most populous had the lowest

FIC coverage and least fully immunised child odds compared to the other regions, while the Southsouth region had the highest fully immunised children odds. In most analyses in this study, the Northeast and Northwest had the least odds while the Southsouth and Southeast had the highest. The pattern and level of the association between the regions and fully immunised child was quite similar.

As expected, children of mothers who felt the distance to the nearest health facility to seek health was a big problem had lower FIC coverage and lower fully immunised child odds than children with mothers who did not see the distance as a big problem. This finding is in line with the results of several studies in Nigeria (Chidiebere *et al.*, 2014) (Abdulraheem *et al.*, 2011; Adedokun *et al.*, 2017). In addition, this study found that over the years in Nigeria, distance to the health facility was significantly related to full immunisation in children, with similar pattern and level in the urban/rural analyses. Difficulty in getting to the health facility due to distance or difficult terrain have been reported as major barriers to child immunisation (Abdulraheem *et al.*, 2012; Adedokun *et al.*, 2017).

8.4 Childhood immunisation in the urban formal and slum (informal)

The quantitative investigation conducted to answer the research question, “In the urban setting, does childhood immunisation coverage vary between urban and slum dwellers and what factors are associated with it?” are discussed in this section. The FIC coverage in urban areas was heterogeneous, with urban formal FIC coverage of 43.5% significantly higher than in the slums (34.4%), which supports the evidence from several studies (Fotso *et al.*, 2007; Mutua *et al.*, 2011; Unger, 2013; Egondi *et al.*, 2015). With the FIC coverage of 34.4% the slum has the urban advantage over the rural (15.2%) and total population (23.2%), unlike the situation in Kenya where the rural FIC coverage was higher than in the slums (Mutua *et al.*, 2011; Egondi *et al.*, 2015). The derivation of the slum households using two of the five UN HABITAT guidelines for the identification of the slums may explain the difference between this study result and the Kenya result. Another explanation may be the national representative nature of this study data in contrast to the Kenya study data. The FIC coverage in Kenya slums compared Ouagadougou (Burkina Faso) slums found that Kenya coverages were much lower, which was likely due to the more adverse health challenges faced by Kenyans (Soura *et al.*, 2015).

This lower FIC coverage of the slum compared to the urban formal setting in Nigeria may be evidence of the setting in of the urban penalty that postulates that the urban poor live in particular parts of the urban area where the exposure to unhealthy environment leads to unfavourable health outcomes (Freudenberg *et al.*, 2005). The FIC coverage across the sociodemographic variables was higher in urban formal compared to slums areas, but with wider point difference between highest and lowest categories seen in slums. The unadjusted odds ratios of the FIC coverage difference between urban formal and slum place of residence across the sociodemographic variables with 95% confidence interval and p-value revealed that urban formal mostly had significantly higher odds compared to slums. The quantification of the urban formal and slum FIC, which showed that urban immunisation coverage levels were heterogeneous, differentiated this study from all the previous relevant studies in Nigeria (Antai, 2009b; Antai, 2011; Babalola, 2011; Adegboye *et al.*, 2014; Ushie *et al.*, 2014; Adedokun *et al.*, 2017; Dudu and Onokerhoraye, 2018).

In the fully adjusted models of the separate multilevel analysis of the pooled urban NDHS data stratified by urban formal and slum locations, the overall odds of being fully immunised was significantly higher in the urban formal compared to slum area. Child level variables- birth order, place of delivery, antenatal attendance and household level variable- maternal education level were significantly related to FIC odds in urban formal and slum HHs (Table 8.3). The household level variables (sex of household head, mother's employment status, media exposure, household wealth) and community level variable (distance to the nearest health facility to seek care) were not significantly associated with FIC in the two urban types of location. The difference in the relationship of FIC was the significant association with household variables (mother's current marital status, religion, decision maker on spending of maternal income) and community variable (region). Two regions (Northeast and Northwest) were found to have a significant association with FIC in the slums alone. One of the household variables (mothers' age at birth of the child) and one community variable (region Southeast and Southsouth) were significant in the urban formal HHs only. The variations in the FIC at both locations due to community factors were mostly significant.

The intraurban patterns in FIC associations between child, household and community variables were similar to that found in the overall datasets (Table 8.3). The association of **child level factors (**birth order, place of delivery, antenatal attendance) and childhood immunisation was stronger in the slums, with wider disparity than urban formal. Lower birth orders, delivery in the health facility and maternal antenatal care attendance increased the fully immunised odds of the child compared to the higher birth orders, home delivery and non-maternal antenatal care attendance respectively. This study corroborated earlier evidence that health facility delivery significantly increased the fully immunised odds in slums compared to home delivery (Mutua *et al.*, 2011).

Studies from Kenya and Burkina Faso reported the increased likelihood of being fully immunised of children of mothers with primary or more education than those with no education mothers (Mutua *et al.*, 2011; Soura *et al.*, 2015). Results from my PhD study confirmed this evidence of higher fully immunised odds among children with primary education or more. The finding was similar in the slum and urban formal but differed with the stronger association in the urban formal. Expectedly, the widest disparity in the difference in fully immunised odds between no education and higher education was seen in urban formal rather than the slum. This suggests slum specific factors may have reduced the positive influence of education on childhood immunisation.

Religion was significantly associated with the child being fully immunised and the Muslim child having a much lower odds compared to the Christian in the slums, but the urban formal result was not significant. The Christian child fully immunised odds compared to all other religions in the slums of Nairobi and Ouagadougou was significantly higher (Soura *et al.*, 2015). This finding of the non-significance of the relationship between FIC and religion in the urban formal is important, as it shows that the religious barrier can be overcome across all sections of the population in Nigeria. The reasons for this urban formal finding maybe due to the better-informed residents as a result of being more educated, having more health facilities, media exposure and understanding of immunisation messages. This PhD qualitative study that explored the views of the urban formal dwellers particularly Muslims on childhood immunisation provided information on how to reduce the adverse effect of religion on the fully immunised odds.

Children of mothers less than 20 years of age and aged 35 years and older were more likely to be immunised than their peers who have mothers aged 20-34 years in studies located in the informal settlements of Nairobi and Ouagadougou (Soura *et al.*, 2015). This PhD study population was larger, and the urban slum population was nationally representative as such making the findings more accurate. Thus, this finding that children of mothers aged 20 years and above are more likely to be fully immunised compared to children of mothers aged 14-19 years of age Nigeria provides better estimates, even though, similar to the studies in other slums elsewhere, the association did not reach significance. The relationship between maternal age and fully immunised child status was mixed in the urban population, the most robust significance was observed in the urban formal while in the slums it was not significant. Probable reasons for the slum results as reported in this PhD qualitative study include the younger mothers having to travel to the rural communities for delivery.

Household exposure to media was associated with fully immunised child status in Nigeria and elsewhere. The association was not significant in the urban formal and slums, although the slum had the widest variation in fully immunised child odds. This may be as the result of the availability of others sources of relevant information beside the media in the urban area. Although the widest disparity in immunisation odds was found in the slums, where the fully immunised odds of the rich households was about twice of the poor household, the relationship was not significant.

The community variables influenced FIC odds in the slum. The pattern and level of the association in the slum differed from the urban formal and findings in section 8.3. In the slums, the fully immunised child odds was lowest for the regions compared to the other places of residence. The children in the Northeast and Northwest were significantly less likely to be fully immunised compared to children from the Northcentral. Contrary to the findings in the total population, distance to the health facility was not significantly related to full immunisation of children in the stratified urban analysis though were almost significant. The widest variation in immunisation odds was seen in the slum than urban formal. Several findings about the slum have remained unexplained because of the limited information in NDHS about stakeholders' views on child immunisation barriers and challenges and the state of the health system in Nigeria. For example, a more substantial proportion of slum dwellers than urban formal saw distance to the health facility as no/ not a big problem, yet the FIC odds in urban formal was significantly higher than the slum.

Table 8.3: Summary of key findings of the association between fully immunised child and child, household and maternal factors in intra-urban locations.

Sociodemographic variables		Urban formal	Slum
Child level factors	Birth order		
	>=6	1.00	1.00
	1	2.43(1.01,5.87)	5.39(1.37,21.29)
	2-3	1.50(0.72,3.12)	3.00 (1.00,9.13)
	4-5	1.38(0.69,2.75)	2.05 (0.78,5.40)
	Place of delivery		
	Home	1,00	1.00
	Health facility	2.62 (1.43,4.79)	5.39(2.18,13.33)
	Antenatal attendance		
	No	1.00	1.00
	Yes	6.82(2.29,20.34)	8.07(2.15,30.25)
	Don't know	2.89 (0.94,8.88)	5.19(1.21,22.37)
Household level factors	Maternal education level		
	No education	1.00	1.00
	Primary	1.77(0.83,3.79)	2.48 (1.02,6.05)
	Secondary	4.57(1.94,10.79)	4.46(1.68,11.82)
	Higher	9.18(3.05,27.64)	5.03(1.52,16.65)
	Religion		
	Islam	1.00	1.00
	Christian	1.59 (0.89,2.86)	5.69(2.09,15.45)
	Traditionalist/ others	0.40 (0.10,1.18)	0.28 (0.09,0.88)
	Maternal age at the child's birth		
	14-19	1.00	1.00
	20-29	5.25(1.86,14.85)	2.18 (0.70,6.84)
	30-39	6.64(2.03,21.75)	2.63(0.66,10.53)
	40-49	9.87(2.01,48.59)	5.40 (0.80,36.48
	Media exposure		
	No	1.00	1.00
	Yes	1.35 (0.65,2.79)	2.49 (0.95,6.53)
	Household wealth		
	Poor	1.00	1.00
	Moderate	0.80 (0.50,1.27)	0.89 (0.51,1.57)
	Rich	0.70 (0.32,1.53)	1.83(0.22,15.58)
Community level factors	Region		
	Northcentral	1.00	1.00
	Northeast	0.56 (0.20,1.55)	0.21 (0.07,0.66)
	Northwest	0.85 (0.33,2.14)	0.20 (0.06,0.67)
	Southeast	3.01 (1.19,7.57)	0.37 (0.11,1.21)

	Southsouth Southwest	5.61(1.88,16.71) 1.12 (0.54,2.33)	0.41 (0.13,1.21) 0.88 (0.34,2.31)
	Distance to nearest Health Facility Big problem No/Not a big problem	1.00 1.77 (0.99,3.17)	1.00 2.21 (0.95,5.13)

8.5 State of the health facility and views of mothers and key stakeholders on childhood immunisation in the slums

The study questions, what are the barriers and enabling factors in the uptake of childhood immunisation and do health workers practice and attitude affect childhood immunisation in Abuja, which were addressed in the qualitative study are discussed in this section. Health system factors affect both the supply and demand aspects of child immunisation. The creation of optimal demand for immunisation without corresponding availability of vaccines and a system to administer the vaccines will not improve fully immunised child coverage. A well-functioning system should consist of an adequate number of well-trained and well-mannered health workers, who deliver quality and timely services, without avoidable adverse events following vaccine administration and with drugs available to treat vaccine side effects (National Primary Health Care Development Agency, 2009). In this PhD study, service delivery and immunisation equipment/consumable availability as assessed with the health assessment tool (Appendix 5) were found to be average in both slums (Slum A =52%, slum B=54%). The health facilities in the two slums were in poor physical condition, immunisation equipment was lacking, the immunisation clinics were overcrowded, quality of service provided was average, and flooding during the rainy season hindered access to the health facility.

The views of the study participants (20 mothers, 2 health workers, and 2 community leaders) on possible barriers and enablers of childhood immunisation provided insight to understanding the lower levels of FIC in slums compared to other urban areas. Five themes: information about immunisation, family influence, culture and religious factors, health facility environment and health seeking behaviour emerged from the thematic analysis of the interviews as important in accessing the routine childhood immunisation programme. These themes have also been mentioned by others elsewhere and are discussed in more detail in the following sub-sections.

Child level factors were identified as important in optimising childhood immunisation. The practice reported by several slum dwellers not to present a child for immunisation if the child was sick, would make a sick child more likely to miss immunisation session, even if the ailment itself is not a contraindication for immunisation (Agarwal *et al*., 2005). Lack of family support for people living in the slum means that pregnant slum dwellers, especially when young and without childbearing experience, travel to deliver their babies in their rural villages of origin, which often lack adequate health facilities. Although this may affect all children irrespective of birth order, when there are more children it may become too expensive to travel with all of them. Analysis of the DHS data from the slums, as presented in Table 8.3, revealed that the lower birth order had higher fully immunised odds than higher birth order, while the qualitative study findings were contrary. Most deliveries in the slums may be at home since the health facilities only provide few hours of service limited to non-high risk pregnancy. This is a barrier to immunisation as home delivery reduces the odds of being fully immunised, with Infants delivered in a health facility likely to have the first immunisation before their discharge from the health facility (Olorunsaiye and Degge, 2016; Adedokun *et al*., 2017). Pregnant women due for antenatal care services may not be able to access the health facility during the peak of the rainy season because of the flooded health facility premises. Non-attendance at antenatal care decreases the likelihood of being fully immunised in children (Olorunsaiye and Degge, 2016; Adedokun *et al*., 2017).

Household level factors' barriers to childhood immunisation identified in my study include mothers' poor knowledge of administered vaccine and immunisation schedule (Babalola, 2011), the inability of health workers to adequately answer mothers' questions, the presence of negative immunisation rumours and misinformation (Babalola, 2011) and an inadequate number of immunisation posters to provide information to clinic attendees. Family support especially that of the father, was recognised in my study as necessary in childhood immunisation by mothers in both slums, which is in line with previous study findings in Nigeria (Babalola, 2011). Examples of where family support are enablers include having a spouse to remind of the immunisation appointment, allay negative vaccination myths and make funds available to cover transport cost. The slum mothers' immunisation attitude to have their child immunised irrespective of barriers has been reported to improve childhood immunisation in developed countries (Falagas and

Zarkadoulia, 2008). The evidence that the mothers' level of education is a key influencer of childhood immunisation globally (Olorunsaiye and Degge, 2016; Crocker-Buque *et al*., 2017; Falagas and Zarkadoulia, 2008) was validated by the findings from this qualitative study in the Abuja slums. Culture and religion are intertwined and these variables were difficult to tease apart. Muslims in the slums cluster together while attending the clinic, and also live closely together (Agarwal *et al*., 2005). In addition, many Muslim mothers are not highly educated and may thus lag behind in knowledge of immunisation (Chidiebere *et al*., 2014), which could account for the significant association between FIC and religion in the slum, which was not seen in urban formal areas. Health seeking behaviour was found to be critical given the challenges slum dwellers face to get their children immunised. Mothers who delivered in a health facility or/and attended antenatal care during pregnancy received regular immunisation education (Adedokun *et al*., 2017), were more knowledgeable and more likely to have their children immunised.

Community level factors enabled and challenged immunisation service delivery in the slums. Increasing the number of health facilities in slums has been suggested to improve access to immunisation services (Unger, 2013). The availability of well-functioning community committees that support the health facility have also been suggested as important in the improvement of childhood immunisation levels (Agarwal et al., 2005). The slum dwellers in this PhD study believed that the government had abandoned the slums, and that the health workers in the slum were not as competent as their counterparts in urban formal areas. Renovation of the health facilities by the government may restore the dwellers' confidence in the health services available in the facility (Agarwal et al., 2005). The desire of mothers to establish an out-of-health facility communication link with the health workers was rejected by the health workers who felt the plan would become burdensome and extend into out-of-office hours, but the slum dwellers felt it was rejected because they resided in the slum. The unavailability of quality 24-hours service provision in the slum health facility may be responsible for the much lower proportion of health facility delivery, and lack of faith in services available. The slum participants knew that the immunisation access and utilisation in the slums were defective and proffered suggestions to improve it. The rapid geographic growth of the slum B may have led to higher transport cost for travel to the facility, which would be a barrier to childhood immunisation, as reported in Zambia and India (Crocker-Buque *et al*., 2017). Some of the community factors, like lack of an out-of-health facility communication link and dilapidated health facilities, could be addressed quickly by the government and health workers, but barriers such as the slum dwellers feeling abandoned by the government, and the perception that the health workers in the slum were not as competent as their counterparts in urban formal areas would need considerable effort from the government and health workers to enact change.

Health system factors included childhood immunisation enablers and challenges that cross the earlier discussed child, household, community, and specific health facility factors. Observation of the immunisation service delivery in the two clinics revealed that health talks were not adequate, and were delivered in an unconducive environment, which could potentially hinder uptake of child immunisation. Overcrowded immunisation sessions lead to long waiting times, which has been reported to be a barrier to childhood immunisation elsewhere (Abdulraheem *et al*., 2011). The inventory of the immunisation equipment and consumables revealed the absence of some cold chain equipment such as refrigerators. This cold chain equipment inadequacy is thus a weakness in the health system that has been suggested to lead to low immunisation coverage or reduced potency of vaccines (Abdulraheem *et al*., 2011; Goodman *et al*., 2013). Episodes of vaccine stock-outs, mentioned in the interviews, led to children not completing their immunisation, a finding in line with literature from Nigeria (Federal Ministry of Health and National Primary Health Care Development Agency, 2013; Oladokun *et al*., 2010; Abdulkarim *et al.*, 2011). Interviewees mentioned that the attitude of the health workers has a role in ensuring that children complete their immunisation, with bad attitude of health workers such as lack of respect shown to parents and being abusive to parents, reducing the number of children with completed immunisation as shown by others (Ehiri *et al*., 2005; Babirye *et al*., 2014). The actual or perceived incompetence of health workers in their ability to answer the mothers' questions on the possible occurrence of adverse events after immunisation are possible challenges to child immunisation uptake, as mothers reported they felt not listened to, and non-return of children that started the routine immunisation schedule reported elsewhere (Agarwal *et al*., 2005). The irregular supervision of these slum health workers is likely to negatively affect the quality of immunisation service provision. This may lead to increase of adverse events following immunisation that leads to reduced immunisation coverage rates (Agarwal *et al*., 2005). Several mothers usually exaggerate the adverse events following immunisation, thereby generating myths that are barriers to immunisation (Ball *et al*., 1998; Babalola, 2011; Jackson *et al*., 2017).

In **summary**, most findings from my qualitative research in the two slums in Abuja are in line with findings from other studies, both in and outside Nigeria: knowledge of vaccine types, vaccine safety, source of vaccine information, mothers desire to provide the best health care for the child, family support, religion, hospital delivery, accessibility of health facility , attitude of health workers, and conducive setting for service delivery have been reported previously from studies in Nigeria (Abdulraheem *et al*., 2011; Abdulkarim *et al*., 2011; Babalola, 2011), developing countries (Ball *et al*., 1998; Agarwal *et al*., 2005; Babirye *et al*., 2014), the United Kingdom (Jackson et al., 2017) and the rest of the developed world (Falagas and Zarkadoulia, 2008; Mills *et al*., 2005). However, the reports on preferential treatment of working mothers, and health facility flooding disrupting immunisation sessions have not been reported in the reviewed literature, and may be more specific to this slum setting.

Despite the differences in the sociocultural and economic environment, this PhD's qualitative findings are mostly similar to evidence synthesised from systematic reviews on barriers to vaccination in developed countries (Falagas and Zarkadoulia, 2008; Mills *et al*., 2005). As expected, the key difference between this PhD study and those reviews was the inability of the Immunisation system to provide regular supply of vaccines as also reported in other studies in Nigeria. Despite the advanced economic and education levels in developed countries, child immunisation barriers seen in Nigeria such as mild illness in children, cost, fear of vaccines, ethnicity, long waiting time, higher birth order, negative myths and distrust of immunisations are also seen in developed country settings (Falagas and Zarkadoulia, 2008; Mills *et al*., 2005). A further common barrier is physicians' reluctance to provide vaccine to sick children (Falagas and Zarkadoulia, 2008), similar to the practice of the less-well educated health workers in Nigeria. In Nigeria negative myths and perceptions about vaccines are spread orally, whereas in the developed world the media, both regular and via the internet, is the perpetuator; as more Nigerians get access to anti-vaccination campaigners' messages and myths via digital and regular media the uptake of childhood vaccination may decrease further. The current low childhood immunisation coverage in Nigeria can be partly explained by serious contextual barriers and the globally reported barriers, but the soon to emerge challenge of vaccine misinformation through the internet in Nigeria has the potential to reverse the recently achieved little improvement in childhood immunisation in Nigeria.

8.6 Study limitations

This study has limitations in the qualitative and quantitative methods used. The qualitative design took cognisance of the challenges of funds and time available to complete the study process that included travel to Nigeria, recruitment, interviews, transcription, translation, analysis and write up. Repeated assurance of confidentiality and how the information provided would be used to improve immunisation programme during the interviews was done to reduce the risk of courtesy bias, where the participants especially the mothers may provide information on the positive and not the negative aspects of the immunisation programme. The study was unable to recruit a male as a parent participant, thus reducing the diversity of needed information. The duration of the study was inadequate to study the slum dwellers behaviour as pertaining to immunisation and studies have found that behaviour do influence the utilisation of immunisation services (Babalola, 2009; Babalola, 2011)

The quantitative data, NDHS were obtained through a retrospective cross-sectional study. The immunisation data was collected from the child immunisation card and if absent, the mother will provide the required information. The mothers' report may be subject to recall bias as the information been recalled may have occurred between one to twelve months before the interview. Maternal education level has been reported to be associated with recall bias, with the mothers of more educated level being more likely to accurately recall the child's immunisation history. Thus, the adjustment for maternal education level in the multilevel logistic models reduced the effect of maternal education on the recall bias(Kazembe *et al.*, 2009). The household wealth variable in NDHS was a proxy rather than a direct measurement of household income and measurement. The results from the analysis of the wealth proxy may differ from that from the direct measurement of household wealth (Filmer and Pritchett, 1998). Some of the selected NDHS variables were not perfectly aligned to the research question, an example was the variable, "the distance to the nearest health facility when seeking health care", while being specific to immunisation would have been more helpful. The NDHS data collection design of clustering into urban and rural place of residence has led to the use of UN HABITAT guidelines to recode the urban data into formal and informal households. This may have introduced selection bias. The DHS sampling process was based on projections from general census held several years earlier, and as such may not be fully representative of the population when the DHS was conducted.

8.7 Implications of findings and recommendations

The aim to inform improvement of childhood immunisation programmes in Nigeria through examination of nationally representative survey data on child immunisation in Nigeria by the child, household, community and health system factors, with a focus on place of residence and explore the views of parents, health workers and community leaders in the slums around Abuja on the enablers and barriers to child immunisation was achieved. This mixed method study has revealed the general and location specific barriers. The utilisation of the study findings can lead to better result from the current use of the huge sums from the scarce resource being deployed to current strategies without stopping the millions of preventable child diseases (Wiysonge and Volmink, 2002; Wiysonge *et al.*, 2009). As a low middle-income country, Nigeria needs to achieve the best value for funds spent on childhood immunisation.

The study showed that mothers who attended antenatal care, delivered in the health facility, are well educated, are Christians, have access to media, live in urban formal and from Southsouth region have children who are more likely to be fully immunised. Based on the pattern and level of fully immunised child status across populations reported in this research, location-specific interventions can be deployed to achieve maximal effect. These changes in pattern and level are further evidence of the complex immunisation concept, “vaccination hesitancy”, the situation where in the presence of vaccines, there is a delay in accepting or outright refusal of immunisation services (Oyo-Ita *et al.*, 2012; Larson *et al.*, 2014). The WHO Strategic Advisory Group of Experts on immunisation grouped factors that influence vaccine hesitancy into three, namely contextual, vaccine and vaccination specific, and individual and social (Oyo-Ita *et al.*, 2012; Larson *et al.*, 2014). These influences vary in time, place, and vaccine (Oyo-Ita *et al.*, 2012; Larson *et al.*, 2014). Thus, strategies and interventions that yielded positive results in other countries or different population may not be successful in Nigeria or a particular place of residence. Consequently, this study’s proposed recommendations are targeted at the government and immunisation programme managers for implementation in collaboration with relevant stakeholders at each level of influence to ensure increased access and sustained utilisation of immunisation services. Most of the recommendations for implementation by the immunisation manager will quickly improve child immunisation in Nigeria especially in the slums who have the lowest proportion of inhabitants who felt the distance to the health facility was a big problem.

The gaps in knowledge at the commencement of the PhD research in 2015, as described in Table 8.1 have mostly been filled. Today, more is now known about the association between FIC and sociodemographic variables in Nigeria. This study provides an accurate reference for future research on childhood immunisation in Nigeria. Further evaluation of the 5 available NDHS is unlikely to provide further insight and instead focus should be on qualitative and implementation research. Quasi experimental interventions to test the efficacy of successful interventions carried out in African and other low- and medium- income countries are the vital next steps (Oyo-Ita *et al.*, 2012; Crocker-Buque *et al.*, 2017). The need to broaden the base of immunisation stakeholders have highlighted in this study, as maternal education, location, provision of good quality health facilities, religious education, infrastructure renewal of slums are beyond the scope of the health sector.

The implementation of the research findings dissemination plan (Annex 8) are in phases, already completed are a presentation in a conference, publication in a peer reviewed journal and the qualitative research findings feedback to the stakeholders in the slum, Federal Capital Territory Primary Health Care Board and Health and Human Services Secretariat. Five more papers, implementation plan to immunisation programme managers and policy brief to the Honourable Minister of Health in Nigeria are the next steps for the PhD candidate.

8.7.1 Policy

Results presented in this thesis suggest that strengthening the implementation of the present government policies that govern immunisation can improve child immunisation coverages in Nigeria

Short term : The current policies that directly impacts on immunisation: national immunisation policy (National Primary Health Care Development Agency, 2009), national routine immunisation strategic health plans (Federal Ministry of Health and National Primary Health Care Development Agency, 2013) and minimum ward health care package (National Primary Health Care Development Agency, 2007) in the short to medium term are adequate to drive the improvement of childhood immunisation in Nigeria. The national immunisation policy and national routine immunisation strategic health plans had targets of 100% availability of vaccines in all health facilities, which will eradicate the incidence of vaccine stockouts that was found to be a challenge in the slums. The full implementation of the Universal Basic Education law (Edho, 2009), which stipulates free and compulsory primary and junior secondary education for all Nigerians will reduce drastically the high numbers of illiterate and primary education level mothers, who made up the majority of in the slums and rural areas. This will improve child immunisation, as evidence from this study revealed higher immunisation coverage among children of educated mothers.

Long term: The Child Right law in Nigeria is a federal law (Nigeria, 2003) that has to be adopted in all states of Nigeria, especially the Northern states, to make it effective. The child right law has sanctions for early child marriages, denial of health services like immunisation and non-attendance of primary and junior secondary school. The nationwide adoption of this law in Nigeria would reduce religious barriers to childhood immunisation and increase the proportion of educated mothers, which enables childhood immunisation

The inclusion of a clause in the next Nigerian national immunisation policy that sets aside a percentage of government and international multilateral and non-governmental organisations spending on immunisation in Nigeria to fund immunisation research will improve the quality of evidence available to immunisation decision makers and planners.

8.7.2 Implementation

The evidence from my PhD research showed that there are immunisation management decisions that can be implemented to improve childhood immunisations

Short term - Immunisation programme managers would improve childhood immunisation coverage by ensuring equitable distribution of staff irrespective of health facility location. The health facility in the slums should run for 24 hours daily like those in the formal urban as this will increase the health facility delivery and antenatal care attendance and increase confidence in the health facility. The present preferential immunisation service to working mothers in the slum should be encouraged and an implementation research conducted to evaluate the benefits. The health managers can liaise with counterparts in the education sector to enforce the use of completed immunisation cards as a pre-requisite for primary school enrolment.

Long term : Immunisation programme managers must utilise research findings to develop the messages for media and inform mothers and patients when the programmes will be aired. The suggestions of the interviewed participants of the beneficial influence of reminder and recall systems(Szilagyi *et al.*, 2000; Eze and Adeleye, 2015) and mass media interventions (Wiysonge *et al.*, 2012) to improve immunisation coverage have been successful in Nigeria and other countries. The government should provide more health facilities in the rural area, and the slum health facilities should be renovated, equipped and well-staffed as envisioned in the minimum ward healthcare package. The introduction of free health facility child delivery and antenatal care in the slums and rural area will build on the important positive influence they have on the completion of the routine immunisation schedule. The collaboration between the immunisation managers, community leaders and government officials in charge of infrastructure can improve access to the slum health facilities. This effort will yield drainages to reduce flooding and roofs to protect the children and mothers from the hot sunrays. The publication/airing of evidence based health messages in the media should be done in line with public service announcement.

8.7.3 Further research

Several knowledge gaps in understanding childhood immunisation in Nigeria was filled by this PhD study. Further research is required to provide the needed to change the current shortage of rigorous research evidence on the effectiveness of interventions for improving immunisation rates in sub-Saharan countries (Wiysonge *et al.*, 2012).

Short term: A scoping review of policies related to immunisation and literature on routine childhood immunisation in Nigeria from 1990 till date. The findings of the scoping review would assist in the design and conduct of systematic review of childhood immunisation in Nigeria.

Long term: The findings from conducting a national representative ethnographic qualitative research into views and perspective of the barriers and enablers of child immunisation with a focus on urban formal Muslims may improve understanding of the barriers especially religious of child immunisation. Replicating successful interventional studies that have been conducted elsewhere, such as use of short message services for reminders, market outreaches, community monitoring before adopting them is the way to go (Oyo-Ita *et al.*, 2012; Crocker-Buque *et al.*, 2017).

8.7.4 Health Facility

The administration of most immunisations holds in the health facilities, which also provides other health services to community members. The provision of health services at all times (24 hours) in slums' health facility would improve the utilisation of these services.

Short term: Recruitment of more staff to meet the minimum ward health care package will reduce the long waiting times that can reduce access to immunisation services. The mobile and outreach services can be offered for the rapidly expanding slums and underserved rural locations to reduce the immunisation challenge of indirect cost like transportation fare. The vaccine logistic mechanism may be strengthened to ensure the constant supply of all vaccines.

Long term: Health talks at the antenatal care clinics, delivery room and child out and inpatient clinics will include more immunisation health messages. Since household media exposure increases fully immunised odds, regular discussion on the importance of accessing the media during immunisation health talks should improve the child immunisation status.

Provision of training on inter personal communication will improve the attitude of health workers. In the period with reduced availability of vaccines, the immunisation managers resolve to ensure equity in vaccine availability will improve slum dwellers confidence in the slum health facility and eliminate the added transport cost required to access immunisation in the urban formal. As suggested by the slum mothers, the immunisation managers can improve immunisation coverage through improved immunisation communication feedback with mothers and establishment of immunisation reminder system. The immunisation barriers of overcrowded sessions and long waiting times in the slums can be resolved through the development of an appointment system rather than the current practice of having all mothers come before 9 am. The supervision of the health workers was non-existent as no documented record of supervision was seen so far in 2017 during this study qualitative field work which took place in February and March 2017, so regular supportive supervision from programme managers will improve the quality of service. The improved quality of service has been reported to reduce dropout rates (Agarwal *et al.*, 2005). Increased participation of the communities in the management of the health facilities is another enabler of childhood immunisation(Oyo-Ita *et al.*, 2012).

8.8 Concluding remarks

Fully immunised child coverage is low in Nigeria and utilisation of immunisation services are influenced by sociodemographic variables acting at child, household, community and health system levels. The most privileged sociodemographic groups like having a higher educated mother, being delivered in a health facility or mother attended antenatal care during pregnancy living in the formal urban area did not achieve the recommended FIC coverage target. With this very low FIC coverage, the prevalence of vaccine preventable diseases will continue, leading to high child mortality rates and increased health expenditure by parents. For public health and economic reasons, the government, immunisation managers and other stakeholders must decide to improve childhood immunisation as quickly as possible.

Pending the conduct of more expansive qualitative and intervention studies, the operationalisation of this study findings will increase the proportion of children who have access to the recommended immunisation. This study has shown that the presence of health facility alone does not lead to optimal immunisation coverage, as other child, household and community factors play influential roles. Strategies and interventions tailored to specific populations will achieve maximum impact. Improving immunisation in the slum will not cost the government any extra fund, it requires the programme managers to simply implement this study's recommendations.

Finally, Nigeria can achieve the universal child immunisation coverage within the next few years if the immunisation service delivery thrust is based on scientific evidence.

Appendix A

Appendix 1- Maternal nutritional status during pregnancy and infant immune response to childhood vaccinations

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Review

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Maternal nutritional status during pregnancy and infant immune response to routine childhood vaccinations

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To systematically review the association between maternal nutritional status in pregnancy and infant immune response to childhood vaccines. We reviewed literature on maternal nutrition during pregnancy, fetal immune system and vaccines and possible relationships. Thereafter, we undertook a systematic review of the literature of maternal nutritional status and infant vaccine response, extracted relevant information, assessed quality of the nine papers identified and present findings in a narrative format. From limited evidence of average quality, intrauterine nutrition deficiency could lead to functional deficit in the infant's immune function; child vaccine response may thus be negatively affected by maternal malnutrition. Response to childhood vaccination may be associated with fetal and early life environment; evaluation of programs should take this into account.

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Keywords childhood • immune response • infant • malnutrition • maternal nutrition • vaccination • vaccines

Routine childhood vaccination prevents many child deaths and has contributed substantially to improvements in survival up until, at least, the age of 5 years [1]. However, routine childhood vaccination programs do not reach all children [2], and concern has been expressed that even where children receive vaccines, some may not be fully protected and may still be at risk of infectious disease [3–6].

Fetal and early development is intricately associated with maternal health; the impact of maternal genetic, nutritional and environmental factors already starts preconception and continues through pregnancy and after birth [7], possibly irrevocably programming the developing fetal systems, including immunological development [8]. Compromised programming can negatively impact thymus size and function and the number of thymus-derived T cells [7,9]. Malnutrition has been put forward as the primary cause of immunodeficiency worldwide [10]. Maternal nutritional status, and exposure during fetal life to an inadequately nurturing environment, could thus impact fetal immune development [3,4], in particular, micronutrients including zinc, iron, vitamin A and protein energy malnutrition (PEM). Dietary macronutrients are the ultimate sources of energy substrates during fetal growth [11]; energy in the form of adenosine triphosphate is required for physiological processes in the fetus and mother, including nutrient transport, cell motility and synthetic pathways [12]. Nutritionally essential microminerals that the body cannot synthesize must be provided in the diet, because they are essential for fetal development, acting directly as second messengers in cell signaling, maintenance of the plasma, electron transport, membrane polarity or indirectly as cofactors for enzymes or components of metalloproteins [11].

Findings from epidemiological and experimental studies have shown that a poorly developed fetal immune system, increased risk of infectious diseases in infancy and its sequelae in adulthood can result from lack of energy, protein and other nutrients during fetal life [11,13]. Suboptimal infant immune development, as a result of a nutrient-deficient fetal environment, may lead to reduced antibody response to routine childhood vaccines due to the inadequate ability of the infant to mount an immune response.

Very little is known about the association between maternal nutritional status, as it pertains to the fetus, and infant response to routine childhood vaccines. In this review, we first provide a brief overview of maternal nutrition

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Appendix 2A- Parents' Information Sheet *[012213]*

Study Title: Optimising Childhood Immunisation in Nigeria

Researcher: Obanewa Olayinka Aderopo

ERGO number: 23986

Please read this information carefully before deciding whether to take part in this research. If you are happy to participate you will be asked to sign a consent form.

What is the research about?

Childhood immunisation is routinely provided in all health care facilities in Nigeria, but not all children receive these immunisations. This research aims to explore the view of parents (including community leaders) and health workers on the challenges and enabling factors which make it less or more likely that a child is immunised. The research is part of a PhD study at the University of Southampton by Dr Obanewa Olayinka (on secondment from the Federal Capital Territory Primary Health Care Board). Information from parents, health workers and community leaders is important but often unavailable, and will help improve the immunisation services.

Why have I been chosen?

The reason you have been chosen is because you are a parent to a child aged 9 - 59 months. Nine months is when the last routine infant immunisation is given.

What will happen to me if I take part?

The study requires you to take part in a one-to-one interview that will last approximately 25-40 minutes. You will be asked about your child's age, your age, where you stay, how long you have stayed there, are you living alone or with other family members, your level of education and similar questions. Then your views with regard to childhood vaccination, its importance and any challenges you may face in bringing your child to a health facility, and any factors that help you take your child to be immunised will be sought. The interview will be tape-recorded to make sure none of the information you provide is missed and the researcher will take some notes using a laptop. Later on, the researcher will listen to the interview tapes and write down what was said during interview using a laptop, this is called transcription. At the end of all the interviews, transcription and further analysis, a summary of the main findings will be displayed in the Health facility's notice boards.

Are there any benefits in my taking part?

Participants do not derive any direct benefit from this interview, but in case you have any questions about immunisation, the researcher will be able to answer them. Overall, this study will help us understand the challenges people face in accessing immunisation clinics and the things that help them do so, which can then inform improvement of the services.

Are there any risks involved?

The only direct risk is sitting for 25 – 40 minutes. So please feel free to walk around the interview room if you want to. Comfortable chairs are available in the interview room. Direct quotes from answers you provide may be used in the publication, but since no name will be mentioned it cannot be traced to any of the at least 20 parents that will be interviewed.

Will my participation and information be confidential?

Confidentiality is maintained at all levels of the study. This study including the data protection aspect was approved by the University of Southampton and Federal Capital Territory Health and Human Services Secretariat. The only time your names will be required is when you sign the consent form; the consent form will not be linked to any information you provide during the interview. During the interview which will be conducted in a room with only the participant and researcher, no names will be required and the interviews will be coded using the participant's interview order. For example the first participant to be interviewed is called parent participant one. Only the researcher will have access to the tapes of the interviews, password protected laptop where the transcripts and field notes are stored and conduct all analysis of the information collected. Also paper records will be scanned. At the end of the study, the tapes and paper records will be destroyed and all electronic records securely stored in a very secure University of Southampton repository for at least 15 years.

What happens if I change my mind?

Participation is totally voluntary, as such you are free not to participate. Even after signing the consent form to participate, a participant can withdraw at any time without fear of any consequence and does not need to provide a reason for the action. Also a participant has the right not to answer any question they are not happy with. The information collected from a participant who has withdrawn will not be used in further analysis.

For non-literate and visually impaired parents

A health worker working in this health facility who is not connected to the research will attest to the fact that the researcher has read out all the information contained in the information sheet and explained the content of the consent form fully. This health worker called a literate independent witness will sit in during the recruitment process until the signing/attestation of the consent where the literate independent witness also signs.

What happens if something goes wrong?

In the event of concern or complaint, participants are encouraged to contact Professor Marie-Louise Newell (M.Newell@soton.ac.uk) or/and University of Southampton Research Governance Office (tel. +44 23 8059 5058, rgoinfo@soton.ac.uk)

Where can I get more information?

The researcher Dr Obanewa Olayinka, +2348068868910, oao1r14@soton.ac.uk will be very happy to answer any question that a potential participant may have after reading this information sheet.

Appendix 2B- Immunisation Service providers' Information Sheet *[012213C]*

Study Title: Optimising Childhood Immunisation in Nigeria

Researcher: Obanewa Olayinka Aderopo

ERGO number: 23986

Please read this information carefully before deciding whether to take part in this research. If you are happy to participate you will be asked to sign a consent form.

What is the research about?

Childhood immunisation is routinely provided in all health care facilities in Nigeria, but not all children receive these immunisations. This research aims to explore the view of parents (including community leaders) and health workers on the challenges and enabling factors which make it less or more likely that a child is immunised. The research is part of a PhD study at the University of Southampton by Dr Obanewa Olayinka (on secondment from the Federal Capital Territory Primary Health Care Board). Information from parents, health workers and community leaders is important but often unavailable, and will help improve the immunisation services.

Why have I been chosen?

The reason you have been chosen is because you are the health worker providing immunisation services in a publicly- owned health facility providing childhood immunisation services to an informal urban settlement in the Federal Capital Territory, Abuja.

What will happen to me if I take part?

The study requires you to take part in a one-to-one interview that will last approximately 25-40 minutes. You will be asked about your age, ethnic group, religion, sex, place of residence, length of stay in the health facility and similar questions. Then your views with regard to childhood vaccination, its importance and any challenges you and health facility may face in providing childhood immunisation services, and any factors that help the immunisation of children in the health facility. The interview will be tape-recorded to make sure none of the information you provide is missed and the researcher will take some notes using a laptop. Later on, the researcher will listen to the interview tapes and write down what was said during interview using a laptop, this is called transcription. At the end of all the interviews (parents, health workers and community leaders), transcription and further analysis, a summary of the main findings will be displayed in the Health facility's notice boards.

Are there any benefits in my taking part?

You do not derive any direct benefit from this interview, but in case you have any questions about immunisation, the researcher will be able to answer them. Overall, this study will help us understand the challenges people face in accessing immunisation clinics and the things that help them do so, which can then inform improvement of the services.

Are there any risks involved?

The only direct risk is sitting for 25 – 40 minutes. So please feel free to walk around the interview room if you want to. Comfortable chairs are available in the interview room. Direct quotes from answers you provide may be used in the publication and the risk of being identified is there since only two immunisation service providers will be interviewed. This may occur even though there will be no name mentioned in the publication. The solution is that this health facility will not be identified (mentioned) and any quote from you will be termed from a stakeholder in the publication.

Will my participation and information be confidential?

Confidentiality is maintained at all levels of the study. This study including the data protection aspect was approved by the University of Southampton and Federal Capital Territory Health and Human Services Secretariat. The only time your names will be required is when you sign the consent form; the consent form will not be linked to any information you provide during the interview. Only the researcher will have access to the tapes of the interviews, password protected laptop where the transcripts and field notes are stored and conduct all analysis of the information collected. Also paper records will be scanned. At the end of the study, the tapes and paper records will be destroyed and all electronic records securely stored in a very secure University of Southampton repository for at least 15 years.

What happens if I change my mind?

Your participation is totally voluntary, as such you are free not to participate. Even after signing the consent form to participate, a participant can withdraw at any time without fear of any consequence and does not need to provide a reason for the action. Also you have the right not to answer any question they are not happy with. The information collected from a participant who has withdrawn will not be used in further analysis.

What happens if something goes wrong?

In the event of concern or complaint, participants are encouraged to contact Professor Marie-Louise Newell (M.Newell@soton.ac.uk) or/and University of Southampton Research Governance Office (tel. +44 23 8059 5058, rgoinfo@soton.ac.uk)

Where can I get more information?

The researcher Dr Obanewa Olayinka, +2348068868910, oao1r14@soton.ac.uk will be very happy to answer any question that a potential participant may have after reading this information sheet.

Appendix 2C- Community Leaders' Information Sheet *[012213b]*

Study Title: Optimising Childhood Immunisation in Nigeria

Researcher: Obanewa Olayinka Aderopo

ERGO number: 23986

Please read this information carefully before deciding whether to take part in this research. If you are happy to participate you will be asked to sign a consent form.

What is the research about?

Childhood immunisation is routinely provided in all health care facilities in Nigeria, but not all children receive these immunisations. This research aims to explore the view of parents (including community leaders) and health workers on the challenges and enabling factors which make it less or more likely that a child is immunised. The research is part of a PhD study at the University of Southampton by Dr Obanewa Olayinka (on secondment from the Federal Capital Territory Primary Health Care Board). Information from parents, health workers and community leaders is important but often unavailable, and will help improve the immunisation services

Why have I been chosen?

The reason you have been chosen is because you are the community leader of an informal urban settlement in the Federal Capital Territory, Abuja.

What will happen to me if I take part?

The study requires you to take part in a one-to-one interview that will last approximately 25-40 minutes. You will be asked about your age, ethnic group, religion, sex, place of residence and similar questions. Then your views with regard to childhood vaccination, its importance and any challenges you and your community may face in bringing your children to a health facility, and any factors that help the immunisation of children in the community. The interview will be tape-recorded to make sure none of the information you provide is missed and the researcher will take some notes using a laptop. Later on, the researcher will listen to the interview tapes and write down what was said during interview using a laptop, this is called transcription. At the end of all the interviews (parents, health workers and community leaders), transcription and further analysis, a summary of the main findings will be displayed in the Health facility's notice boards and sent to you.

Are there any benefits in my taking part?

You do not derive any direct benefit from this interview, but in case you have any questions about immunisation, the researcher will be able to answer them. Overall, this study will help us understand the challenges people face in accessing immunisation clinics and the things that help them do so, which can then inform improvement of the services.

Are there any risks involved?

The only direct risk of being interviewed is sitting for 25 – 40 minutes. So please feel free to walk around the interview room if you want to. Direct quotes from answers you provide may be used in the publication and the risk of being identified is there since only two community leaders will be interviewed. This may occur even though there will be no name mentioned in the publication. The solution is that this settlement will not be identified (mentioned) and any quote from you will be termed from a stakeholder in the publication.

Will my participation and information be confidential?

Confidentiality is maintained at all levels of the study. This study including the data protection aspect was approved by the University of Southampton and Federal Capital Territory Health and Human Services Secretariat. The only time your names will be required is when you sign the consent form; the consent form will not be linked to any information you provide during the interview. Only the researcher will have access to the tapes of the interviews, password protected laptop where the transcripts and field notes are stored and conduct all analysis of the information collected. Also paper records will be scanned. At the end of the study, the tapes and paper records will be destroyed and all electronic records securely stored in a very secure University of Southampton repository for at least 15 years.

What happens if I change my mind?

Your participation is totally voluntary, as such you are free not to participate. Even after signing the consent form to participate, a participant can withdraw at any time without fear of any consequence and does not need to provide a reason for the action. Also you have the right not to answer any question they are not happy with. The information collected from a participant who has withdrawn will not be used in further analysis.

What happens if something goes wrong?

In the event of concern or complaint, participants are encouraged to contact Professor Marie-Louise Newell (M.Newell@soton.ac.uk) or/and University of Southampton Research Governance Office (tel. +44 23 8059 5058, rgoinfo@soton.ac.uk)

Where can I get more information?

The researcher Dr Obanewa Olayinka, +2348068868910, oao1r14@soton.ac.uk will be very happy to answer any question that a potential participant may have after reading this information sheet.

Appendix 3A- Parents consent form

Study title: Optimising Childhood Immunisation in Nigeria

Researcher name: Olayinka A. Obanewa

ERGO reference: 23986

Please initial the box(es) if you agree with the statement(s):

I have read and understood the information sheet [*14-12-16 /012213]* and have had the opportunity to ask questions about

I agree to take part in this research project, for the interview to be audiotaped and for my data to be used for the purpose of this

I understand my participation is voluntary, may withdraw at any

Name of participant (print name)………………………………………………….

Signature of participant……………………………………………………………..

Date……………………………………………………………………………….

Name of researcher (print name)...

Signature of participant...

Date...

For non-literate and visually impaired parents only.

Name of literate independent witness (print name)..

Signature of Literate independent witness ....

Date...

Appendix 3B- Immunisation Service Providers' consent form [*103916C*]

Study title: Optimising Childhood Immunisation in Nigeria

Researcher name: Olayinka A. Obanewa

ERGO reference: 23986

Please initial the box(es) if you agree with the statement(s):

I have read and understood the information sheet [*14-12-16 /012213C]* and have had the opportunity to ask questions about

I agree to take part in this research project, for the interview to be audiotaped and for my data to be used for the purpose of this

I understand my participation is voluntary, may withdraw at any

Name of Service Provider (print name)…………………………………………………

Signature of Service Provider………………………………………………………..

Date…………………………………………………………………………

Name of researcher (print name)…………………………………………………

Signature of researcher ………………………………………………………..

Date…………………………………………………………………………

Appendix A

Appendix 3C- Community Leaders Consent form

Study title: Optimising Childhood Immunisation in Nigeria

Researcher name: Olayinka A. Obanewa

ERGO reference: 23986

Please initial the box(es) if you agree with the statement(s):

I have read and understood the information sheet [*14-12-16 /012213b*] and have had the opportunity to ask questions about

I agree to take part in this research project, for the interview to be audiotaped and for my data to be used for the purpose of this

I understand my participation is voluntary, may withdraw at any

Name of Community Leader (print name)………………………………………………….

Signature of Community Leader…………………………………………………………..

Date……………………………………………………………………………

Name of researcher (print name)……………………………………………………

Signature of researcher ……………………………………………………………..

Date…………………………………………………………………………………

Appendix 4A- Interview guide for parents

A. Opening formalities
  - Greeting
  - Thank you for volunteering

1. Socio-demographics

Mother/father's age –

Child's age –

Name of place of residence and length of stay there –

If migrant, previous place of residence –

Are you living alone or with family and friends –

Mother/father's level of education –

Religion –

Ethnicity –

Other sociodemographic information –

2. What birth rank is your child (last child)?
  - Birth order

3. How was the pregnancy?
- ANC care – attendance, health information for pregnancy and child
- Place of delivery – health information on child health including vaccination

4. How is the child's immunisation background?
- Have you heard of vaccines
- What are vaccines
- Roles of vaccines
- Advantages and disadvantages of vaccines/why are vaccines given to young children

5. Has your child had the childhood vaccines?
- Why/why not? Reasons?
- Which ones? Can you remember?

6. How did you come to making that decision?
- Whose decision was it to have the child immunised or not?
- How do you become aware of what you are meant to do with your child and immunisation visits? Other circumstances can be explored
- Barriers/Enablers – religion, ethnic group, Health system factors (like attitude of health workers, non-availability of vaccine, long waiting time, refusal to be immunised for coming late or because of too few numbers to open a new vaccine vial), transportation cost, distance to health facility, fears and others

7. What was the most important factor when making your immunisation decision?
- Details

8. Did you talk to any person including health professionals about your decision?
- Who?
- What was discussed?
- What information was given?
- Experiences

9. Suggestions on how to increase child immunisation?
- Child level - sex, maternal ANC attendance, delivery in a health facility, birth order
- Maternal level - education level, religion, ethnicity, wealth
- Community level - place of residence, region, distance from health facility
- Health system level - vaccine availability, equipment adequacy, truly free service, sex of health worker, attitude of health worker

Throwaway question – Just to confirm if the parents especially those without records are in the group they claim to be.

Did your child suffer any vaccine preventable diseases

Do you know the reason,

Thank you for taking part in this interview. Is there anything else you would like to add? Do you have questions? Thank you

Appendix 4B- Interview guide for immunisation service PROVIDERS

A. Opening statement
- Greeting
- Thank you for volunteering for the interview
- I must commend you for a great job

1. Personal information
- How long have you being in this clinic
- Age
- Sex
- Ethnicity
- Religion
- Place of residence
- Other sociodemographic information

2. Is there stress in this job? How does the system work (is it daily immunisation service or special days)?
3. How do you cope with the stress of administering vaccines?
- Impatient parents
- Parents who come late for vaccination

4. What is the service delivery process?
- How are parents made aware of need for immunisation, are they sent reminders
- Vaccine availability
- Vaccine vial opening policy
- In what circumstances do you refuse to administer vaccines on eligible children. For example: A. Will a very ill child who came for immunisation be vaccinated, 2. Will you open the 20 dose vial of BCG for just one or two children and discard the unused 18 doses left ? having just two children coming for the BCG vaccination

5. Are children optimally accessing immunisation services? In your opinion, is attendance affected by :
- Child level factors – sex, maternal ANC attendance, delivery in a health facility, birth order
- Maternal factors – education level, religion, ethnicity, wealth
- Community factors - place of residence, region, distance from health facility
- Health system – vaccine availability, equipment adequacy, truly free service

6. What do you consider the barriers to child immunisation?
- Child level factors – sex, maternal ANC attendance, delivery in a health facility, birth order
- Maternal factors – education level, religion, ethnicity, wealth
- Community factors - place of residence, region, distance from health facility
- Health system – vaccine availability, equipment adequacy, truly free service

7. What are the enablers of child immunisation?

- Child level factors – sex, maternal ANC attendance, delivery in a health facility, birth order
- Maternal factors – education level, religion, ethnicity, wealth
- Community factors - place of residence, region, distance from health facility
- Health system – vaccine availability, equipment adequacy, truly free service

8. Suggestions on how to increase child immunisation?

- Child level factors – sex, maternal ANC attendance, delivery in a health facility, birth order
- Maternal factors – education level, religion, ethnicity, wealth
- Community factors - place of residence, region, distance from health facility
- Health system – vaccine availability, equipment adequacy, truly free service

Thank you for taking part in this interview. Is there anything else you would like to add? Do you have questions? Thank you

Appendix 4C- Interview guide for community leaders

Opening statement

- Greeting
- Appreciation for volunteering
- Commend on great job.
- How long have you been the head of the community
- How do you cope with the stress of leading the communities

1. Personal information
- Age
- Sex
- Ethnicity
- Religion
- Place of residence
- Other sociodemographic information

2. Utilising health services
- Public owned health facility that serves the community
- Mention the health needs that makes the community seek health service. If not mentioned ask of immunisation, antenatal care, hospital delivery

3. Immunisation background
- Have you heard of vaccines
- What are vaccines
- Roles of vaccines
- Advantages and disadvantages of vaccines

4. Are children optimally accessing immunisation services? Is it affected by :
- Child level factors – sex, maternal ANC attendance, delivery in a health facility, birth order
- Maternal factors – education level, religion, ethnicity, wealth
- Community factors - place of residence, region, distance from health facility
- Health system – vaccine availability, equipment adequacy, truly free service

5. What are the barriers to child immunisation
- Child level factors – sex, maternal ANC attendance, delivery in a health facility, birth order
- Maternal factors – education level, religion, ethnicity, wealth
- Community factors - place of residence, region, distance from health facility
- Health system – vaccine availability, equipment adequacy, truly free service

6. What are the enablers of child immunisation
- Child level factors – sex, maternal ANC attendance, delivery in a health facility, birth order
- Maternal factors – education level, religion, ethnicity, wealth

- Community factors - place of residence, region, distance from health facility
- Health system – vaccine availability, equipment adequacy, truly free service

7. Suggestions on how to increase child immunisation?

- Child level factors – sex, maternal ANC attendance, delivery in a health facility, birth order
- Maternal factors – education level, religion, ethnicity, wealth
- Community factors - place of residence, region, distance from health facility
- Health system – vaccine availability, equipment adequacy, truly free service

Thank you for taking part in this interview. Is there anything else you would like to add? Do you have questions? Thank you

Appendix 5 – Health assessment tool

SN		Health Facility Service Delivery and Management Issues	Available: Yes	Available: No
1	Planning and Management of Resources	**Is there an up to date immunization session schedule displayed on the wall?**		
		<u>Procedure</u>		
		❖ Is there is an immunization session schedule display on the wall (check whether there is a table showing date of immunization both for fixed and outreaches displayed on the wall (if *there is answer yes otherwise answer no*)		
		❖ If there immunization session schedule -Check whether is for current period or not (if current answer yes, otherwise no)		
2		**Is the immunization session schedule being conducted as displayed?** **<u>Procedure</u>** ❖ Check the number of sessions planned for the month and check from the tally sheet whether they agree with session conducted (answer 'Yes' if they do otherwise answer 'NO')		
3		**Does the health facility have a defined catchment area map?**		
		<u>Procedure</u>		
		❖ Check if there is a map showing the location of the health facility and all the communities served by the health facility with indication of population and strategy to reach communities Yes/No		
		❖ Check if a table showing list of communities in the catchment area and target age group to be served by Strategy Yes/No		

		❖ Does the HF have estimates of vaccine required per month displayed Yes/No		
		(Provide on the job training and guidance to the officer on how to conduct/organize with the community the development or updating of the catchment area maps.		
4		**Does the HF have at least one(1) qualified HW**		
		<u>Procedure</u>		
		❖ *Ask for Qualification of the HW(s) that you found providing RI service*		
		❖ If there is at least 1 qualified and competent HW at the HF, answer is Yes, if not answer is No (put the Number(s) and Qualification(s) of the HW(s) available in the comment column)		
5		**Is there a management of defaulter tracking system in place?(Yes/no)**		
		If above yes State the type of the tracking system in place at the remark column and also the yield of the defaulter tracking.		
6	**Cold Chain Management**	**Is there at least 2 Giostyle vaccine carriers in the health facility (*yes/no)***		
7		**does the Giostyle contain 4 conditioned ice pack**		
		Check number of Ice packs in each giostyle vaccine carrier and see if the ice-packs are conditioned, frozen or warm (comment on ice-packs in the remarks column.).If ice packs are 4 and all conditioned, answer Yes. If not answer No. if answer is No, ensure the officer understands the importance of conditioned ice packs to the potency of vaccines		
8		**Are all vaccines bundled at the health Facility**		
		❖ Check all available vaccines and cross checks the available diluents and droppers to ascertain whether there are equal and correct if there are correct answer' yes' otherwise 'no'		
		❖ Is there equal number of AD and re-constitution syringes to match the vaccines available.		

		❖ Is there adequate number of safety boxes to match the number of AD and re-constitution syringes (Y/N)		
9		**Is the foam pad in the vaccine carrier used for holding vaccines while in session**		
		❖ Is there a foam pad in the giostyle vaccine carrier (Yes/No)		
		❖ If yes; is the foam pad being used in the vaccine carrier for holding vaccine while in session (Yes/No)		
		❖ If foam pad is not used during session demonstrate how to use foam pad on vaccine carrier while in session.		
		❖ If there is no foam pad assist the officer to get one from L.G.A.		
10		**Do all vaccines have readable labels and have not expired and with VVM stage 1 & 2?**		
		❖ Check that all vaccines are with readable labels		
		❖ Check that vaccines being used or in stock have not expired (yes/no)		
		❖ Check the vaccines being used for their VVM (answer 'YES' if all checked vaccines are in VVM is at stage 1 or 2 and answer NO if any vial is in VVM 3 or 4		
		❖ *If any vaccine has no readable label or has expired or VVM in stage 3 & 4 stop the session with the vaccines and ensure they are replaced with potent ones.*		
11	Service Delivery	**Does the HF provide adequate benches for clients to seat comfortably?**		
		❖ Does the HF have at least two benches for client to seat on *(yes/no)*		
		❖ If During session, are all Clients comfortably seated or some are standing or hanging on the windows (yes/ no)		
12		**Did the officer wash his hands before handling vaccines?**		

		❖ Is there a water bowl and stand for washing hand in the vaccination room or nearby (Yes/No)		
		❖ Did the officer wash his/her hands before handling vaccine,(yes/ no) confirm		
13		**Are all vaccines available during the immunization sessions(Yes/No)** *Identify the unavailable ones(if any) in the remark column*		
14		**Does the officer use correct diluents for reconstituting each vaccine?**		
		❖ Check diluents being used to reconstitute vaccine whether they are the correct diluents for reconstituting each vaccine (Yes only if all vaccines are being correctly reconstituted)		
		If the officer is not using correct diluents for reconstituting any vaccine please stop the session and ensure immediate correction of the error		
15		**Does the officer use one sterilized syringe/needle for reconstituting each vial of Measles, BCG and Yellow fever vaccines?**		
		❖ If the officer uses one sterile syringe/needle for reconstituting each vial *(answer yes)*		
		❖ If the officer is using one sterile syringe/needle for reconstituting more than one vial of vaccine (answer no)		
16		**Did the officer give the vaccine at the correct site, route, and dose?**		
		❖ Is the officer is giving the vaccine at the correct dose. *Check this*		
		❖ Is the officer is giving the vaccine at the correct site. *Check this*		
		❖ Is the officer is giving the vaccine at the correct route .*Check this*		

		If all the above are correct answer is Yes, if not answer is No. If any of the above is no, please correct the officer immediately		
17		**Did the officer use ONLY one syringe/needle for each dose of antigen given?**		
		❖ If the officer use only one syringe/needle for each dose *(answer yes)*		
		❖ If the officer use one syringe/needle for more than one dose (answer no)		
		If the officer is using one syringe/needle for more than one dose, the officer should be stopped immediately and provided with on the job training of using one syringe/needle per dose per child.		
18		**Does the service provider enter on the card the date of next visit and explain to caretaker**		
		❖ Observe entries in the card, if the date of next visit has been entered *(yes/no)*		
		❖ Observe during sessions whether date of next visit is being explained to the caretaker *(yes/no)*		
		If all the above are correct, then answer is Yes. If not answer is No. If not, support the officer to ensure that dates of next visits are entered and explained to the caretaker		
19		**Does the service provider give the 6 key messages to the caregiver?**		
		Observe the service provider giving these 6 key messages to the caregiver,		
		1. Is the SP educating care-givers on which diseases the immunization is offering protection		
		2. Is the SP telling the parents of the Immunization schedule		
		3. Is SP educating parents on the number of visits needed to complete the immunization schedule		
		4. Is the SP informing caregivers of possible AEFI and how to manage them?		

		5. Is SP informing the caregivers on the date of next visit		
		6. Is SP telling caregivers to keep the child health card well and to bring it to every visit		
		If the service provider is providing all the 6 key messages to the caregiver, answer is Yes, if not answer is No. If answer is No, provide the 6 key messages and educate the health worker on the importance of providing these messages		
20		**Conduct an exit interview of at least 3 parents to find out.**		
		• Is the care giver aware of the vaccinations given to the child		
		• Is the care giver aware of how many visits are needed to complete the schedule		
		• Is the care caregiver aware of how to manage possible side-effects of the vaccination		
		• Does the care-giver know the date of next appointment?		
		• Is the care –giver satisfied by the friendliness of the H/workers		
21	**Safe Waste Disposal**	**Did the officer during the session avoid recapping the needle after use?**		
		❖ Observe the officer during session to see if the officer is not recapping needle after use		
		If the officer is recapping the used syringe/needle advice the officer to stop recapping after use and provide on the job training		
22		**Is there a safety box used for discarding used syringe/needle(Yes/No)**		
23		**Is the safety box properly assembled (yes/no)**		
24		**Is the safety box not more than 3/4 full (yes/No)**		
25		**Are all used syringes/needles discarded into the safety box immediately?**		

		❖ Observe the officer to see if the officer is discarding the empty syringe and needle into a safety box immediately – (answer yes if so and 'No if this is not happening.)		
		If the officer is not discarding syringe/needle in to the safety boxes immediately demonstrate/provide on the job training on how to discard the syringe and needle into a safety box immediately.		
26		**Does the facility have a pit or access to one for burning and burying filled safety boxes of used syringes/needles?**		
		Procedure		
		If there is burn and bury site located in appropriate site and is as far from the Health Facility and the community as possible, the area should be cleared and fenced answer yes; otherwise answer no.		
		The pit at least 1.5 meter wide and 2 metres deep		
		If all these conditions are met answer yes otherwise answer no		
27		**Is there a standard drum over the pit**		
		Check if there is a drum cut at both end lying on top of a wire mesh over the pit. If this is present answer yes otherwise answer no		
		If the dept is up to 2 meters in length then answer Yes if not answer No, then advice for the upgrading or digging of new pit of standard length		
		Is the pit being Managed efficiently and effectively		
		Check that there is no littering of the area around pit, and no residual need littering around the pit and c*overed completely each layer of burnt waste with a thin layer of soil till the last day.* *Check for log of all safety boxes burnt in the last 3 months.* *If all these are present answer yes; otherwise answer no*		
		If there is no pit provide on the job training on waste disposal and advocate with LGA and community to assist in identifying and digging a standard burn and bury site.		

28	Data management	**Is there an immunization register (children) being used?**		
		❖ Is there is a standard immunization register (children) in the facility		
		❖ Are traceable addresses of clients being entered in the register		
		❖ Are dates being entered for doses given in the register (rather than a tick)		
		If all the above are correct then answer Yes, if not answer No. If there is no register assist the officer to obtained one from the L.G.A and If the register is available but not being used or the entries are not correct and up to date, assist the officer to make correct entries and up date the register on the spot. *Indicate the defects in the remarks column*		
29		**Is the immunization register being used with correct entries** (Y/N)		
		Check whether the entries correctly filled.		
		If the Above is correct, then answer is Yes. If not answer is No. Then support the officer to ensure that entries are correctly done in the register		
30		**Is the immunization register up-to-date(Y/N)**		
		❖ *Check whether entries are up to date*		
		If the Above is correct, then answer is Yes. If not answer is No. Then support the officer to ensure that entries are made during all sessions		
31		**Is the tally sheet book let available?**		
		❖ Is there a standard immunization tally sheet booklet (children) in the Health Facility (*Y/N)*		
		Support the HF to obtain Tally from LGA where not available and provide training on problems observed with tallying.		

32		**Is the immunization tally sheet (children) being used with correct entries** ❖ *Observe if tallying is done immediately and correctly by the health worker during session* If the Above is correct, then answer is Yes. If not answer is No. If not support the officer to ensure that entries are made correctly into the tally sheet during all sessions		
33		**Does the number of children in the tally sheet correspond with the number in the register and monthly facility immunization summary form**		
		❖ Randomly select two or three months and recount the tally for those months for a few antigens and compare with the entries in the summary sheet, if they all tally *answer 'Yes' otherwise answer 'No' and indicate the discrepancies in remarks column.*		
		❖ Also compare the recounted tally figures with the entry in the Immunization register and see if they agree, if they all do *answer 'Yes' otherwise put 'No' and indicate the discrepancies in remarks column.*		
34		**Is there a DPT1/DP3 monitoring chart displayed (yes/no)**		
35		**Is the DPT1/DP3 monitoring chart up dated (yes/no)**		
36		**Can the health worker adequately explain the development and use of the Monitoring chart(yes/No)**		
37		**Is there a table of data analysis (YES/No)**		
38		**Is the table up-to date(yes/no)**		
39		**Is the health worker able to interpret the analysis table?(yes/no)**		
40		**Is the HF monitoring coverage by strategy(fixed, outreach & mobile)** *Check if the HF chart/table disaggregating its coverage by strategy is available and up to date.If it is answer is Yes, if not answer is No. If answer is No, support the officer to monitor HF coverage by strategy.*		

41		**Is the Health facility monitoring trends of VPD in the communities in the catchment area(yes/No)**		
42	Community Link	**Is there a community linking Plan in the health facility**		
		Confirm to see the plan if available and up to date		
		If plan is available and up to date answer is Yes ,if not answer is No.Support the officer if there is no plan to develop one		
43		**Is there a community linking committee or VDC for the health facility?**		
		Check if there are reports/records of meetings with the community or VDC (Yes/No) indicate how many reports are available for the last 3 months at the remark column. (If VDC does not exist advocate to the LGA for the formation of one)		
44		**Does the health worker have regular meetings with the community/VDC(Yes/No)** Confirm from the attendance		
45		**Is the VDC or other committee involved in any of the following**:		
		1) Defaulter tracking		
		2) New born registration;		
		3) Community announcement for immunization sessions		
		4) Community Education on Immunization and other health Issues		
		5) Provide logistic support to the HF(please specify)		
		If at least 3 of the above are provided by the VDC answer Yes if Not answer is No. (Tick appropriately the items listed that		

		are provided. Specify on the remark column other additional activities of the VDC not indicated above)		
46	Supportive Supervision	**Has the HF received support supervision from higher level(National, State, LGA) in the last one month(Yes/no)(check for evidence)**		
47		**Was Written feed back/reports provided to the HF (Yes/no)(probe)**		
48		**Were the recommendations/Action points of the supervision specific to the HF carried out(Yes/No)(probe)**		
		Total Number of YES/NO		
		Percentage YES/NO		

Appendix 6 – Federal Capital Territory Health Research Approval

FEDERAL CAPITAL TERRITORY
Health Research Ethics Committee

Research Unit, Room 10, Block A Annex, HHSS, FCTA Secretariat,
No. 1 Kapital Street Area 11, Garki, Abuja - Nigeria

Name of Principal Investigator:	Dr. Obanewa Olayinka Aderopo
Address of Principal Investigator:	Plot 106, Jubilation Estate, Lokogoma, Abuja, Nigeria.
Date of receipt of valid application:	03/01/2017

Notice of Research Approval
Approval Number: FHREC/2017/01/04/19 - 01-17

Study Title: Optimising Childhood Immunization in Nigeria

This is to confirm that the FCT Health Research Ethics Committee (FCT HREC) has approved the research described in the above stated protocol.

Effective Date: - 19/01/2017
Expiration Date: - 18/01/2018

Note that no activity related to this research may be conducted outside of these dates. Only the FCT HREC approved informed consent forms may be used when written informed consent is required. They must carry FCT HREC assigned protocol approval number and duration of approval of the study.

The National Code of Health Research Ethics requires you to comply with all institutional guidelines, rules and regulations, and with the tenets of the code. The FCT HREC reserves the right to conduct compliance visit to your research site without prior notification.

Modifications: Subsequent changes are not permitted in this research without prior approval by the FCT HREC.

Problems: All adverse events or unexpected side effects arising from this project must be reported promptly to FCT HREC.

Renewal: This approval is valid until the expiration date. If you are continuing your project beyond the expiration date, endeavor to submit your annual report to FCT HREC early, and request for renewal of your approval to avoid disruption of your project.

Closure of Study: At the end of the project, a copy of the final report of the research should be forwarded to FCT HREC for record purposes, and to enable us close the project.

Desmond Emereonyeokwe
Ag. Secretary, FCT HREC
January 19, 2017.

Appendix 7- University of Southampton ERGO approval

Submission Number: 23986

Submission Name: Optimising childhood immunisation in Nigeria

This is email is to let you know your submission was approved by the Ethics Committee.

You can begin your research unless you are still awaiting specific Health and Safety approval (e.g. for a Genetic or Biological Materials Risk Assessment)

Comments

1.Dear Dr Obanewa, Re: ERGO reference 23986: Optimising childhood immunisation in Nigeria Thank you for submitting your carefully revised application relating to the above research study. I am pleased to inform you that full approval has now been granted by the Faculty of Medicine Ethics Committee. Approval is valid from today until 15/07/2017, which is the end date specified in your application. Please note the following points: â¢ the above ethics approval number must be quoted in all correspondence relating to your research, including emails; if you wish to make any substantive changes to your project you must inform the Faculty of Medicine Ethics Committee as soon as possible. Please note that this email will now constitute evidence of ethical approval. Should you require a paper signed copy of this approval, please contact the FoMEC Administrative Team via email at: Medethic@soton.ac.uk. We wish you success with your research.

Yours sincerely

Dr Catherine Hill Chair of the Faculty of Medicine Ethics Committee

Appendix 8- Study findings dissemination

Dissemination completed

During the course of this study, a conference presentation and publication has been published

- ✓ Obanewa O, Newell ML, Madise NJ. CHILDHOOD IMMUNISATION TRENDS IN NIGERIA: Inequalities by Wealth, Education and Residence. Oral presentation. University of Southampton Faculty of Medicine research conference (2016)
- ✓ Obanewa O, Newell M-L. Maternal nutritional status during pregnancy and infant immune response to routine childhood vaccinations. *Future Virol* (2017) 12:525–36.

Government policy brief and study summary for immunisation managers

A two-page policy brief will be written to the Honourable Minister of Health of Nigeria. This document will summarise important findings and enumerate the short and long term recommendations needed to improve childhood immunisation. A five-page implementation plan for immunisation programme managers will be developed, which includes the summary of this study findings and relevant recommendations

Publication plan

This study has added to knowledge and produced evidence on improving childhood immunisation in Nigeria. The evidence will be developed into five (5) academic papers. They are made up of a systematic review that covers chapter 2 and four (4) papers that answer seven (7) research questions from the four result chapters (chapters 4-7). The publication plan is presented in the table below

Appendix A

Proposed papers name and description or research questions

Name of paper	Description or Research question
Systematic review of childhood immunisation in Nigeria, 1990 – 2018.	It will synthesise evidence from the 118 included literature. Meta-analysis will not be done as some of the data are not compatible due to the different age cohort of the participants
Levels of childhood immunisation in Nigeria 2013, and associated factors	What is the childhood immunisation coverage presently? What are the child, household and community-related factors associated with childhood immunisation coverage in Nigeria?
Patterns of child immunisation over time and the role of urban and rural place of residence	What are child, maternal/household and community related factors associated with childhood immunisation coverage in Nigeria and have they changed over time? What is the difference in childhood immunisation coverage between urban and rural areas, and are the associations with child, household and community factors different in rural and urban areas?
A multilevel analysis of the association of fully immunised child status with sociodemographic characteristics in urban Nigeria	In the urban setting, does childhood vaccination coverage vary between urban and slum dwellers and what factors are associated with it?
The view of parents, community leaders and health workers on childhood immunisation challenges and enabling factors in the slums of Abuja	What are the barriers and enabling factors in the uptake of childhood immunisation? Do health workers practice and attitude affect childhood immunisation in Abuja?

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