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DECLARATION

I declare that Assessment of Factors Associated with Incomplete Immunization among Children Aged 12-23 Months in Ethiopia is my own work, that it has not been submitted for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Full Name: Dr. Raji Tajudeen Mohammed Date: November 13th 2015

Signed: 

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ABSTRACT

Ethiopia has achieved its target for Millennium Development Goal 4 by recording 69 % reduction in its under-five mortality. The proportion of fully immunized children in Ethiopia has increased from 14 % in 2000 to 24 % in 2011. Though progress has been made, about 3 out of 4 children still remain incompletely immunized. The purpose of this study is to determine the socio-demographic and socioeconomic factors associated with incomplete immunization among children aged 12-23 months in Ethiopia.

This study is based on secondary analysis of the 2011 Ethiopia Demographic and Health Survey. Information on 1,889 mothers of children aged 12–23 months were extracted from the children dataset. Records from vaccination cards and mothers' self-reported data were used to determine vaccine coverage. The association between child immunization status and determinants of non-utilization of immunization services was assessed using bivariate and multivariate analyses.

The findings of this study showed that the prevalence of incompletely immunized children is 70.9%. Children of mothers from the poor (AOR = 2.27; 95 % CI: 1.34 – 3.82) wealth quintile were more likely to be incompletely immunized. Children of mothers from Affar (AOR = 15.80; 95 % CI: 7.12 – 35.03), Amhara (AOR = 4.27; 95 % CI: 2.31 – 7.88), Oromiya (AOR = 8.10; 95 % CI: 4.60 – 14.25), Somali (AOR = 4.91; 95 % CI: 2.65 – 9.10), Benishangul-Gumuz (AOR = 4.20; 95% CI: 2.34 – 7.57), Southern Nations Nationalities and Peoples' (AOR = 4.76; 95 % CI: 2.53 – 8.94), Gambela (AOR = 7.75; 95 % CI: 3.68 – 16.30) and Harari (AOR = 3.22; 95 % CI: 1.77 – 5.89) regions were more likely to be incompletely immunized. Mothers with inadequate exposure to media (AOR = 1.60; 95% CI: 1.21 – 2.14), who are not aware of community conversation programme (AOR = 1.80; 95% CI: 1.40 – 2.32) and who attended no antenatal care (AOR = 2.21; 95% CI: 1.72 – 2.83) were more likely to have incompletely immunized children.

Despite efforts to increase rates of childhood immunization, the proportion of children with incomplete immunization in Ethiopia is considerably high. Therefore, targeted

interventions at the identified socio-demographic factors are needed to increase immunization rates.

CHAPTER 1

1.1 Introduction

Immunization remains a key public health intervention and a cost effective strategy to reduce childhood morbidity and mortality associated with infectious diseases (Odusanya, Alufohai, Meurice & Ahonkhai, 2008). Each year, an estimated 2.5 million under-five deaths are averted through immunization (Brenzel, Wolfson, Fox-Rushby, Miller & Halsey, 2006; Sullivan, Tegegn, Tessema, Galea, & Hadley, 2010; WHO, 2013). Additionally, immunization reduces the risk of disability from infectious diseases such as poliomyelitis. Despite the proven cost-effectiveness of immunization, it is not always available to those who need it the most, particularly the poor (O'Grady, Krause & Andrews, 2009).

Despite major progresses to improve the health status of the population in the last two decades, Ethiopia's child population still face a high rate of morbidity and mortality and the health status remain low in terms of quality and equity in access to services (FMOH, 2015). The major causes of under-5 deaths in Ethiopia are neonatal (47%), pneumonia (17%), diarrhea (8%) and measles (4%) with undernutrition associated with around half of the deaths (Countdown to 2015, 2015). Several of these causes are preventable through high immunization coverage.

The 2011 Ethiopia Demographic and Health Survey (EDHS) observed that infant and child mortality continue to decline, child vaccination is slowly improving, and fewer children are malnourished. The proportion of fully vaccinated children increased from 14% in 2000 to 24% in 2011, ranging from 9% in Affar to 79% in Addis Ababa (EDHS, 2011). The under-five mortality level decreased from 205 deaths per 1,000 live births in 1990 to 64 deaths per 1,000 live births in 2013. Ethiopia has achieved its target for Millennium Development Goal 4 for child survival by attaining a 69% reduction in its under-five mortality (UN IGME, 2014). Despite this success, routine immunization coverage still remains low.

According to WHO guidelines, children are considered fully vaccinated when they have received vaccination against tuberculosis (BCG), three doses of polio vaccines, three

doses each of DPT (diphtheria, pertussis, and tetanus), and a measles vaccination before their second birthday. The goal of immunization programmes is for countries to reach at least 90% national vaccination coverage and at least 80% vaccination coverage in every district or equivalent administrative unit (WHO & UNICEF, 2005). However, the national immunization coverage rates are aggregates that do not show the disparities within countries (Mathew, 2012). The factors determining receipt of immunization are complex and interlinked, and are grouped into population and service delivery factors (Kiros & White, 2004; O'Grady, Krause & Andrews, 2009; Payne, Townsend, Jasseh, Jallow & Kampmann, 2013; Sullivan *et al*, 2010). Population factors include maternal education, distance to health facility, place of residence, mothers' attendance of antenatal care, etc. Service delivery factors that influence childhood immunization include quality of service provided by healthcare workers, attitude of the healthcare workers, immunization publicity and distribution, availability of immunization booklets and education about immunization issues.

In order to understand who are the unimmunized children in Ethiopia, there is a need to look at the determinants of incomplete immunization coverage.

1.2 Problem Statement

Despite the presence of the Expanded Programme on Immunisation (EPI) in Ethiopia for the past 34 years, completion rate of routine childhood immunization remains low (Sullivan *et al.,* 2010; WHO, 2013). An estimated 472,000 children still die each year before their fifth birthday largely from vaccine preventable diseases (Federal Ministry of Health, 2010; Odusanya *et al*, 2008). After neonatal causes, pneumonia and diarrhoeal disease are two leading causes of death amongst under-five children in Ethiopia. Evidence indicates that routine immunization with pertussis, *Haemophilus influenzae* type b conjugate, pneumococcal conjugate and measles vaccines prevents pneumonia (Madhi, Levine, Hajjeh, Mansoor & Thomas, 2008). Mahdi *et al* (2010) asserted that rotavirus vaccine significantly reduced the incidence of severe rotavirus gastroenteritis among African infants. Therefore, there is a pressing need to find ways to increase immunization coverage. To the best knowledge of the investigator, there is paucity of

recent data on factors associated with incomplete immunization among children in Ethiopia.

1.3 Purpose of the Study

Ethiopia has recorded sizable improvements in vaccination coverage from 14% in 2000 to 24% in 2011 (ICF International, 2012). Under-five mortality levels have decreased from 123 per 1,000 live births in 2005 to the current level of 64 per 1,000 live births (ICF International, 2012; UN IGME, 2014). Still, 1 in 12 Ethiopian children die before their fifth birthday largely from vaccine preventable diseases and about 3 out of 4 children remain incompletely immunized (ICF International, 2012). Despite the impressive gains in child survival, further gains will be difficult without increasing immunization coverage. Thus, this study aimed to provide a better understanding of the determinants of incomplete immunization that can help shape interventions to reduce disparities in complete immunization coverage among children of differing demographic and socioeconomic groups.

CHAPTER 2: LITERATURE REVIEW

This chapter focuses on review of national and international literature related to immunization coverage amongst under-five children.

2.1 ETHIOPIA COUNTRY BACKGROUND

Ethiopia is a low-income country located in the interior of the Horn of Africa. It occupies 1.1 million square kilometers of diverse topography. It is bordered by Djibouti, Eritrea, Sudan, Southern Sudan, Kenya, and Somalia. It is home to approximately 85.8 million people and about 82 percent of the population lives in rural areas (UNDP, 2015). Ethiopia is one of the few African countries to have maintained its independence, even during the colonial era. The climate varies with the topography, from as low as 10 degrees Celsius in the highlands to as high as 47 degrees Celsius in the Affar Depression**.**

The WHO launched its Expanded Program on Immunization (EPI) in 1974 and introduced it into Ethiopia in 1980 (ARISE, 2012; Bugvi *et al*, 2014). The primary aim of the program was to control six childhood diseases: tuberculosis, diphtheria, pertussis, tetanus, polio and measles. Since the inception of the programme in Ethiopia, considerable progress has been made in terms of reduction in disease burden. Despite these achievements, the burden of vaccine-preventable diseases remains unacceptably high, in comparison to the western world and many developing countries (ICF International, 2012).

Economy

According to the World Bank, Ethiopia's annual GDP was estimated at US$28.5 billion in 2009. Ethiopia has recorded average annual economic growth rates in excess of 10 percent over the past decade, a particularly notable achievement in a period of global economic uncertainty (UNDP, 2015). Although Ethiopia is one of the 10 countries globally that has attained the largest absolute gains in its Human Development Index (HDI) over the last several years, it still ranks 173rd out of 186 countries (UNDP, 2015). About 25 million Ethiopians remain in poverty, and these and many other Ethiopians just above the poverty line are vulnerable to shocks and food insecurity (UNDP, 2015). The HDI is an indication of the economic wellbeing and standard of living in Ethiopia, which

may affect decisions around uptake of childhood immunization. The cost-benefit analysis at the household level may prevent parents from demanding immunization for their children.

Education

Ethiopia has recorded a rapid expansion in education over the past 15 years (UNDP, 2015). Primary school attendance currently stands at 85.7% of primary school age children. Secondary school enrolment has also increased, but remains very low, especially in rural areas and among the poorest income groups. Gender parity has been achieved at primary level and significant progress made at secondary school level. The average adult literacy rate in Ethiopia is about 42% with adult male literacy rate of 50% and female rate of 35%. However, educational indicators suggest ongoing problems with the quality of education across the country (UNDP, 2015). Additionally, the main determinants of inequity and exclusion from education are outside the classroom and they remain largely unattended (UNDP, 2015). These determinants include: poverty and food insecurity; child labour both at home and commercially; distance to schools (especially to secondary schools); gender disparities (in particular early marriage); and continuous access to education for children from pastoralist families.

Health System

Trends in access to basic health services and health gains over the last 10 years have shown dramatic improvement (UNDP, 2015). The health sector has undergone significant reforms, with focus on fiscal and political decentralization of the health system, continued emphasis on nationwide access to an integrated package of Primary Health Care services, provision of support for public private partnerships and promotion of meaningful community participation (Wamai, 2009). Furthermore, the Government's health policy emphasizes preventive measures as most health problems in the country are related to communicable diseases (UNDP, 2015). The health system currently reaches 89.6% of the population. While governance and responsibility for health service delivery is decentralized to the regions and districts, all levels of the health sector continue to rely on centralized policy, planning, budget decisions and national supply chain for vaccines

and other medical supplies (Federal Ministry of Health of Ethiopia, 2010). The Federal Ministry of Health and the Regional Health Bureaus focus on policy matters and technical support, while the District Health Offices manage and coordinate the operation of Primary Health Care services, including immunization service delivery. Ethiopia has accomplished multi-front health gains including the attainment of the MDG 4 on child mortality three years ahead of the target date and improved life expectancy at birth for both men and women, which currently stands at 62.2 years (ARISE, 2012).

Ethiopia is making noteworthy improvements in maternal and child health (UNDP, 2015). The percentage of deliveries assisted by skilled health personnel rose from 16.6% in 2010 to 20.4% in 2012. More children are now vaccinated against major childhood killer diseases and most pregnant women receive antenatal and postnatal care. The number of pregnant women receiving antenatal care from a health provider rose to 97.4% in 2013. Access to modern contraceptive increased from 15% in 2005 to 29% in 2010. Good improvements were achieved in the under-five mortality rate, which fell from 123 per 1,000 live births in 2005 to 88 per 1000 live births in 2010. Infant mortality rate decreased from 77 to 59 per 1,000 live births during the same period. More importantly, the global MDG 4 target of declining child mortality has been achieved.

Despite the positive outcomes in the health sector, the availability of effective health care is inconsistent across the country (UNDP, 2015). While several regions show promising increases in health indices, the less developed regions like Affar, Gambela and Somali, are behind the national average with some showing downward trends. The percentage of skilled health care deliveries ranged from 14% in Gambela to 73% in Addis Ababa. Ethiopia still has higher than expected prevalence of malnutrition compared to countries at the same income level. The maternal mortality ratio is also strikingly and exceptionally high. Expenditures on health care accounted for 11% of total government spending compared to 15% recommendation by WHO (ARISE, 2012). Per capita health spending on health is estimated at $15, compared with $34 per capita recommended by WHO for providing effective health services in developing countries. According to the World Bank, out-of-pocket expenditures still account for 42% of total health expenses. Although the health workforce density has increased from 0.7 per 1000 population in 2009 to 1.3

per 1000 population in 2013, it still well below the WHO recommendation of 2.3 per 1000 population (UNDP, 2015).

Social and Demographic Background

The country has a diverse population made up of 80 different ethnic groups. The Oromo (34.5 %), Amhara (26.9 %), Somali (6.2 %) and Tigre (6.1 %) ethnic groups account for more than two-thirds of the population. Additional ethnic groups include the Sidama (4%), Guarage (2.5 %), Wolaita (2.3 %), and Afar (1.7 %), with the remaining 3 % of the population comprising numerous smaller ethnic groups. Of the major religious groups, 43.5 % are Orthodox Christians, 33.9 % are Muslims and 18.6 % are Protestants (Government of Ethiopia, 2007). Amharic is the official language, but English is commonly spoken and is taught across secondary schools.

Political Structure

Ethiopia is a federal republic with a tiered government system consisting of executive, legislative, and judiciary branches and authority decentralized to the regions. It is made up of nine ethnically based administrative states (Tigray, Affar, Amhara, Oromiya, Somali, Benishangul-Gumuz, Southern Nations Nationalities and Peoples [SNNP], Gambela, and Harari) and two City Administrations (Addis Ababa and Dire Dawa). The states and the city administrations are subdivided into 103 zones, which are further subdivided into approximately 800 Woredas (Districts) and 15,000 Kebeles (Wards). The regional councils have legislative and executive powers to direct internal affairs of their regions. As a result, there is extensive decentralization of service delivery.

2.2 CHILDHOOD IMMUNIZATION

History of Vaccination

Over the last half of the 20th century, diseases that were once very common became rare in the Western world, due primarily to widespread immunization (PATH, 2009). The story of vaccines began with the long history of infectious disease in humans, particularly with early uses of smallpox material to provide immunity to the disease (PAHO & WHO, 2002). In 1796, Edward Jenner successfully used cowpox material to create immunity to

smallpox and this practice quickly became widespread (PATH, 2009). Over the next 200 years, Edward Jenner's method underwent scientific changes and eventually, it resulted in the eradication of smallpox. Next was Louis Pasteur's 1885 rabies vaccine to make an impact on human disease (Bordenave, 2003). Vaccines and antitoxins against diphtheria, pertussis, tetanus, anthrax, cholera, plague, typhoid, tuberculosis, and more were developed through the 1930s (PATH, 2009). The middle of the 20th century was an active time for vaccine research and development, and this led to the creation of vaccines for polio, measles, mumps, and rubella (PAHO & WHO, 2002). The discovery of vaccines against these diseases reduced the global disease burden greatly.

The Expanded Program on Immunization (EPI) was created in 1974 by the WHO as a means to continue the great success that had been recorded earlier with the eradication of smallpox (PAHO & WHO, 2002). Less than five percent of the children in the developing world were receiving immunizations at that time. The six diseases addressed under the EPI at the time were tuberculosis, diphtheria, tetanus, pertussis, polio, and measles. In 1988, the WHO recommended that yellow fever vaccine be added to the national immunization programs of those countries with endemic disease (WHO and UNICEF 1996). Later, in 1992, the World Health Assembly recommended that all infants should receive hepatitis B vaccination. Most recently the WHO has recommended that the *Haemophilus influenzae* type B (Hib) conjugate vaccine, *Pneumococcal* conjugate vaccine, *Rotavirus* vaccine and Human papilloma virus vaccine be implemented into national immunization programs (WHO 2006; WHO, UNICEF & World Bank, 2009).

Vaccine Preventable Diseases

The EPI is said to be one of the most equitable public health programs, providing protection to the entire population when it is successfully implemented (World Bank, 1993). It is the most cost-effective public health tool, particularly among the world's children (PATH, 2009). Routine vaccination programs have saved billions of dollars in public health expenditures (PATH, 2009). Vaccines prevent more than 3 million child deaths annually and it has been observed that children who receive all appropriate

vaccinations by nine months of age are less likely to die than those who do not (PATH, 2009; Rutherford *et al*., 2009).

Smallpox was responsible for an estimated 300 to 500 million deaths in the 20th century alone, more than double the number of people killed during the wars of that same period (PATH, 2009). Within ten years of massive immunization campaign against small pox, a disease that had plagued human civilization for thousands of years was eradicated. The wild-virus polio was once circulated widely in nearly every region of the world. Immunization campaigns have reduced polio rates by more than 99%, down to near eradication (Duclos, Okwo-Bele, Gacic-Dobo & Cherian, 2009; PATH, 2009; WHO, 2013). Polio is now present in only two countries (Pakistan and Afghanistan) and the fight to fully eradicate it worldwide continues. The global measles mortality dropped by 74% from an estimated 750,000 deaths in 2000 to 197,000 in 2007 (Duclos *et al*, 2009; Jheeta & Newell, 2008; PATH, 2009). However, more than 18 million people, primarily children continue to be infected with measles each year, resulting in 145,700 deaths globally in 2013 – about 400 deaths every day (WHO, 2015). Diphtheria was once a major cause of death in children. While it is now rare in the developing world, it is re-emerging in some areas of the world and is responsible for about 5,000 deaths each year in developing countries, primarily among children (PATH, 2009). The global prevalence of pertussis infection has fallen significantly since the arrival of the pertussis vaccine. However, pertussis still kills almost 300,000 people every year globally (PATH, 2009).

An estimated 600,000 future deaths are prevented annually through hepatitis B vaccination (Duclos *et al*, 2009). Through the introduction of new vaccines, such as those against rotavirus and pneumococcal diseases, vaccination has made significant contribution towards the achievement of the MDG4 (Duclos *et al*, 2009). Immunizing children with pneumococcal and rotavirus vaccines provides protection against diarrhoeal disease and pneumonia, two leading causes of under-five mortality in developing countries (Duclos *et al*, 2009; Jheeta & Newell, 2008). The use of novel vaccines like human papilloma virus, have greatly increased the armamentarium against infectious and cancer-causing agents. With immunization, measles, rubella, diphtheria, tetanus and pertussis have been reduced from frightening epidemics to rare outbreaks within a few

decades (PATH, 2009). The advantages of immunization are increasingly being extended to adolescents and adults. Immunization provides protection against life-threatening diseases such as influenza, meningitis, and cancers that occur in adulthood (WHO, UNICEF & World Bank, 2009).

Despite the abovementioned successes, almost 20 million children globally, mainly in developing countries remain unimmunized (WHO & UNICEF, 2005). Vaccine-preventable diseases are still responsible for about 25% of the 10 million deaths occurring annually among children under five years of age (Duclos *et al*, 2009.

Childhood Immunization in Ethiopia

In line with the WHO's recommendations, Ethiopia launched its national EPI in 1980, with a goal of achieving 75% vaccination coverage of children under one year of age by 1990 (ARISE, 2012). As a result of massive external financial and technical support during the 1980s in pursuit of a global goal of achieving universal childhood immunization by 1990, vaccination coverage increased rapidly to 50% for DTP3 by 1990 from less than 5% in 1980 (ARISE, 2012). After 1990, external donors withdrew much of their financial support, and coverage dropped precipitously. With support from the Global Alliance for Vaccines and Immunization (GAVI) Ethiopia successfully added Hepatitis B and Haemophilus influenza type b vaccines to its national EPI schedule in 2007. Furthermore, in October 2011, GAVI supported Ethiopia to introduce pneumococcal vaccine as part of its EPI schedule (ARISE, 2012). The addition of pneumococcal vaccine to the EPI schedule resulted in significant reduction of deaths from pneumonia which is the most common cause of death for children under age five in Ethiopia and globally. Rotavirus vaccine was introduced into the national EPI schedule in 2012.

The Ethiopia immunization schedule for the basic EPI vaccines for children and tetanus immunization for women of reproductive age strictly follow the WHO recommendations for developing countries (EDHS, 2011). The Ministry of Health in collaboration with WHO, UNICEF, and other partners are responsible for managing the immunization program. Regional Health Bureaus and district health offices are concerned with

implementation. The national EPI currently prescribes five visits for children to receive one dose of Bacille Calmette Guerin (BCG), four doses of oral polio vaccine, two doses of rotavirus vaccine, three doses of diphtheria, pertussis and tetanus vaccine, three doses of hepatitis B vaccine, three doses of pneumococcal conjugate vaccine, three doses of *hemophilus influenza* type B vaccine and one dose of measles vaccine. The program also covers women of reproductive age (15 to 49 years old) with five doses of tetanus toxoid vaccine.

Although full vaccination coverage among Ethiopian children has increased since 2000, when 14% of children were fully vaccinated, Ethiopia still compares unfavourably with neighboring countries (ICF International, 2012). Vaccination coverage is twice as high in Uganda (52%), and more than three times as high in Tanzania (75%), Kenya (77%), and Rwanda (90%). Immunization services in Ethiopia are delivered free of charge through static sites (defined as health facilities with a refrigerator), outreach sites and mobile teams. Missionary hospitals and private health facilities are also involved in the delivery of vaccination services.

Global goals and strategies related to specific disease control initiatives, for example measles mortality reduction, polio eradication, and maternal and neonatal tetanus elimination, are incorporated into the Ethiopia national immunization policy (Federal Ministry of Health, 2010). The routine EPI activities as well as the supplemental immunization activities include efforts to provide Vitamin A supplementation to under-five children. Ethiopia approves WHO multi-dose open vial policy (reuse of open vials of vaccines), as well as policies that call for the exclusive use of auto-disable syringes for delivering all immunization injections (Lloyd & Milstien, 1999; WHO, 2014).

Development partners and the government of Ethiopia are responsible for funding the routine and supplemental immunization activities, with donors providing most of the financial resources (ARISE, 2012). Funds are channelled largely through UNICEF, WHO, and GAVI. UNICEF finances most of the traditional vaccines while GAVI finances the bulk of the costs for new vaccines. WHO, UNICEF, and other development partners provide funding for a number of other components, such as technical support,

cold chain equipment, transport equipment, social mobilization, outreach activities and some operational costs.

The implementation of the Reaching Every District and Sustainable Outreach Services approaches to immunization have supported improvements in coverage for the past 12 years (ARISE, 2012). Currently, nearly all public health facilities, as well as selected private hospitals in urban areas, provide immunization services. Despite the abovementioned progress towards more equitable geographical distribution of healthcare, systemic barriers to universal immunization coverage continue to exist. In order to address these challenges, bridging approaches such as the Enhanced Outreach Strategy and Enhanced Routine Immunization Activity (ERIA) are being implemented to support improvements in coverage in remote districts (Fielder & Chuko, 2008). Additional challenges hindering immunization coverage in Ethiopia include: limited harmonization of health and health-related outreach initiatives; need for training and retraining of health workers; limited use of immunization cards as a mobilizing strategy among community members to ensure children stay on schedule; and the need to ensure that unit costs and service delivery mechanisms are the most cost-effective in the face of limited financial resources (Federal Ministry of Health of Ethiopia, 2010).

State of Childhood Immunization According to the 2011 EDHS

The Demographic and Health Survey, a nationally representative household survey to collect health and demographic coverage information was first undertaken in Ethiopia in 2000 and then subsequently in 2005 and 2011. These surveys provide data on immunization coverage nationally, by region and across a range of socio-demographic explanatory variables. Ethiopia also conducts a national immunization coverage survey, the most recent of which was undertaken in 2012 (Federal Ministry of Health, 2015). The percentage of children aged 12-23 months fully vaccinated at the time of the surveys increased from 14% in 2000 to 20% in 2005, and to 24% in 2011. While the 2011 vaccination coverage represents a 19% increase from the level reported in the 2005 EDHS, the percentage of children who are fully vaccinated remains far below the goal of 66% coverage set by the Ethiopia Federal Ministry of Health in 2010. Data from the

EDHS generally show lower vaccination coverage rates compared to data from the service statistics of the Ministry of Health. This is possibly due to differences in the sampling frame, design, sample size, representativeness of the sample, and selection methodology, as well as differences in the phrasing of questions, and reporting of data, all of which could help to explain these differences (EDHS, 2011).

2.3 DETERMINANTS OF CHILDHOOD VACCINATION

Population Factors that Influence Uptake of Childhood Immunization

Studies have shown that maternal education is the strongest and most consistent predictor of a child's vaccination status (Kiros & White, 2004; Sullivan *et al*., 2010). It has been documented that female education improves child survival because of greater knowledge of the protective effect of childhood immunization (Streatfield, Singarimbun, & Diamond, 1990). Education is also likely to improve responsiveness to new ideas and services, and more social confidence in dealing with health personnel (Kiros & White, 2004). Additionally, education may enhance the ability and willingness to cover distances in search of health services (Kiros & White, 2004).

Gage, Sommerfelt & Piani (1997) highlighted that household structure is an important determinant of childhood immunization in Nigeria. Immunization status of children from nuclear households is worse-off than those from extended households. This was attributable to low socioeconomic status and low maternal education level in nuclear households. Higher socioeconomic status is often associated with household extension rather than nucleation in traditional African settings (Gage, Sommerfelt & Piani, 1997). However in Niger that shares several commonalities with Nigeria, there was no significant association between household structure and children's likelihood of being fully immunized. The reason for the lack of association between household structure and childhood immunization in Niger was not explored. In another study from the Caribbean, a direct relationship was observed between household structures and children's immunization coverage, and this was attributable to household income (Bronte-Tinkew & Dejong, 2005).

Paternal factors may also influence vaccination outcome. A report from Ghana asserted that the ability of a father to speak English was significantly associated with childhood vaccination (Brugha, Kevany & Swan, 1996). A similar study from Ethiopia observed that paternal factors such as age, education, and opinions of the nearest health center might also impact on completion of a vaccination series (Sullivan *et al*., 2010). However, a potential bias that was not controlled for in the studies above was the possibility that father and mother discussed the survey, before the father was interviewed, especially where the father was interviewed subsequent to the mother.

A report from Turkey suggested that children from families with a higher socio-economic status have a higher chance of being fully vaccinated (Topuzoglu, Ozaydın, Cali, Cebeci, Kalaca & Harmanci, 2005). Mother's education level and employment status were found to determine the completion of vaccination series. Similarly, Antai (2009) observed that household wealth and mothers' occupation influence vaccination uptake. Bugvi and colleagues (2014) observed that the children of manual workers were at higher risk of incomplete immunization than the children of relatively better off professionals. The aforementioned underscores the importance of broader social context in accounting for variations in child welfare, including vaccination patterns.

A study from Nigeria revealed a significant association between ethnicity and complete immunization (Antai, 2009). This ethnic difference is a reflection of differences in social identity, attitudes and health-seeking behaviour and disparities in socio-economic position (Antai, 2009). The children of the Ibos who have high economic power are twice as likely to be fully immunized compared to the children of the Hausas who have low economic power. This study further underscores the fact that increased socio-economic position increases the likelihood of children being fully immunized (Antai, 2009).

A significant relationship has been observed between women that complete the recommended ANC visits and the immunization status of their children in Ethiopia (Sullivan *et al*, 2010). This may be an indication that a mother's contact with the healthcare system is extended to her child's healthcare. It can be argued that ANC provides an avenue to engage women and perhaps even men in healthcare with emphasis

on immunization and follow up of young children. Similarly, hospital delivery was found to be associated with higher likelihood of full immunization (Antai, 2009). This association is expected; given that skilled attendant at delivery is one of the very important strategies under integrated maternal newborn and child health programme of which childhood immunization is a component (Antai, 2009).

In a study that examined the impact of parental migration on immunization of children (Kiros & White, 2004), it was observed that children born to migrant women were significantly less likely to get immunized compared to children born to non-migrant resident women. A similar observation was made in a study from Turkey (Topuzoglu, *et al*., 2005). A possible explanation for the significant difference in immunization status is the limited social networks of migrant women and their disconnectedness from the social fabric of the host community (Kiros & White, 2004). It has been observed that collective notions about child vaccinations tend to emerge when members of social networks, relatives, or neighbors share ideas and information about the quality of health services provided in the community, side-effects associated with vaccinations, and their experiences related to vaccinating children (Streefland, Chowdhury & Ramos-Jimenez, 1999).

Immunization uptake may also vary by sex of the child (Kiros & White, 2004). Male children are more likely than females to receive full immunization. Antai (2009) demonstrated that the pattern of full immunization clusters within families as well as within communities. Children living within the same community tend to experience similar likelihood of immunization.

The primary reason for some parents not taking their children for immunization is the perception that their children will not be infected with certain diseases such as polio, diphtheria and measles (Bugvi *et al*, 2014). Additionally, some of the vaccine preventable diseases are no longer prevalent, the risks associated with the diseases are often forgotten and the need for immunization programs to control such diseases is sometimes underappreciated (Hardt *et al,* 2013).

Reasons for low vaccine confidence include concerns from caregivers about the side effects of vaccination (Bugvi *et al*, 2014; Hardt, Schmidt-Ott, Glismann, Adegbola, & Meurice, 2013). Because vaccine recipients are often healthy and young children, there is a lower level of tolerance for the risk of adverse events than with other medicines (Hardt *et al,* 2013). Adverse events to vaccination are mostly time-limited and mild, most commonly local reactions at the injection site (pain, swelling or reddening), fever and irritability (PAHO & WHO, 2002). Rare and severe adverse events to vaccination, such as convulsions, anaphylaxis, episodes of hypotonia and hyporeactivity and inconsolable persistent crying, are usually characterized by spontaneous remission with no sequelae (PAHO & WHO, 2002). However, fear of such adverse reactions can discourage caregivers from having their children vaccinated.

Misleading or unproven rumours about vaccine safety is a strong barrier to immunization uptake globally. It has been observed that loss of public confidence in a vaccine due to real or spurious links to adverse events can curtail or even halt immunization activities, with potentially disastrous consequences. For example, about a decade ago, rumours that the Oral Polio Vaccine was being used to lower the fertility of young girls led Nigeria to suspend polio vaccination campaigns for almost a year (Jegede, 2007). That in turn sparked an explosion of polio cases in Nigeria and ultimately in 20 previously polio-free countries in Africa, Asia, and the Middle East. Similarly, a scientifically flawed, but widely publicized study linking the measles-mumps-rubella (MMR) combination vaccine to autism, has fuelled continuing anxieties among parents about the safety of the vaccine and has caused a decline in vaccine coverage in many countries (Wakefield, 1999). Consequently, measles is making a comeback in several industrialized countries, including Austria and the United Kingdom.

Service Delivery Factors that Influence Uptake of Childhood Vaccination

Proximity to the nearest health center has an important effect on childhood immunization (Kiros & White, 2004). In a study from rural Mozambique, distance and use of transport to get to the nearest health facility were observed to have a strong negative influence on immunization uptake (Jani, Schacht, Jani, & Bjune, 2008).

Topuzoglu, *et al*. (2005) observed that systematic questioning about the vaccination status of every child attending a primary healthcare center for any reason improved vaccination coverage. A previous study from Mozambique identified missed opportunities for vaccination and inappropriate use of contra indications by healthcare workers as important deterrents of immunization coverage (Jani *et al*, 2008). Thus, exploiting all visits for curative care would be a cost-effective way of completely immunizing a child and increasing the overall immunization coverage.

A strategy that focus on integrating immunization activities with other services provided by the health system will go a long way in improving immunization coverage (WHO, UNICEF & World Bank, 2009). Similarly, immunization and linked interventions have been shown to make significant contribution to the achievement of Development Goals (WHO & UNICEF, 2005). Antai (2009) emphasized the need for greater community involvement in the conceptualization and implementation of vaccination programs. Although unclear, evidence suggests that strengthening advocacy, communication and social mobilization at the community level improve informed and willing participation in vaccination programmes (Jheeta & Newell, 2008). Vaccination strategies are likely to be more successful if they are based on an understanding of sociocultural behaviour of the people (Jheeta & Newell, 2008).

A major obstacle to universal immunization coverage in many developing countries is the underlying weakness of the health system (WHO, UNICEF & World Bank, 2009). The health facilities have inadequate number of trained health workers. Health infrastructures and logistical support system are often overloaded making supply of vaccines and other related medical products very difficult. Inadequate funding is equally an important barrier to the achievement of global immunization-related goals.

The health systems in developing countries is faced with unreliable power supply resulting in inefficent refrigeration systems at health centers and clinics (PATH & WHO, 2009). Consequently, the cold chain is compromised. Cold chain maintenance and insufficient medical supplies are major service delivery obstacles facing immunization programme in Ethiopia (Sullivan *et al*, 2010).

An evidence-based strategy to address the burden of poor completion rate of childhood immunization requires accurate knowledge of the underlying factors (Wiysonge, Uthman, Ndumbe & Hussey, 2012). There is need for interventions designed to improve childhood immunization to address individual, household, community and societal factors that contribute to the problem (Wiysonge *et al*., 2012). While Ethiopia has achieved significant reduction in childhood mortality, additional efforts to improve vaccination coverage, especially in the hard to reach populations, will contribute to the continued reduction of childhood deaths.

2.4 AIM AND OBJECTIVES

2.4.1 Aim:

The aim of this study is to determine the factors associated with incomplete immunization coverage among children aged 12-23 months in Ethiopia using the 2011 EDHS.

2.4.2 Objectives:

1. To determine the influence of socio-demographic factors on childhood immunization in Ethiopia.
2. To examine socioeconomic inequalities in childhood immunization in Ethiopia.

CHAPTER 3: METHODOLOGY

This chapter focuses on methods used in undertaking this study and these include study design, study setting, sampling procedures, data collection methods, data analysis, ethical considerations, study validity and reliability.

3.1 STUDY DESIGN

This thesis was based on secondary analysis of the 2011 EDHS. The EDHS is part of the worldwide MEASURE DHS project, a USAID-funded project that provides support and technical assistance in the implementation of population and health surveys in countries worldwide. The Demographic and Health Surveys are national representative household surveys. Ethiopian Central Statistical Agency (CSA) with support from the Ministry of Health conducted the 2011 EDHS. The 2011 survey is the third Demographic and Health Survey conducted in Ethiopia. The first and second EDHS were conducted in 2000 and 2005 respectively.

The 2011 EDHS was designed to measure levels, patterns, and trends in demographic and health indicators. The survey was undertaken between December 2010 and June 2011. Three types of questionnaires namely, household, man's and woman's were used by trained interviewers for data collection. The woman's questionnaire was used to collect information from all women aged 15-49 years. Information obtained included; background characteristics such as age, education and media exposure; birth history and childhood mortality; antenatal, delivery and postnatal care; employment status; wealth index; marital status; husband's background characteristics; vaccinations and childhood illnesses etc. The household questionnaire collected information on characteristics of the household's dwelling unit, such as the source of water, type of toilet facilities and ownership of various fixed and durable assets. The man's questionnaire was administered to all men aged 15-59 years in the selected households. The man's questionnaire collected similar health status information to the woman's questionnaire but was shorter because it did not contain exhaustive questions on maternal and child health.

Immunization details of children aged 12-23 months were collected from their vaccination cards. If the details were not present on the card then the mother's recall was

used. If a vaccination card was not available, mother's recall on the vaccinations received was used. If the child had not received any vaccine the reasons for not taking the child for vaccination was collected. Children in the age group 12 – 23 months were selected because they are the youngest cohorts who have reached the age by which they should be fully vaccinated. The course of basic vaccinations for children in Ethiopia is completed by the age of 9 months. Additionally, some previous studies have used the same age group for studying the uptake of immunization, hence this will allow for comparative analysis (Bugvi *et al*, 2014).

3.2 STUDY SETTING

Ethiopia is one of the sub-Saharan African countries located in the horn of Africa. It has an estimated population of 79.2 million based on the 2007 national population and housing census and it is the second most populous country in Africa. Ethiopia is made up of nine regional states namely: Tigray, Afar, Amhara, Oromiya, Somali, Benishangul Gumuz, Southern Nations Nation- alities and Peoples (SNNP), Gambella and Harari, and two Administration councils (Addis Ababa and Dire Dawa). The 2011 EDHS was conducted in the nine regional states and the two city administrations. Ethiopia houses a complex variety of nationalities and over 80 ethnic groups with diverse customs and cultures (EDHS, 2011). Around 84% of the total population is rural and their main occupation is farming and livestock production (EDHS, 2011). Hence agriculture accounts for 43% of the gross domestic product.

According to the 2007 census, children below 1 year of age constitute about 3.64% of the total population. An estimated 17.5% of the population is aged less than 5 years, and women in the reproductive age group (15-49 years) constitute about 24% of the total population. The health service currently reaches about 89% of the population including outreach programmes and health posts (FMOH, 2010). However, critical gaps still exist in the provision of basic health services.

3.3 STUDY POPULATION AND SAMPLING

The survey sample was selected using a stratified two-stage cluster sampling method (EDHS, 2011). The 2007 Ethiopia Population and Housing Census provided the sampling frame from which the EDHS sample was drawn. Ethiopia has a total of 11 geographic and administrative regions. The regions were administratively divided into zones, and zones into administrative units called Woreda (District). Each Woreda is further subdivided into the smallest administrative units, called Kebele (Ward). Each Kebele is subdivided into census enumeration areas (EAs). The sampling frame consisted of a total of 85,057 EAs. With stratification of the regions into urban and rural areas, there were 17,548 EAs (21%) in urban areas and 67,509 (79%) in rural areas. In the first stage cluster sampling, 624 EAs were selected (187 in urban areas and 437 in rural areas) using probability proportional to the EA size and with independent selection in each sampling stratum. The sampling units for the second stage were households. All conventional households (people living in normal housing units and not school dormitories, camps or barracks) in each of the 624 selected EAs were listed. A nationally representative sample of 17,817 households was selected. A total of 17,385 eligible women aged 15 - 49 were identified and 16,515 of the identified women were interviewed, representing a response rate of 95%.

Inclusion Criteria

- Women living in conventional households.
- Mothers of children aged 12 – 23 months.

Exclusion Criteria

- Women residing within institutional living arrangements e.g., military barracks, police camps, school dormitories etc.
- Women living in areas that pose security threat.

3.4 SAMPLE SIZE

Information on 1,889 women with children aged 12–23 months were extracted from the variable, current age of child in the 2011 EDHS dataset and this constituted the sample size.

3.5 DEFINITION OF KEY TERMS

In this study, complete immunization is defined as a child aged 12 – 23 months that has received a BCG vaccination against tuberculosis; three doses of DPT vaccine to prevent diphtheria, pertussis, and tetanus (DPT); at least three doses of polio vaccine; and one dose of measles vaccine. Incomplete immunization is when a 12–23 months old child has not received any of the abovementioned vaccines. Antenatal care attendance refers to when a woman receives routine health services during pregnancy according to the WHO recommendations of at least four visits for a low-risk pregnancy. The wealth index is a proxy indicator of household level wealth and the rank is assigned to each individual household member. It is constructed using household asset data (ownership of assets such as radio and television, and house characteristics including water source, type of floor and toilet type) through principal components analysis (EDHS, 2011). Occupation status is defined as non-paid or paid individual who is engaged in the areas of professional/ technical/managerial, clerical, sales and services, skilled manual, unskilled manual and agricultural occupation (EDHS, 2011). Community conversation programme is a facilitated interactive process that explores the underlying causes of health issues in a community and focuses on generating action plans. Adequate media exposure means access to newspaper, radio or television at least once a week. Postnatal care is defined as mothers who received post delivery check-up within two months after birth from health facilities. Number of living children is defined as the total number of living children of an included mother.

3.6 DATA ANALYSIS

Secondary analysis was conducted on the nationally representative 2011 EDHS using STATA version 12 (Stata Corporation, College Station, TX, USA). Of all the interviewed women, a total of 1,889 had children aged 12 – 23 months. Relevant information about

this group of mothers and their children were extracted from the variable current age of child in the 2011 EDHS dataset. This data was collected during the survey using the woman's questionnaire. The data entry was done twice (double entry), then validated, it was subsequently cleaned and several consistency checks carried out to ensure accuracy and completeness by the Ethiopia statistical agency prior to making the dataset publicly available. All the data in the 2011 EDHS were already weighted. Sample weights were applied to address the non-proportional allocation of sample to different regions and to their urban and rural areas. Weighting is aimed at ensuring representativeness of the survey results at the national and regional levels. The sample weights were calculated based on sampling probabilities separately for each sampling stage and for each cluster of the two-stage stratified cluster sample. Design weights were adjusted for household non-response and as well as for individual non-response to get the sampling weights (EDHS, 2011). Information on potential independent variables such as socioeconomic and demographic factors was extracted accordingly. In order to allow for comparative analysis further recoding of variables was done. In this analysis, incomplete immunization status was the outcome (dependent) variable. Children who had received a single dose of BCG, three doses of polio and DPT and a dose of measles vaccines were classified as fully immunized and others as not fully immunized (Bugvi *et al*, 2014; WHO, 2013). The dependent variable had five response groups: no, vaccination dates on card, vaccination marked on card, reported by mothers and don't know. The variable was recoded into 0 and 1. "No" answers were recoded as "0" and labeled "not received the vaccine", while the other responses "vaccination date on card, reported by mothers, vaccination marked on card" were recoded together as "1" and labeled "received the vaccine". All yes responses to the questions on specific vaccines were put together and labeled as "Immunization status". The immunization status was recoded as "0" if the child had received all doses of the required vaccines and categorized as "complete immunization". If the child had missed one or more doses of vaccinations, the immunization status was recoded as "1" and categorized as "incomplete immunization".

The independent variables considered in this study were age of mothers, mother's occupation, religion, mother's education, child's father's education, wealth index, birth

order, awareness of community conversation (CC) programme, exposure to media, sources of vaccination information, received postnatal care after birth, antenatal care (ANC), place of delivery, number of living children, sex of child and marital status. Other independent variables that were considered include place of residence and administrative regions.

Descriptive statistics such as frequency distributions and percentages were used to determine the level of immunization coverage by socioeconomic and demographic characteristics. Bivariate analysis was used to analyze the relationship between incomplete immunization status and independent variables. Odds ratio with 95 % CI was used in the multivariable model. All the independent variables that were significant at the 0.05 level were entered one by one into the multivariable model. A stepwise approach was used to assess the iteration of variables and to control for potential confounders.

3.7 RELIABILITY

In order to improve accuracy of data collection, the questionnaires were translated into the three major and most widely spoken Ethiopian languages - Amharigna, Oromiffa, and Tigrigna in addition to English. Before the start of the fieldwork, training was conducted for all the interviewing staff and their supervisors. The questionnaires were pretested in all the three local languages and English to make sure that the questions were clear and could be understood by the respondents. The questionnaires were revised based on lessons inferred from the pretest exercise (EDHS, 2011).

3.8 VALIDITY

A nationally representative sample of 17,817 households was selected for the survey and all the data in the survey were weighted to correct for under- or over-representation of groups. In addition to the interviewing teams, a quality control team was present in each of the 11 regions. The quality control teams regularly visited and often stayed with the interviewing teams throughout the period of the fieldwork to closely supervise and monitor the quality of the interviews. In order to further reduce translation error, previously validated standard model questionnaires developed for demographic and health surveys relevant to Ethiopia were used (EDHS, 2011).

3.9 GENERALIZABILITY

The 2007 Census provided the sampling frame from which the EDHS sample was drawn. Due to non-proportional allocation of sample to different regions and to urban and rural areas, sampling weights were used to analyze the 2011 EDHS data to ensure the actual representativeness of the survey results at the regional and national levels. Additionally, the questionnaires were translated into the three major Ethiopian languages in addition to English to make sure that the questions were clear and could be understood by all respondents. Therefore, the findings and conclusion from this study can be extended to the Ethiopian population at large.

3.10 ETHICAL CONSIDERATIONS

The Ethiopia Health and Nutrition Research Institute (EHNRI) Review Board, the National Research Ethics Review Committee (NRERC), the Institutional Review Board of ICF International, and United States Centers for Disease Control and Prevention (CDC) provided the ethical clearance for the 2011 EDHS. All participants in the survey provided verbal informed consent to be interviewed. The present study requires no ethical approval as it is based on secondary analysis of publicly available 2011 EDHS. However, permission to use the data was obtained from the Demographic and Health Survey Program, ICF International, USA.

3.11 CONTRIBUTION OF THE STUDENT

This is a secondary analysis of data from the 2011 EDHS. With support from my supervisor, Professor Tanya Doherty and co-supervisor, Dr. Lucia Knight, I conducted cleaning and analysis of all data used in this study. I defined and created variables for the analysis in consultation with my supervisor, co-supervisor and a statistician. The work generated from this mini thesis will also be submitted for publication in a peer-reviewed scientific journal.

CHAPTER 4: RESULTS

4.1 Background Characteristics of the Study Participants

A nationally representative sample of 16,515 women aged 15 - 49 in all selected households were interviewed. However, information on vaccination status for children aged 12 - 23 months was available for 1,889 (weighted) mothers and they constituted the sample size for this analysis. It was observed from Table 1 that of the 1,889 mothers interviewed, 1001 (53.0%) were in the age range 25 – 34 years, 1,558 (82.5%) resided in rural areas, 612 (32.4%) had primary or higher education, 1,664 (88.1%) of mothers were married, 812 (43.0%) had four and above total children, and 854 (45.2%) were Muslims. In terms of wealth index, 897 (47.5%) children belong to the lowest two wealth quintiles. One thousand and thirty-nine (55.0%) of the mothers were not employed.

4.2 Immunization Status by Specific Vaccines

Figure 1 shows that 66% of the children received BCG vaccine and 56% received measles vaccine. A relatively higher percentage of children received the first dose of DPT (64%). However, only 37% received the third dose of DPT, reflecting a dropout rate of 42%. More than eight out of every ten children (82%) received the first dose of polio, but only about four in ten (44%) received the third dose, reflecting a dropout rate of 46%. Even though DPT and polio vaccines are often routinely administered at the same time, DPT coverage was lower than polio coverage.

4.3 Socio-Demographic Characteristics and Immunization Status

Seventy one percent (70.9%) of selected children were incompletely immunized (Figure 2). The proportion of incompletely immunized boys (71.7%) was similar to that of girls (70.2%). Mothers who self-reported their children's vaccination status were more than two times as likely as mothers who had vaccination cards to have children with incomplete immunization (88.8% compared with 43.0%). The proportion of children who had incomplete immunization in rural areas was almost twice as high as the proportion in urban setting (76.5% versus 44.7%). About 76.4% of children of mothers who were unaware of the community conversation program were incompletely immunized compared to 54.5% among children of mothers who were aware of the programme.

Table 1: Background Characteristics of the Study Participants

Variables	Frequency	Percentage
Age of Mothers		
15 - 24	515	27.3%
25 - 34	1,001	53.0%
35 - 49	373	19.7%
Regions		
Tigray	201	10.6
Affar	166	8.8
Amhara	223	11.8
Oromiya	284	15.0
Somali	145	7.7
Benishangul-Gumuz	168	9.0
SNNP	250	13.2
Gambella	147	7.8
Harari	112	5.9
Addis Ababa	77	4.1
Dire Dawa	116	6.1
Mothers' Education Status		
No education	1,277	67.6
Primary	500	26.4
Secondary	94	5.0
Higher	18	1.0
Source of vaccination record		
Vaccination card	548	29.0
Mothers' report	1341	71.0

Antenatal care		
No	1,055	55.9
Yes	834	44.1
Sex of child		
Male	960	50.8
Female	929	49.2
Place of residence		
Rural	1,558	82.5
Urban	331	17.5
Exposure to media		
Adequate	443	23.5
Inadequate	1446	76.5
Wealth index		
Poorest	563	29.8
Poorer	335	17.7
Middle	309	16.4
Richer	308	16.3
Richest	374	19.8
Heard of Community Conversation Programme		
Yes	470	24.9
No	1,419	75.1
Birth order		
1 - 3	970	51.4
4 - 6	592	31.3
> 6	327	17.3

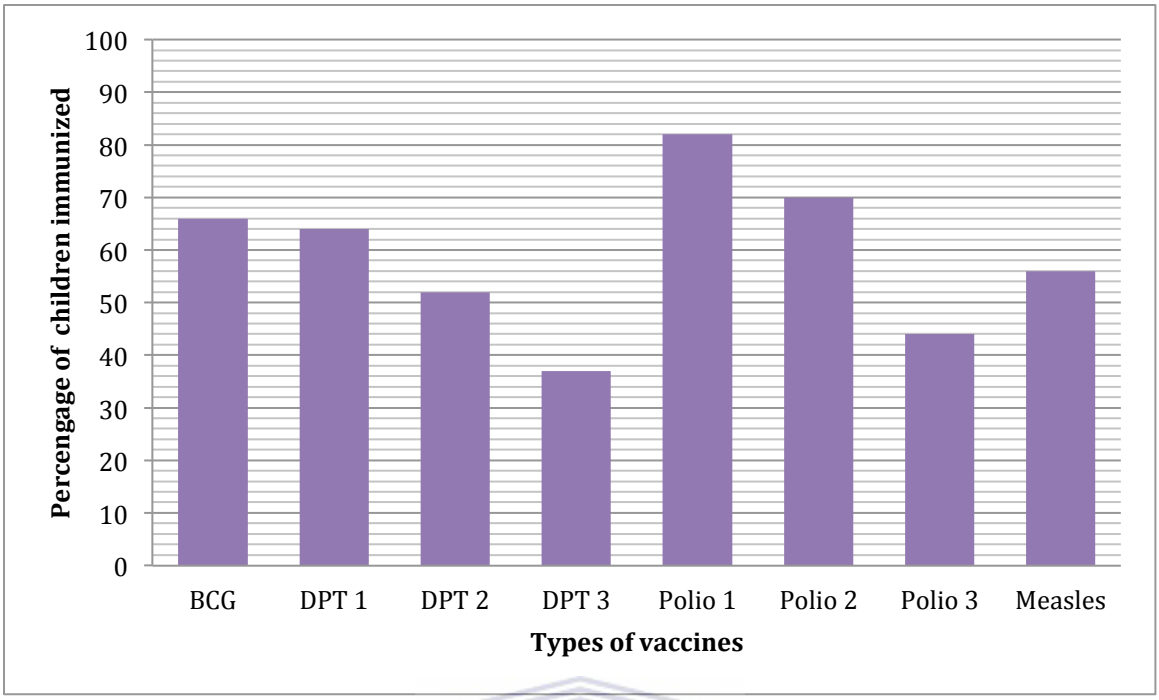

Figure 1: National immunization coverage rate by specific vaccines for children aged 12 - 23 months

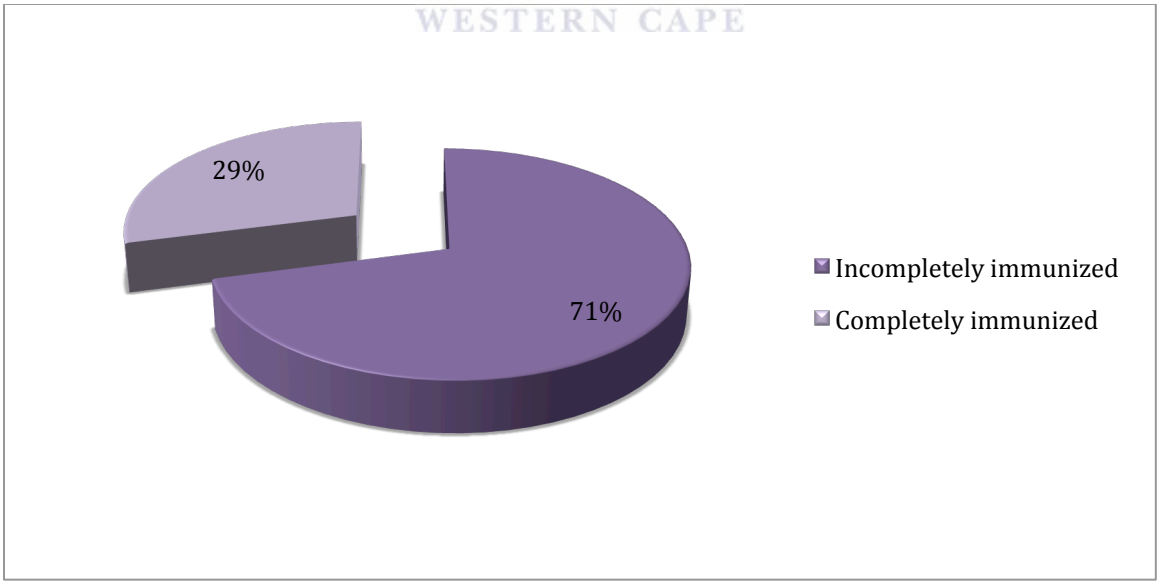

Figure 2: **Immunization status of children aged 12 - 23 months**

The children of mothers with adequate media exposure were less likely to have incomplete immunization compared to children of mothers with inadequate exposure (51.7% versus 76.8%).

There was a wide regional variation in immunization coverage rate (Table 2), the proportion of children with incomplete immunization status ranged from 18.2% in Addis Ababa to 94.0% in Affar. Mothers age appear to have no influence on children immunization status (Table 3). The incomplete immunization rate among children of mothers in age group 15 - 24, 25 - 34 and 35 - 49 was 73.8%, 69.7% and 70.2%, respectively. Table 4 shows the percentage of children aged 12 – 23 months who are fully vaccinated by level of education of their parents. An inverse relationship was observed between educational status of mothers and immunization status of their children (Figure 3). Children whose mothers had higher education were less likely to be incompletely immunized than children born to mothers with no education (33.3% and 76.0%, respectively). Similarly, 45.8% of children of fathers with higher education were less likely to be incompletely immunized, compared with 76.8% of children of fathers with no education. The analysis showed that children from the poorest households were also those with the higher likelihood of incomplete immunization status (Figure 4). Forty-four percent of children from the richest wealth quintile were incompletely immunized, compared with 73.8% of children from the poorest wealth quintile.

There is a wide variation between children from different religious groups with regards to incomplete immunization status, ranging from 55.9% among Orthodox Christians to 89.5% among mothers practicing traditional religion (Table 5). The study observed an inverse relationship between incomplete immunization status and utilization of health services (Table 6). Children whose mothers did not attend antenatal care during pregnancy were more likely to be incompletely immunized than those born to mothers who attended antenatal care (82.8% and 55.9%, respectively). Similarly, 75.9% of children that were delivered at home were incompletely immunized, compared with 46% of children that were delivered at a health facility. In the same vein, children whose mothers did not attend postnatal care were more likely to miss some basic vaccinations than children whose mothers attended postnatal care (71.4% compared with 60.5%).

Table 2: Immunization Status of Children Aged 12 – 23 Months by Administrative Regions

Regions	Respondents (N=1889)		Total
	Completely immunized N (Weighted%)	Incompletely immunized N (Weighted%)	
Tigray	117 (58.2)	84 (41.8)	201 (100)
Affar	10 (6.0)	156 (94.0)	166 (100)
Amhara	61(27.3)	162 (72.7)	223 (100)
Oromiya	47 (16.5)	237 (83.5)	284 (100)
Somali	26 (17.9)	119 (82.1)	145 (100)
Benishangul-Gumuz	40 (23.8)	128 (76.2)	168 (100)
SNNP	57 (22.8)	193 (77.2)	250 (100)
Gambella	21(14.3)	126 (85.7)	147 (100)
Harari	39 (34.8)	73 (65.2)	112 (100)
Addis Ababa	63 (81.8)	14 (18.2)	77 (100)
Dire Dawa	68 (58.6)	48 (41.4)	116 (100)
Total	549	1340	1889

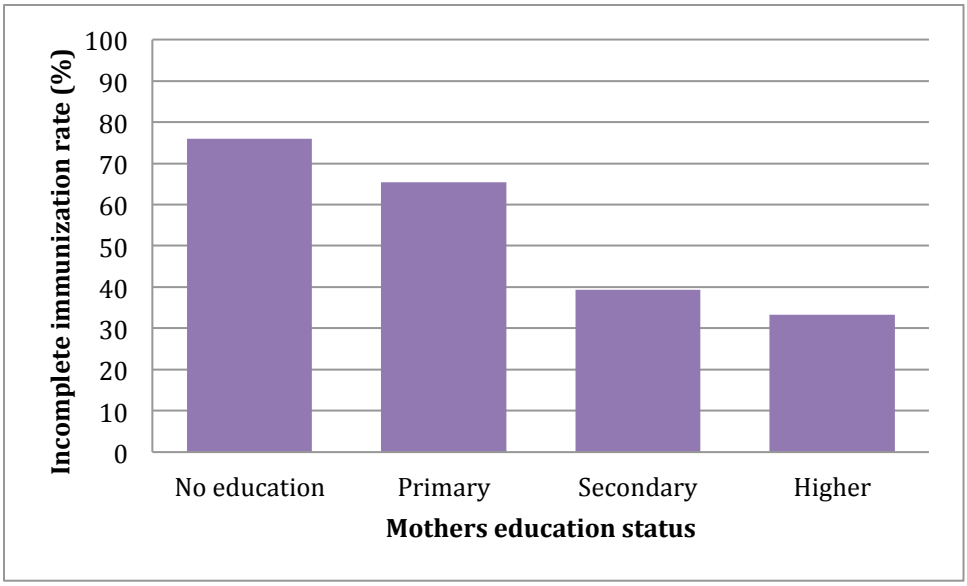

Figure 3: Incomplete immunization rate by educational status of mothers of children aged 12 – 23 months

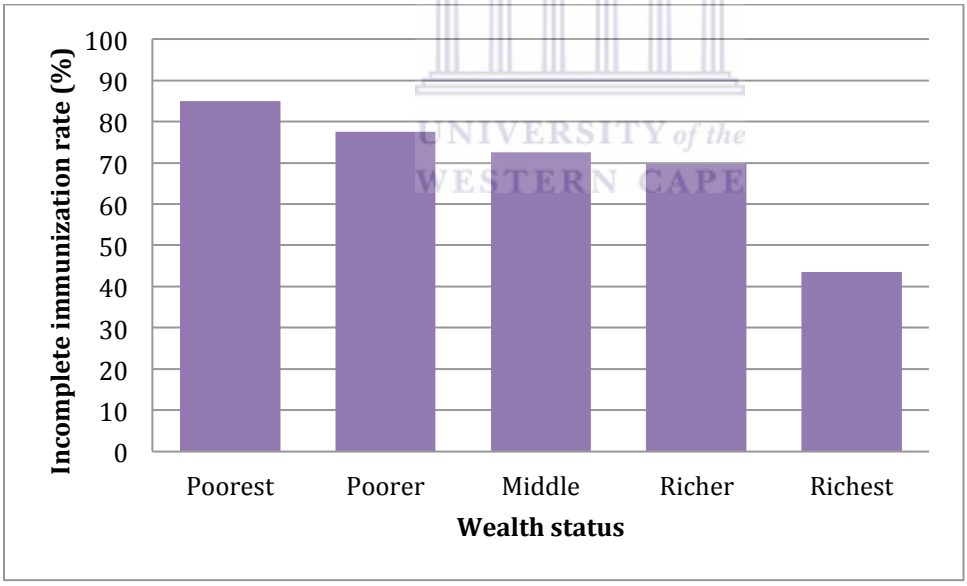

Figure 4: Incomplete immunization rate by household wealth status of mothers of children aged 12 – 23 months

Table 3: Immunization Status of Children Aged 12 – 23 Months by Mothers' Age

Age (Years)	Respondents (N=1889)		Total
	Completely immunized N (Weighted%)	Incompletely immunized N (Weighted%)	
15 - 24	135 (26.2)	380 (73.8)	515 (100)
25 - 34	303 (30.3)	698 (69.7)	1,001 (100)
35 - 49	111 (29.8)	262 (70.2)	373 (100)
Total	549	1340	1889

Table 4: Immunization Status of Children Aged 12 – 23 Months by Education Status of Parents

Education status	Respondents (N=1889)		Total
	Completely immunized N (Weighted%)	Incompletely immunized N (Weighted%)	
Mother			
No education	307 (24.0)	970 (76.0)	1,277 (100)
Primary	173 (34.6)	327 (65.4)	500 (100)
Secondary	57 (60.6)	37 (39.4)	94 (100)
Higher	12 (66.7)	6 (33.3)	18 (100)
Father			
No education	222 (23.2)	734 (76.8)	956 (100)
Primary	225 (32.2)	474 (67.8)	699 (100)
Secondary	63 (38.9)	99 (61.1)	162 (100)
Higher	32 (54.2)	27 (45.8)	59 (100)

Table 7 shows no relationship between mothers' marital status and the immunization status of their children. The incomplete immunization rate among children whose mothers never married, currently married and formerly married were 68.6%, 71.2% and 69.7%, respectively. It was observed from Table 8 that first births were less likely to be incompletely immunized (67.7%) than births of order four and higher (74.0%). Similarly, there was an inverse trend between number of mothers' living children and immunization status. Sixty-eight percent of children of mothers who had less than 4 living children were incompletely immunized, compared with 75% of children of mothers who had four and higher living children.

Lastly, the relationship between mothers' occupation and the immunization status of their children is shown in Table 9. Analysis of children of mothers who are not employed revealed that 74.8% of them were incompletely immunized. Contrarily, only 29.4% of children of mothers who are professionals were incompletely immunized.

Table 5: Immunization Status of Children Aged 12 – 23 Months by Religious Group

Religion	Respondents (N=1889)		Total
	Completely immunized N (Weighted%)	Incompletely immunized N (Weighted%)	
Orthodox	271 (44.1)	343 (55.9)	614 (100)
Catholic	4 (28.6)	10 (71.4)	14 (100)
Protestant	68 (19.0)	292 (81.0)	360 (100)
Muslim	199 (23.3)	655 (76.7)	854 (100)
Traditional	2 (10.5)	17 (89.5)	19 (100)
Others	5 (17.9)	23 (82.1)	28 (100)
Total	549	1340	1889

Table 6: Immunization Status of Children Aged 12 – 23 Months by Maternal Utilization of Health Services.

Variables	Respondents (N=1889)		Total
	Completely immunized N (Weighted%)	Incompletely immunized N (Weighted%)	
Antenatal care			
No	181 (17.2)	874 (82.8)	1,055 (100)
Yes	368 (44.1)	466 (55.9)	834 (100)
Place of delivery			
Home	380 (24.1)	1196 (75.9)	1576 (100)
Health facility	169 (54.0)	144 (46.0)	313 (100)
Postnatal care			
No	519 (28.6)	1294 (71.4)	1813 (100)
Yes	30 (39.5)	46 (60.5)	76 (100)

Table 7: Immunization Status of Children Aged 12 – 23 Months by Maternal Marital Status

Marital Status	Respondents (N=1889)		Total
	Completely immunized N (Weighted%)	Incompletely immunized N (Weighted%)	
Never married	33 (31.4)	72 (68.6)	105 (100)
Currently married	479 (28.8)	1185 (71.2)	1664 (100)
Formerly married	37 (30.8)	83 (69.2)	120 (100)
Total	549	1340	1889

Table 8: Immunization Status of Children Aged 12 – 23 Months by Birth Order and Number of Living Children

Variables	Respondents (N=1889)		Total
	Completely immunized N (Weighted%)	Incompletely immunized N (Weighted%)	
Birth order			
1 - 3	313 (32.3)	657 (67.7)	970 (100)
4 - 6	154 (26.0)	438 (74.0)	592 (100)
≥ 7	82 (25.1)	245 (74.9)	327 (100)
Number of living children			
1 - 3	345 (32.0)	733 (68.0)	1078 (100)
4 - 6	162 (25.2)	480 (74.8)	642 (100)
≥ 7	42 (24.9)	127 (75.1)	169 (100)

Table 9: Immunization Status of Children Aged 12 – 23 Months by Mothers' Occupation

Occupation	Respondents (N=1889)		Total
	Completely immunized N (Weighted%)	Incompletely immunized N (Weighted%)	
Not working	257 (25.2)	762 (74.8)	1019 (100)
Manual work	152 (29.5)	364 (70.5)	516 (100)
Clerical/Sales/ General service	121 (38.7)	192 (61.3)	313 (100)
Professional	12 (70.6)	5 (29.4)	17 (100)
Total	549	1340	1889

4.4 Simple Binary Logistic Regression Analysis

Simple binary logistic regression analysis of socio-demographic factors associated with incomplete immunization among children aged 12 – 23 months is shown in Table 10. The odds of incomplete immunization were high for children of mothers from Affar (Odds Ratio [OR] = 22.1; 95% CI: 10.56 – 46.25), Amhara (OR = 3.76; 95% CI: 2.35 – 6.03), Oromiya (OR = 7.14; 95% CI: 4.40 – 11.59), Somali (OR = 6.48; 95% CI: 3.69 – 11.38), Benishangul-Gumuz (OR = 4.53; 95% CI: 2.72 – 7.57) and Southern Nations Nationalities Peoples - SNNP (OR = 4.80; 95% CI: 2.99 – 7.70) administrative regions compared to children from Dire Dawa. The odds of incomplete immunization were high for children of mothers from rural settings (OR = 3.26; 95% CI: 2.90 – 3.66) compared to children of mothers from urban areas. The odds of incomplete immunization were less for children of birth order 1 – 3 (OR = 0.70; 95% CI: 0.53 – 0.93) compared to children of birth order ≥ 7. Compared to children of mothers who had never married, children of mothers who are currently married (OR = 2.47; 95% CI: 1.14 – 5.38) and children of mothers who were previously married (OR = 3.21; 95% CI: 1.21 – 8.52) were more likely to be incompletely immunized. The analysis also revealed that children of mothers that had no vaccination card (OR = 2.59; 95% CI: 2.32 – 2.88) were more likely to be incompletely immunized compared to children of mothers with vaccination certificates. However, there was no association between incomplete immunization status and number of living children in a family. Similarly, there was no relationship between incomplete immunization status and mothers' age, so also mothers' religion.

Table 11 shows simple binary logistic regression analysis of socioeconomic factors associated with incomplete immunization among children aged 12 – 23 months. The odds of incomplete immunization were high for children born to mothers from the poorest (OR = 7.28; 95% CI: 5.35 – 9.91) and middle (OR = 3.41; 95% CI: 2.47 – 4.71) wealth quintiles compared to children from rich wealth quintile. Children of mothers and fathers who had no education were respectively 6.3 (OR = 6.32; 95% CI: 2.35 – 16.98) and 3.9 (OR = 3.92; 95% CI: 2.30 – 6.68) times more likely to be incompletely immunized compared to children whose parents had higher education. Children of mothers who were not employed (OR = 7.12; 95% CI: 2.48 – 20.39), manual worker (OR = 5.75; 95% CI:

1.99 – 16.59) and clerical/sales/service staff (OR = 3.80; 95% CI: 1.31 – 11.08) were more likely to be incompletely immunized compared to children of professionals.

Table 10: Simple Binary Logistic Regression Analysis of Socio-demographic Factors Associated with Incomplete Immunization among Children aged 12 – 23 Months

Variables	Crude OR (95% CI)	P - value
Regions		
Tigray	1.02 (0.64 – 1.62)	> 0.94
Affar	22.1 (10.56 – 46.25)	< 0.0001
Amhara	3.76 (2.35 – 6.03)	< 0.0001
Oromiya	7.14 (4.40 – 11.59)	< 0.0001
Somali	6.48 (3.69 – 11.38)	< 0.0001
B. Gumuz	4.53 (2.72 – 7.57)	< 0.0001
SNNP	4.80 (2.99 – 7.70)	< 0.0001
Gambella	8.50 (4.71 – 15.36)	< 0.0001
Harari	2.65 (1.55 – 4.53)	< 0.0001
Addis Ababa	0.32 (0.16 – 0.63)	< 0.001
Dire Dawa	1.00	
Place of residence		
Rural	3.26 (2.90 – 3.66)	< 0.0001
Urban	1.00	
Mothers' age		
15 - 24	1.19 (0.89 – 1.60)	> 0.05
25 - 34	0.98 (0.75 – 1.27)	> 0.05
35 - 49	1.00	
Child's sex		
Male	1.07 (0.88 – 1.31)	> 0.05
Female	1.00	

Table 10: Simple binary logistic regression analysis of socio-demographic factors associated with incomplete immunization among children aged 12 – 23 months (*Continued*)

Variables	Crude OR (95% CI)	P - value
Birth order		
1 - 3	0.70 (0.53 – 0.93)	< 0.015
4 - 6	0.95 (0.70 – 1.30)	> 0.05
≥ 7	1.00	
No of living children		
1 - 3	0.70 (0.49 – 1.02)	> 0.05
4 - 6	0.98 (0.66 – 1.45)	> 0.05
≥ 7	1.00	
Religion		
Orthodox	0.28 (0.10 – 0.73)	< 0.01
Catholic	0.54 (0.12 – 2.46)	> 0.05
Protestant	0.93 (0.34 – 2.54)	> 0.05
Muslim	0.72 (0.27 – 1.91)	> 0.05
Traditional	1.85 (0.32 – 10.69)	> 0.05
Others	1.00	
Marital status		
Married	2.47 (1.14 – 5.38)	< 0.022
Previously married	3.21 (1.21 – 8.52)	< 0.019
Never married	1.00	
Source of vaccination record		
Mothers' report	2.59 (2.32 – 2.88)	< 0.0001
Vaccination card	1.00	

Table 11: Simple Binary Logistic Regression Analysis of Socioeconomic Factors Associated with Incomplete Immunization among Children Aged 12 – 23 Months

Variables	Crude OR (95% CI)	P - value
Wealth index		
Poorest	7.28 (5.35 – 9.91)	< 0.0001
Poorer	4.49 (3.23 – 6.23)	< 0.0001
Middle	3.41 (2.47 – 4.71)	< 0.0001
Richer	2.9 (2.18 – 4.11)	< 0.0001
Richest	1.00	
Mothers education		
No education	6.32 (2.35 – 16.98)	< 0.0001
Primary	3.78 (1.40 – 10.25)	< 0.009
Secondary	1.30 (0.45 – 3.76)	> 0.05
Higher	1.00	
Fathers' education		
No education	3.92 (2.30 – 6.68)	< 0.0001
Primary	2.50 (1.46 – 4.27)	< 0.001
Secondary	1.86 (1.02 – 3.40)	> 0.05
Higher	1.00	
Mothers' Occupation		
Not working	7.12 (2.48 – 20.39)	< 0.0001
Manual work	5.75 (1.99 – 16.59)	< 0.001
Clerical/sales/service	3.8 (1.31 – 11.08)	< 0.014
Professional	1.00	

Table 12 shows that children of mothers with inadequate exposure to media (OR = 3.32; 95% CI: 2.94 – 3.75) and mothers that lack awareness of the community conversation programme (OR = 3.23; 95% CI: 2.86 – 3.66) were more likely to be incompletely immunized. Additionally, Table 12 revealed that the odds of incomplete immunization were high for children born to mothers that did not attend antenatal care during

pregnancy (OR = 4.83; 95% CI: 4.11 – 5.67), mothers that delivered at home (OR = 2.49; 95% CI: 2.25 – 2.76) and mothers that attended no postnatal care after delivery (OR = 3.69; 95% CI: 2.88 – 4.75).

Table 12: Simple Binary Logistic Regression Analysis of Exposure to Information and Incomplete Immunization among Children Aged 12 – 23 Months

Variables	Crude OR (95% CI)	P - value
Exposure to media		
Inadequate	3.32 (2.94 – 3.75)	< 0.0001
Adequate	1.00	
Awareness of community conversation programme		
No	3.23 (2.86 – 3.66)	< 0.0001
Yes	1.00	

Table 13: Simple Binary Logistic Regression Analysis of Health Services Utilization and Incomplete Immunization among Children Aged 12 – 23 months

Variables	Crude OR (95% CI)	P -value
Antenatal care attendance		
No	4.83 (4.11 – 5.67)	< 0.0001
Yes	1.00	
Place of delivery		
Home	3.69 (2.88 – 4.75)	< 0.0001
Health facility	1.00	
Postnatal care attendance		
No	2.49 (2.25 – 2.76)	< 0.0001
Yes	1.00	

4.5 Multivariable Logistic Regression Analysis

Multivariable logistic regression analysis of factors associated with incomplete immunization among children aged 12 – 23 months is shown in Table 14. Wide inequalities in immunization coverage rates were observed across the different wealth quintiles. Children of mothers from the poorest and poorer wealth quintile were 2.3 (Adjusted Odds Ratio [AOR] = 2.27; 95 % CI: 1.34 – 3.82) and 1.8 times (AOR = 1.82; 95 % CI: 1.08 – 3.07) respectively, more likely to be incompletely immunized compared to those from the richest wealth quintile. Looking at the regional variations and immunization status, children of mothers from Affar (AOR = 15.80; 95 % CI: 7.12 – 35.03), Amhara (AOR = 4.27; 95 % CI: 2.31 – 7.88), Oromiya [AOR = 8.10; 95 % CI: 4.60 – 14.25), Somali (AOR = 4.91; 95 % CI: 2.65 – 9.10), Benishangul-Gumuz (AOR = 4.20; 95% CI: 2.34 – 7.57), SNNP (AOR = 4.76; 95 % CI: 2.53 – 8.94), Gambela (AOR = 7.75; 95 % CI: 3.68 – 16.30) and Harari (AOR = 3.22; 95 % CI: 1.77 – 5.89) regions were more likely to be incompletely immunized compared to children of mothers who reside in Dire Dawa. Children of mothers with inadequate exposure to media were 1.6 times (AOR = 1.60; 95% CI: 1.21 – 2.14) more likely to have incomplete immunization compared to children of mothers with adequate media exposure. Children of mothers who are not aware of community conversation programme were 1.8 times (AOR = 1.80; 95% CI: 1.40 – 2.32) more likely to be incompletely immunized compared to children born to mothers who are aware of the programme. Children of mothers who attended no antenatal care at a health facility were 2.2 times (AOR = 2.21; 95% CI: 1.72 – 2.83) more likely to receive incomplete immunization than children of mothers who attended antenatal care.

Availability of vaccination card, religion, postnatal care attendance, place of delivery, birth order, place of residence, fathers' education, marital status, mothers' occupation and mothers' education were not associated with immunization status in the multivariable analysis after adjusting for all variables.

Table 14: **Multivariable Logistic Regression Analysis of Factors Associated with Incomplete Immunization among Children Aged 12 – 23 Months**

Variables	Crude OR (95% CI)	Adjusted OR (95% CI)	P - value
Wealth index			
Poorest	7.28 (5.35 – 9.91)	2.27 (1.34 – 3.82)	< 0.002
Poorer	4.49 (3.23 – 6.23)	1.82 (1.08 – 3.07)	< 0.025
Middle	3.41 (2.47 – 4.71)	1.42 (0.85 – 2.39)	> 0.05
Richer	2.9 (2.18 – 4.11)	1.43 (0.87 – 2.34)	> 0.05
Richest	1.00	1.00	
Regions			
Tigray	1.02 (0.64 – 1.62)	1.5 (0.80 – 2.87)	> 0.05
Affar	22.1 (10.56 – 46.25)	15.8 (7.12 – 35.03)	< 0.0001
Amhara	3.76 (2.35 – 6.03)	4.27 (2.31 – 7.88)	< 0.0001
Oromiya	7.14 (4.40 – 11.59)	8.10 (4.60 – 14.25)	< 0.0001
Somali	6.48 (3.69 – 11.38)	4.91 (2.65 – 9.10)	< 0.0001
B. Gumuz	4.53 (2.72 – 7.57)	4.20 (2.34 – 7.57)	< 0.0001
SNNP	4.80 (2.99 – 7.70)	4.76 (2.53 – 8.94)	< 0.0001
Gambella	8.50 (4.71 – 15.36)	7.75 (3.68 – 16.30)	< 0.0001
Harari	2.65 (1.55 – 4.53)	3.23 (1.77 – 5.89)	< 0.0001
Addis Ababa	0.32 (0.16 – 0.63)	0.94 (0.42 – 2.10)	> 0.05
Dire Dawa	1.00	1.00	
Exposure to media			
Inadequate	3.32 (2.94 – 3.75)	1.60 (1.21 – 2.14)	< 0.001
Adequate	1.00	1.00	

Table 14: Multivariable logistic regression analysis of factors associated with incomplete immunization among children aged 12 – 23 months (*Continued*)

Variables	Crude OR (95% CI)	Adjusted OR (95% CI)	P - value
Awareness of community conversation programme			
No	3.23 (2.86 – 3.66)	1.80 (1.40 – 2.32)	< 0.0001
Yes	1.00	1.00	
Antenatal care attendance			
No	4.83 (4.11 – 5.67)	2.21 (1.72 – 2.83)	< 0.0001
Yes	1.00	1.00	

CHAPTER 5: DISCUSSION

This study identifies the factors associated with incomplete immunization coverage of children aged 12 – 23 months in Ethiopia. In order to understand who are the unimmunized children, there is need to look at the socioeconomic and demographic factors that affect distribution of immunization coverage within countries. A child is expected to have completed the course of basic vaccinations before the second birthday; however, this study revealed that 71% of children aged 12-23 months in Ethiopia are not fully immunized. The study observed a large dropout of children between initial and subsequent vaccine doses. Of the selected socio-demographic and socioeconomic factors available in the 2011 EDHS and included in this analysis: wealth index, antenatal care, region of residence, mother's exposure to media and mother's awareness of community conversation programme were significantly associated with incomplete immunization status.

The prevalence rate of completely immunized children of 29% in this study is lower than most district level and regional survey findings in Ethiopia, and remains far below the target of 66% coverage set by the Ethiopia Federal Ministry of Health in 2010. Etana & Deressa (2012) reported complete immunization coverage rate of 36% among children aged 12–23 months from Ambo Woreda, Central Ethiopia. In a similar study from Southern Ethiopia, nearly three quarters (73.2%) of the children studied were fully immunized (Animaw, Taye, Merdekios, Tilahun & Ayele, 2014). Another study from rural southwestern Ethiopia recorded a complete immunization prevalence rate of 37% among children aged 12 – 23 months (Wado, Afework & Hindin, 2014). Mohamud and colleagues (2014) from Somali region of Ethiopia reported a prevalence rate of fully vaccinated 12 – 23 months old of 36.6%. The 2011 EDHS was conducted on a broader population and reported as an aggregate of rural and urbanized areas of the country, hence the observed difference between the findings of this study and the local studies. Additionally, differences in the sampling frame, design, sample size, representativeness of the sample, and selection methodology, as well as differences in the source of information, phrasing of questions, and reporting of data could help explain the observed differences in prevalence (EDHS, 2011).

The rate of complete immunization coverage in this study is lower than what was reported from other sub-Sahara African countries like Kenya 52.7% (Canavan, Sipsma, Kassie & Bradley, 2014), Malawi 51% (Munthali, 2007) and Uganda 37.7% (Canavan *et al,* 2014). The observed variation in complete immunization coverage between countries could be due to differences in the health service coverage including immunization services.

The findings of the specific vaccines' coverage observed in this study indicate that there might be large dropouts before completion of subsequent doses of a specific vaccine particularly for DPT and Polio. For instance DPT3 and Polio3 had only 36.5% and 44.4% coverage compared to BCG and DPT1 immunization coverage that had 66% and 64% coverage, respectively. This high percentage of defaulters could be due to inadequate vaccine supply, low utilization of maternal and child health care services, lack of local motivators for reminding/tracking defaulters and absence of health workers at health facilities. Other researchers from comparative settings have made similar observations (Mohamud, Feleke, Worku, Manay & Sharma, 2014; Tadesse, Deribew & Woldie, 2009).

Though, DPT and polio vaccines are routinely administered at the same time, polio coverage is higher than DPT coverage. This is for the most part due to the success of supplementary immunization activities, during which polio vaccines are administered (EDHS, 2011). The aforementioned underscore the importance of supplementary immunization activities in populations that have poor access to well-functioning health systems. Supplementary immunization activities is largely responsible for the near global eradication of polio and significant reduction in global burden of measles and maternal/neonatal tetanus (WHO, UNICEF & World Bank, 2009). In this approach, a mass-mobilization campaign-style is adopted, during which all children receive certain vaccine, often regardless of prior immunization. The approach has the potential to rapidly and equitably reach more children, particularly those missed by routine immunization. A study from Kenya revealed measles vaccine campaign uptake of over 90% in all wealth quintiles, compared to routine immunization that reached only 60% of the poorest wealth quintile (Vijayaraghavan *et al,* 2007).

The study observed that the proportion of incompletely immunized children varied significantly from one geographical region to the other, ranging from 18.2% in more developed urban Addis Ababa to 94% in less developed rural Affar region. This could suggest a wide range in the quality, coverage and effectiveness of the healthcare infrastructure in Ethiopia. Regional variation in vaccination could imply differential access to vaccinations due to either transport problems or difficulties in supply chain management (Humphreys, 2011; Jani *et al*, 2008). Other factors including fewer health facilities, shortage of health workers, staff commitment, quality of care available, quality of health information as well as the large differences in socio economic status can also account for differences in vaccination coverage across the different geographical regions. Previous researchers have also observed that children from relatively less developed rural provinces were more likely to have incomplete immunization compared to children from a well developed urban province (Antai, 2009; Bugvi *et al,* 2014; Fadnes et al, 2011). Therefore, there is need for a strategy that will reach the vulnerable children who are typically in remote rural areas with immunization services. This is very essential if the immunization-related global goals are to be equitably achieved. The Reaching Every District (RED) strategy is an approach that takes the district as its primary focus and aims to improve equity in access to immunization by targeting hard-to-reach populations (Vandelaer, Bilous & Nshimirimana, 2008). It encourages district-level immunization officials to identify and resolve local immunization-related problems, organize regular outreach vaccine delivery services and ensure that vaccines are delivered regularly to all districts. In less developed, rural and mobile regions like Somali, Gambela and Affar where the health infrastructure is weak and populations tend to be sparse, other approaches should be considered other than the traditional static and outreach strategies.

The study identified mothers' attendance at antenatal care as a significant determinant of immunization status of their children. Children of mothers who received no antenatal care were more likely to be incompletely immunized. The reason could be that mothers who did not attend antenatal care had no acquaintance with health workers and hence were less aware of the benefits of childhood immunization. Other researchers have linked childhood immunization and its timely dispensation to parents' previous interactions with

the healthcare system (Antai, 2009; Bugvi *et al*, 2014). Researchers have observed that information about childhood immunization is available to pregnant mothers that attend antenatal care, and such information is very helpful in getting children immunized after delivery (Antai, 2009; Bugvi *et al*, 2014; Dixit, Dwivedi & Ram, 2013). Though not statistically significant, children delivered at a health facility and children whose mother attended postnatal care were less likely to receive incomplete immunization compared to their counterparts. Initial contact with the health care system may be an avenue for communicating the importance of childhood immunization and its timely administration to mothers (Antai, 2009). Therefore, attendance at antenatal care should be promoted and greater utilization of health services by mothers encouraged (Mohamud *et al*, 2014). Additionally, ensuring that regular outreach vaccine delivery services are organised and delivered regularly to all districts will address the need of mothers who do not make use of the health facilities (Vandelaer, Bilous & Nshimirimana, 2008).

In this study, mothers from the poorest wealth quintile were more likely to have incompletely immunized children compared to children from the richest wealth quintile, and this is consistent with study findings in southwestern Ethiopia (Tadesse, Deribew & Woldie, 2009) and Pakistan (Bugvi *et al*, 2014). It is likely that mothers from the poorest wealth quintile may not find the resources to go to the health facilities for immunization. Another study from Turkey observed that employment status (an indicator of wealth status) is a determinant of completion of vaccination series (Topuzoglu, 2005). Mothers from poorest wealth quintile may not have the required education and media access to be able to properly comprehend the preventive benefits of timely and complete immunization (Bugvi *et al*, 2014; Topuzoglu *et al*, 2005). Therefore, to address the problem of incomplete immunization, all people without distinction of social or economic condition should have a right of equal access to the needed vaccines (WHO & UNICEF, 2005). Providing mothers of young children with voucher incentives is likely to improve immunization uptake among mothers from poor socioeconomic background (Chandir *et al,* 2010; Glassman, Todd & Gaarder, 2007). A mass mobilization campaign coupled with supplementary immunization activity has the potential to rapidly and equitably reach

more children, particularly those missed by routine immunization (WHO, UNICEF & World Bank, 2009).

Children from urban areas appear less likely to be incompletely vaccinated compared to their rural counterparts in this study. Though the observed relationship was found not to be statistically significant, it may be of public health significance. Therefore, interventions aimed at addressing low immunization coverage and uptake should be nationwide but with greater emphasis on the rural poor populace.

Information could play a decisive role in determining the health behavior of individuals. This study observed that inadequate access to media among mothers increases the likelihood of incomplete immunization of their children. Studies from Asia and sub-Saharan Africa have shown that mothers with mass media exposure (regularly watching TV and listening to radio) were more likely to fully immunize their children than mothers who had no mass media exposure (Bugvi *et al*, 2014; Olumuyiwa, Ewan, Francois & Vincent, 2008). Therefore, dedicating few days every year to National Immunization Campaigns to increase the level of awareness and motivation about immunization and its timely completion through print and electronic media, and town criers is of paramount importance (Bugvi *et al*, 2014; Duclos *et al*, 2009).

This study observed that mothers' awareness of community conversation programme was significantly associated with complete immunization status of their children. This could be due to the fact that mothers have received health education on the benefits of immunization through community conversation programme. The community conversation programme is a strategy for social mobilization that creates dialogue among community members aimed at raising awareness and inducing behavioral change concerning healthcare (FMOH, 2010). In Ethiopia, the facilitators of community conversation programme are the Community Health Extension Workers (CHEWs) who share ethnicity, dialect, and had grown up in the same district as the community conversation programme participants. The CHEWs engage a network of community leaders such as religious leaders, traditional rulers, women's associations, and village volunteers. They work closely with the community to organize services, spread the word

about the importance of immunization, and build local credibility for immunization programmes. Effective communication is a key component of a successful immunization programme (Jani *et al,* 2008). It plays a major role in increasing immunization coverage rates and reduces the number of children who default before completing all their vaccinations. The Ethiopian Ministry of Health implements the community conversation programme in every district on a regular basis (FMOH, 2010). The foregoing is in line with the assertion that successful immunization programme calls for community mobilization, especially in areas where there is high illiteracy and poor access to the media (WHO, UNICEF & World Bank, 2009). The active involvement of village volunteers to assist CHEWs to track children who are due for their next dose of vaccine, and to identify newborns or pregnant women is widely used in developing countries (FMOH, 2010; WHO & UNICEF, 2005). A systematic review has found that CHEWs can effectively promote immunisation uptake thereby reducing child morbidity and mortality (Lewin *et al*, 2010).

There was no evidence that the child's gender had any impact on immunization uptake in this study. This finding is similar to that of Jani *et al* (2008) from Mozambique. In some societies with cultural discrimination against the girl child, boys have a greater chance of being immunized (Kiros & White, 2004).

Low educational status of mothers has been previously documented to be associated with incomplete immunization status of children (Bugvi *et al*, 2014; Jani *et al,* 2008). Similarly, the present study observed an inverse relationship between mothers' educational level and incomplete immunization status. However, the aforementioned relationship was not statistically significant, probably because very few mothers had more than primary school education.

Limitations

Information on child vaccination status in the EDHS is based on either immunization cards or the self-reports of mothers. Information received through self-reports is subject to recall and social desirability biases. Secondly, this study cannot establish causal relationships between vaccination status and any of the independent variables because of

the cross-sectional nature of the survey. Thirdly, only the mothers were interviewed in the survey for information on their children's immunisation status. Ethiopia is a society where power and decision-making is equally under the control of the men. Additionally, this study did not address the influence of supply side factors including access and availability of services on immunization coverage. A binary categorization (complete immunization versus incomplete immunization) was used and this could have led to loss of some information. Lastly, this study is unable to adequately investigate district level differences in vaccination status because DHS data are sampled to be representative at a national and regional level and is not conducive to smaller area estimation.

Conclusion

Overall, the incomplete immunization rate of 71% in Ethiopia is very high, given the national target of complete immunization rate of 66%. Children of mothers from poor households, lack of antenatal care attendance during pregnancy, residence in less developed regions of Ethiopia, mother's inadequate media exposure and lack of mother's awareness of the community conversation programme were independently associated with incomplete immunization among Ethiopian children. Despite the limitations, this study highlights the fact that immunization services are not reaching the target population. Efforts should be deployed to provide full and timely immunization coverage to all children across the country with great emphasis on the poor and rural communities.

Recommendations

Regional based vaccine implementation programmes within administrative regions of the country are needed to enhance immunization coverage, with emphasis on hard to reach and less developed regions of the country. The Reaching Every District (RED) strategy, an approach that takes the district as its primary focus and aims to improve equity in access to immunization by targeting hard-to-reach populations needs to be strengthened in Ethiopia. The role of Community Health Extension Workers (CHEWs) in bridging the gap between health facilities and the communities especially in hard-to-reach areas, promoting immunization acceptance and following up defaulters is key to improving immunization coverage. Strengthening the health system through increasing the number

of health posts as well as the CHEWs could be an important strategy to increase immunization coverage. The use of mobile immunization teams to reach children whose families are mobile and those in hard to reach areas with immunization services will significantly address regional variations in immunization services (FMOH, 2015).

In order to address the problem of high percentage of defaulters and dropouts, children taken to health facilities for any purpose should be screened to check their immunization status so as to prevent missed opportunities.

Continuous awareness raising interventions through the media and the community conversation programme messages on the importance of immunization and its timely completion is fundamental. The role of CHEWs in community engagement of a network of community leaders such as religious leaders, traditional rulers and women's associations to improve childhood immunization coverage cannot be overemphasized. The strengthening of engagement, communication, education and information skills of the CHEWs is an important step towards improving immunization services.

Antenatal clinics should be employed as a platform for educating pregnant women on the benefits of child immunization. In order to address the immunization needs of children of mothers who do not make use of health facilities, regular outreach vaccine delivery services should be organised and delivered regularly to all districts.

Promotion of child health days, regular events designed to deliver an integrated package of preventive services including immunization have been shown to reduce inequalities in access to basic health services in many African countries, thus achieving high immunization coverage rate.

Given the fact that the proportion of incompletely immunized children is very high among the poorest households; conditional cash transfer, vaccine vouchers and poverty alleviation programmes could be explored through research to determine their effectiveness as strategies to increase immunization completion.

A longitudinal study is needed to explore the factors associated with high dropout rate between initial and subsequent doses of routine vaccinations. Research on innovative

approaches that will improve immunization coverage in less developed, rural and sparsely populated areas is of paramount importance. In view of the fact that only 44% of the women in this study attended antenatal care and a direct relationship was observed between antenatal care attendance and childhood immunization status, a qualitative research to explore the barriers women face in accessing health services is recommended.

Sharing the findings and recommendations of this study with the officials of Ministry of Health and all partners involved in childhood immunization programme in Ethiopia will be a significant step towards improving childhood immunization coverage in Ethiopia.

REFERENCES

Africa Routine Immunization System Essential (ARISE). (2012). *A Study of the Drivers of Routine Immunization System Performance in Ethiopia.* Virginia: JSI Research & Training Institute.

Ahmad, O., Lopez, A. & Ionue, O. (2000). The Decline in Child Mortality: a Reappraisal. *Bull World Health Organ,* 78:1175-91.

Animaw, W., Taye, W., Merdekios, B., Tilahun, M. & Ayele, G. (2014). Expanded Program of Immunization Coverage and Associated Factors among Children Age 12 – 23 Months in Arba Minch Town and Zuria District, Southern Ethiopia, 2013. *BMC Public Health*, 14: 464.

Antai, D. (2009). Inequitable Childhood Immunization Uptake in Nigeria: a Multilevel Analysis of Individual and Contextual Determinants. *BMC Infectious Diseases*, 9:181-91.

Arora, K.N., Lal, A.A., Hombach, M.J., Santos, I.J., Bhutta, A.Z., Sow, O.S. & Greenwood, B. (2013). The Need for Targeted Implementation Research to Improve Coverage of Basic Vaccines and Introduction of New Vaccines. *Vaccine,* 31 (2): 129–36.

Bordenave, G. (2003). Louis Pasteur (1822–1895). *Microbes Infect*, **5** (6):553–60.

Black, R.E., Morris, S.S. & Bryce, J. (2003). Where and Why are 10 Million Children Dying Every Year? *Lancet*, 361:2226-34.

Borooah, V. K. (2004). Gender Bias among Children in India in their Diet and Immunization against Disease. *Social Science & Medicine*, 58(9), 1719–31.

Brenzel, L., Wolfson, L.J., Fox-Rushby, J., Miller, M. & Halsey, N.A. (2006). Ch 20 - Vaccine Preventable Diseases. In DT Jamison, JG Breman, AR Measham, G Alleyne, M Claeson, DB Evans, P Jha, A Mills & P Musgrove (eds). *Disease Control Priorities in Developing Countries.* Washington: Oxford University Press and World Bank: 389-411.

Bronte-Tinkew, J. & Dejong, F.G. (2005). Do Household Structure and Household Economic Resources Predict Childhood Immunization? Evidence from Jamaica and Trinidad and Tobago. *Population Research and Policy Review*, 24 (1): 27-57.

Brugha, R. F., Kevany, J. P. & Swan, A. V. (1996). An Investigation of the Role of Fathers in Immunization Uptake. *International Journal of Epidemiology*, 25(4): 840–5.

Bugvi, S.A., Rahat, R., Zakar, R., Zakar, Z.M., Fischer, F., Nasrullah, M. & Manawar, R. (2014). Factors Associated with Non-utilization of Child Immunization in Pakistan: Evidence from the Demographic and Health Survey 2006-07. *BMC Public Health*, 14: 232.

Canavan, M.E., Sipsma, H.L., Kassie, G.M. & Bradley, E.H. (2014). Correlates of Complete Childhood Vaccination in East African Countries. *PLoS ONE* 9(4): e95709. doi:10.1371/journal.pone.0095709

Central Statistical Agency [Ethiopia] and ICF International. (2012). *Ethiopia Demographic and Health Survey 2011 (EDHS)*. Addis Ababa, Ethiopia and Calverton, Maryland, USA: Central Statistical Agency and ICF International.

Chandir, S., Khan, A.J., Hussain, H., Usman, H.R., Khowaja, S., Halsey, N.A. & Omar, S.B. (2010). Effect of Food Coupon Incentives on Timely Completion of DTP Immunization Series in Children from a Low-Income Area in Karachi, Pakistan: a Longitudinal Intervention Study. *Vaccine*, 28 (19): 3473 – 8.

Countdown to 2015. (2015). *A Decade of Tracking Progress for Maternal, Newborn and Child Survival: The 2015 Report.* Geneva: UNICEF and World Health Organization.

Dixit, P., Dwivedi, L.K. & Ram, F. (2013). Strategies to Improve Child Immunization via Antenatal Care Visits in India: A Propensity Score Matching Analysis. *PLoS ONE* 8(6): e66175. doi:10.1371/journal.pone.0066175

Duclos, P., Okwo-Bele, J., Gacic-Dobo, M. & Cherian, T. (2009). Global Immunization: Status, Progress, Challenges and Future. *BMC International Health and Human Rights,* 9 (1): S2.

Etana, B. & Deressa, W. (2012). Factors Associated with Complete Immunization Coverage in Children Aged 12–23 Months in Ambo Woreda, Central Ethiopia. *BMC Public Health*, 12: 566.

Fadnes, L.T., Jackson, D., Engebretsen, I.M., Zembe, W., Sanders, D., Sommerfelt, H. & Tylleskär, T. (2011). Vaccination Coverage and Timeliness in Three South African Areas: a Prospective Study. *BMC Public Health*, 11, 404. http://doi.org/10.1186/1471-2458-11-404.

Fantahun, M., Berhane, Y., Wall, S., Byass, P. & Hogberg, U. (2007). Women's Involvement in Household Decision-Making and Strengthening Social Capital—Crucial Factors for Child Survival in Ethiopia. *Acta Paediatrica*, 96(4): 582–9.

Federal Ministry of Health of Ethiopia (FMOH). (2010). *Ethiopia National Expanded Programme on Immunization: Comprehensive Multi-Year Plan 2011 – 2015.* Addis Ababa: Federal Ministry of Health.

Federal Ministry of Health of Ethiopia (FMOH). (2015). *Ethiopia National Expanded Programme on Immunization: Comprehensive Multi-Year Plan 2016 – 2020.* Addis Ababa: Federal Ministry of Health.

Fiedler, J. L. & Chuko, T. (2008). The Cost of Child Health Days: a Case Study of Ethiopia's Enhanced Outreach Strategy. *Health Policy Plan*, 23(4): 222–33.

Gage, J.A., Sommerfelt, E.A. & Piani, L.A. (1997). Household Structure and Childhood Immunization in Niger and Nigeria. *Demography*, 34 (2): 295-309.

GAVI. (2015). Saving Children's Lives and Protecting People's Health by Increasing Access to Immunisation in Poor Countries: 2014 Annual Progress Report. Geneva: GAVI, The Vaccine Alliance.

Glassman, A., Todd, E.J. & Gaarder, M. (2007). Performance-Based Incentives for Health: Conditional Cash Transfer Programs in Latin America and the Caribbean. *Center for Global Development Working Paper* No. 120.

Government of Ethiopia (2007). *2007 Ethiopian Census*. Addis Ababa: Ethiopian Central Statistical Agency.

Hardt, K., Schmidt-Ott, R., Glismann, S., Adegbola, A.R., & Meurice, P.F. (2013). Sustaining Vaccine Confidence in the 21st Century. *Vaccines*, 1: 204–24.

Humphreys, G. (2011). Vaccination: Rattling the Supply Chain. *Bull World Health Organ*, 89: 317 - 92.

ICF International. (2012). Children's Health and Nutritional Status: Data from the 2011 Ethiopia Demographic and Health Survey. Calverton, Maryland, USA: ICF International.

Jani, J.V., Schacht, C.D., Jani, I.V. & Bjune, G. (2008). Risk Factors for Incomplete Vaccination and Missed Opportunity for Immunization in Rural Mozambique. *BMC Public Health*, 8:161. doi: 10.1186/1471-2458-8-161

Jegede, A.S. (2007). What Led to the Nigerian Boycott of the Polio Vaccination Campaign? *PLoS Med,* 4(3): 417–22.

Jheeta, M. & Newell, J. (2008). Childhood Vaccination in Africa and Asia: the Effects of Parents' Knowledge and Attitudes. *Bulletin of the World Health Organization*, 86 (6): 419-20.

Johnson, B., & Christensen, L. (2008). *Educational Research: Quantitative, Qualitative, and Mixed Approache*s (p. 34). Thousand Oaks, CA: Sage Publications.

Jones, G., Steketee, W.R., Black, E.R., Bhutta, A.Z. & Morris, S.S. (2003). How Many Child Deaths Can we Prevent this Year? *Lancet*, 362 (9377): 65–71.

Kiros, G. & White, J.M. (2004). Migration, Community Context, and Child Immunization in Ethiopia. *Social Science & Medicine*, 59: 2603–16.

Lewin, S., Munabi-Babigumira, S., Glenton, C., Daniels, K., Bosch-Capblanch, X., van Wyk, B.E., Odgaard-Jensen, J., Johansen, M., Aja, G.N., Zwarenstein, M. & Scheel, I.B. (2010). Lay Health Workers in Primary and Community Health Care for Maternal and Child Health and the Management of Infectious Diseases. *Cochrane Database of*

Systematic Reviews, Issue 3. Art. No.: CD004015. DOI: 10.1002/14651858.CD004015.pub3.

Lichtman, M. (2006). *Qualitative Research in Education: A User's Guide* (pp. 7-8). Thousand Oaks, CA: Sage Publications.

Lloyd, J.S. & Milstien, J.B. (1999). Auto-Disable Syringes for Immunization: Issues in Technology Transfer. *Bulletin of the World Health Organization*, 77(12): 1001 – 1007.

Mathew, L.J. (2012). Inequity in Childhood Immunization in India: A Systematic Review. *Indian Pediatr*, 49: 203 – 23.

Madhi, A.S., Cunliffe, A.N., Steele, D., Witte, D., Kirsten, M., Louw, C., Ngwira, B., Victor, C.J., Gillard, H.P., Cheuvart, B.B., Han, H.H. & Neuzil, M.K. (2010). Effect of Human Rotavirus Vaccine on Severe Diarrhea in African Infants. *N Engl J Med*, 362:289 - 98.

Madhi, A.S., Levine, S.O., Hajjeh, R., Mansoor, D.O. & Thomas, C. (2008). Vaccines to Prevent Pneumonia and Improve Child Survival. *Bull World Health Organ,* 86:365 – 72.

Mohamud, N.A., Feleke, A., Worku, W., Manay, K.M. & Sharma, R.H. (2014). Immunization Coverage of 12–23 Months Old Children and Associated Factors in Jigjiga District, Somali National Regional State, Ethiopia. *BMC Public Health*, 14:865.

Munthali, C.A. (2007). Determinants of Vaccination Coverage in Malawi: Evidence from the Demographic and Health Surveys. *Malawi Medical Journal*, 19(2):79 – 82.

Odusanya, O.O., Alufohai, F.E., Meurice, P.F. & Ahonkhai, I.V. (2008). Determinants of Vaccination Coverage in Rural Nigeria. *BMC Public Health*, 8: 381

O'Grady, K., Krause, V. & Andrews, R. (2009). Immunization Coverage in Australian Indigenous Children: Time to Move the Goal Posts. *Vaccine,* 27: 307–12.

PAHO (Pan American Health Organization) & WHO. 2002. *Immunization Safety: How to Address Events Allegedly Attributable to Vaccination or Immunization?* Washington, DC: Pan American Health Organization.

PATH (Program for Appropriate Technology in Health). (2009). *A History of Vaccines*. Washington, DC: Program for Appropriate Technology in Health.

PATH (Program for Appropriate Technology in Health) & WHO. (2009). *Optimize Immunization Systems and Technologies for Tomorrow: A Transformation in the Vaccine Landscape*. Geneva: World Health Organization.

Payne,S., Townsend, J., Jasseh, M., Jallow, Y.L. & Kampmann, B. (2013).Achieving Comprehensive Childhood Immunization: an Analysis of Obstacles and Opportunities in The Gambia. *Health Policy and Planning*: 1–11.

Robson, C. (2011). Ch 5 – Fixed Designs. *In Real World Research*: 81 – 93. West Sussex: John Wiley and Sons.

Rohini, P. (2003). Selective Gender Differences in Childhood Nutrition and Immunization in Rural India: The Role of Siblings. *Demography*, 40(3): 395–418.

Rutherford, M.E., Dockerty, J.D., Jasseh, M., Howie, S.R.C., Herbison, P., Jeffries, D.J., Mulholland, K., Adegbola, R.A. & Hill, P.C. (2009). Preventive Measures in Infancy to Reduce Under-five Mortality: a Case-Control Study in the Gambia. *Tropical Medicine and International Health,* 14:149–55.

Sadoh, E.A. & Eregie, O.C. (2009). Timeliness and Completion Rate of Immunization among Nigerian Children Attending a Clinic-based Immunization Service. *J HEALTH POPUL NUTR*, 27(3):391-5.

Sanou, A., Simboro, S., Kouyaté, B., Dugas, M., Graham, J. & Bibeau, G. (2009).Assessment of Factors Associated with Complete Immunization Coverage in Children Aged 12-23 Months: a Cross-Sectional Study in Nouna District, Burkina Faso. *BMC International Health and Human Rights*, 9(1):S10.

Streefland, P., Chowdhury, A. M. R., & Ramos-Jimenez, P. (1999). Patterns of Vaccination Acceptance. *Social Science & Medicine*, 49: 1705–16.

Streatfield, K., Singarimbun, M., & Diamond, I. (1990). Maternal Education and Child Immunization. *Demography*, 27: 447–55.

Sullivan, M., Tegegn, A., Tessema, F., Galea, S. & Hadley, G. (2010). Minding the Immunization Gap: Family Characteristics Associated with Completion Rates in Rural Ethiopia. *J Community Health*, 35:53–9.

Tadesse, H., Deribew, A. & Woldie, M. (2009). Predictors of Defaulting from Completion of Child Immunization in South Ethiopia: a Case Control Study. *BMC Public Health,* 22(9): 150.

Topuzoglu, A., Ozaydın, G.A.N., Cali, S., Cebeci, D., Kalaca, S. & Harmanci, H. (2005). Assessment of Sociodemographic Factors and Socio-Economic Status Affecting the Coverage of Compulsory and Private Immunization Services in Istanbul, Turkey. *Public Health*, 119: 862–9.

UN Inter-agency Group for Child Mortality Estimation (UN IGME). (2014). *Levels & Trends in Child Mortality***.** New York: United Nations Children's Fund**.**

UNDP. (2015). *National Human Development Report 2014: Accelerating Inclusive Growth for Sustainable Human Development in Ethiopia*: Addis Ababa: United Nations Development Programme.

Wamai, R. G. (2009). Reviewing Ethiopia's Health System Development. *International Medical Community JMAJ*, 52(4): 279-286.

Wassenaar, D.R. (2007). Ch 4 – Ethical Issues in Social Science Research. In Terre Blanche, M. & Durrheim, K. (Eds). *Research in Practice: Applied Methods for the Social Science:* 67. Cape Town: UCT Press.

Wiysonge, C.S., Uthman, O.A., Ndumbe, P.M. & Hussey, G.D. (2012). Individual and Contextual Factors Associated with Low Childhood Immunisation Coverage in Sub-Saharan Africa: A Multilevel Analysis. *PLoS ONE* 7(5): e37905.

Vandelaer, J., Bilous, J. & Nshimirimana, D. (2008). Reaching Every District (RED) Approach: a Way to Improve Immunization Performance. *Bull World Health Organ,* 86 (3): A.

Vijayaraghavan, M., Martin, M.R., Sangrujee, N., Kimani, N.G., Oyombe, S. & Kalu, A. (2007). Measles Supplemental Immunization Activities Improve Measles Vaccine Coverage and Equity: Evidence from Kenya, 2002. *Health Policy,* 83(1): 27–36.

Wado, D.Y., Afework, F.M. & Hindin, J. M. (2014). Childhood Vaccination in Rural Southwestern Ethiopia: the Nexus with Demographic Factors and Women's Autonomy. *Pan Afr Med J*., 17 (1): 9.

Wakefield, A.J. (1999) MMR Vaccination and Autism. *Lancet*, 354:949–50.

World Bank. (1993). *World Development Report 1993: Investing in Health*. New York: Oxford University Press.

WHO. (2013). *Global Vaccine Action Plan 2011 – 2020*. Geneva: World Health Organization.

WHO. (2014). *WHO Policy Statement: Multi-dose Vial Policy (MDVP)*. Geneva: World Health Organization.

WHO. (2015). *Measles Fact Sheet N^{o} 286.* Geneva: World Health Organization.

WHO & UNICEF. (1996). *State of the World's Vaccines and Immunization*. Geneva: World Health Organization.

WHO & UNICEF. (2005). *Global Immunization Vision and Strategy, GIVS 2006–2015*. [Online]. Available: www.who.int/vaccines-documents/www.unicef.org. [Downloaded: 16/11/13 5:00 PM].

WHO, UNICEF & World Bank. (2009). *State of the World's Vaccines and Immunization*, 3rd ed. Geneva, World Health Organization.

APPENDIX 1: UWC Senate Research Committee Approval

OFFICE OF THE DEAN
DEPARTMENT OF RESEARCH DEVELOPMENT

UNIVERSITY of the
WESTERN CAPE

16 September 2015

To Whom It May Concern

I hereby certify that the Senate Research Committee of the University of the Western Cape approved the methodology and ethics of the following research project by:
Dr TM Raji (School of Public Health)

Research Project:	Assessment of factors associated with incomplete immunization among children aged 12-23 months in Ethiopia.
Registration no:	15/6/14

Any amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

The Committee must be informed of any serious adverse event and/or termination of the study.

Ms Patricia Josias
Research Ethics Committee Officer
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